The North-west Marine Bioregional Plan

Bioregional Profile

A Description of the Ecosystems, Conservation Values and Uses of the North-west Marine Region

Australian Government
Department of the Environment, Water, Heritage and the Arts

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Ministerial Foreword

As an island continent, Australia is responsible for around 60 000 kilometres of coastline and more than 15 million square kilometres of ocean, an area almost twice the size of our continental land mass. These oceans support fishing, tourism, mineral and petroleum industries worth billions of dollars each year to the Australian economy.

Our marine systems extend from the tropical seas of northern Australia to the Antarctic ice-shelf. The extraordinary natural diversity and biological richness of our oceans means that globally, Australia is a prominent global steward of marine biodiversity.

Our national record in marine conservation is a mixed one. We lead the world in the protection of coral reef systems and in our stewardship of iconic marine animals such as whales, turtles and sea birds. Our performance in other areas, such as halting the decline in important fish stocks and taking early action to address the cumulative impacts of human activities on the marine environment, has not been as effective. The Australian Government is committed to addressing the issues of ecologically sustainable development and protection of the biological diversity in the oceans we manage.

The limited information about Australia's marine biodiversity, especially for the species and ecosystems of the more remote and deeper oceanic areas, has been a barrier to developing a strategic approach to sustainable management of our oceans. Our lack of knowledge adds to the difficulty in developing effective responses to both large and small scale impacts on ocean ecosystems, including those resulting from global climate change.

Marine bioregional planning will help Australians better understand and protect our marine environments and biodiversity. It will deliver greater certainty to industry by clearly identifying the Government's conservation priorities and will help project proponents understand their obligations under Commonwealth legislation in each Marine Region.

The North-west Bioregional Profile consolidates, for the first time, the best available information on this vast and unique area that stretches from the Kimberley in the north to Ningaloo and Shark Bay in the south; from the marine communities of the vast and shallow North-west Shelf to the 5000 metre depths of the Cuvier and Argo abyssal plains.

The North-west Bioregional Profile is the starting point for developing a Marine Bioregional Plan for the Region, due for release in mid 2010. The North-west plan is one of four that together will identify the conservation values of our oceans, the actions we need to protect them, and the areas we will look to include in the National Representative System of Marine Protected Areas.

The natural world carries profoundly strong cultural connections for Indigenous communities and sea country is an integral part of this world for coastal communities. We will be working with Aboriginal people to ensure their views and conservation goals are incorporated in the planning process.

The North-west marine bioregional planning process will complement the Kimberley Strategic Assessment being undertaken collaboratively with the Western Australian Government. The Strategic Assessment and the North-west Marine Bioregional Plan will help to ensure that development in the Kimberley and of the vast natural gas reserves of the Browse Basin does not imperil the region's wonderful cultural and environmental values, and brings substantial benefits to the nation and to the Kimberley's Indigenous people.

Peter Garrett
Minister for the Environment, Heritage and the Arts

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Pelican on beach, Shark Bay World Heritage Area. Photo: Rory Chapple, Department of Environment and Conservation, WA.

Preface

Marine bioregional planning is the Australian Government's world-leading approach to protecting Australia's marine environment. Marine bioregional planning is underpinned by the principles of ecologically sustainable development and takes an ecosystem approach in managing Australia's marine biodiversity and environment.

This Bioregional Profile has been prepared by the Department of the Environment, Water, Heritage and the Arts as the first step in the development of a Marine Bioregional Plan for Australia's North-west Marine Region. It establishes the information base upon which the North-west Marine Bioregional Plan will be developed. In particular, it focuses on the natural assets of the North-west Marine Region, describes its ecological characteristics, outlines its conservation values and explains how new Marine Protected Areas will be identified. Additionally, it provides a broad description of the human activities that take place in the Region.

The Bioregional Profile complements information available on the Department's website <www.environment.gov.au>. The reports that underpin this Profile are an important step in building our information base for this Marine Region, large parts of which are still poorly understood. These reports are available on the internet at <www.environment.gov.au/coasts/mbp/north-west>.

While every attempt has been made to gather the best available information and provide a comprehensive picture of the North-west Marine Region, there will certainly be other information sources available that will be helpful in the next stages of the planning process. The Department of the Environment, Water, Heritage and the Arts welcomes any contribution from the public about information and data that may be relevant to developing a Bioregional Plan for the North-west Marine Region.

Additional information, as well as any questions or comments you might have concerning this document, can be directed to:

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A glossary has been developed to assist with technical terminology used in the Bioregional Profile. The glossary is located on page 266.

Separate large-format maps of the geomorphic and key ecological features of the Region can be found in the envelope inside the back cover.

Appendices are available on compact disc, also inside the back cover.

Sea snake. Photo: Australian Institute of Marine Science.

Executive Summary

This Bioregional Profile is the first step in the development of a Marine Bioregional Plan for Australia's North-west Marine Region. Marine Bioregional Plans will provide strategic guidance for the Minister for the Environment, Heritage and the Arts, government decision-makers and marine users by:

- describing each Marine Region's conservation values, including mapping sites of importance for protected species and communities;
- identifying regional priorities for action, based on an assessment of threats to conservation values and long-term policy goals; and
- developing strategic guidance for proponents and decision-makers, for example by providing a regional context for national guidelines to help proponents consider whether their action in a Marine Region might result in a significant impact on matters of national environmental significance.

Information on marine bioregional planning and the North-west Marine Bioregional Profile can be found in Chapter 1.

Marine bioregional planning is also the process by which the Australian Government identifies areas within Commonwealth waters for inclusion in the National Representative System of Marine Protected Areas (MPAs). The guidelines the Government is using to develop the National Representative System of MPAs have been agreed upon with the States and the Northern Territory. They are summarised in Chapter 4 and can be found online at <www.environment.gov.au/coasts/mpa>.

The North-west Marine Region comprises Commonwealth waters from the Western Australian – Northern Territory border to Kalbarri, south of Shark Bay. It covers some 1.07 million km^2 of tropical and sub-tropical waters. The Region's north-western boundary is defined in accordance with the Perth Treaty negotiated with the Republic of Indonesia. The Region includes only those areas where Australia has jurisdiction over both the water column and seabed.

Those parts of the Region adjacent to the Kimberley and Pilbara include thousands of square kilometres of shallow continental shelf (about 30 per cent of the total Region), although Australia's narrowest shelf margin is also to be found within the Region at Ningaloo Reef. Over 60 per cent of the seafloor in the Region is continental slope, of which extensive terraces and plateaux make up a large proportion. Those parts of the Argo and Cuvier abyssal plains that are included within the Region comprise about 10 per cent of the Region's total area. Overall, the Region is relatively shallow with more than 50 per cent of the Region having water depths of less than 500 m. The deepest parts of the Argo and Cuvier abyssal plains within the Region, however, reach water depths of almost 6000 m.

This Bioregional Profile describes the environmental and socio-economic characteristics of the Region.

Dolphin, Shark Bay World Heritage Area. Photo: Ian Anderson, Department of Environment and Conservation, WA.

The environment of the North-west Marine Region

The Region is characterised by shallow-water tropical marine ecosystems. While in general endemism is not particularly high by Australian standards, the Region is home to globally significant populations of internationally threatened species.

Although the Leeuwin Current is a signature of the Region, the Region overall is dominated by the Indonesian Throughflow. The Throughflow is one of the primary links in the global exchange of water and heat between ocean basins and is an essential element in the global climate system. It delivers warm, oligotrophic (low in nutrients) and low salinity water from the western Pacific Ocean to the Indian Ocean and is a fundamental driver of oceanographic and ecological processes in the North-west Marine Region.

The Region exhibits monsoonal climatic patterns characterised by a pronounced cyclone season between December and March when the Kimberley experiences a wet season and the Pilbara is subject to sporadic and intense storms. There are large influxes of freshwater run-off in the Kimberley during the wet season and cyclonic storms making landfall in the Pilbara produce sporadic but pronounced freshwater inflows in the central part of the Region. During the summer months the north of the Region is subject to onshore winds while the Region's south experiences strong southerlies. During winter the winds moderate in the south and are generally offshore in the north.

The Integrated Marine and Coastal Regionalisation of Australia Version 4.0 (IMCRA v. 4.0) is an ecosystem-based classification of Australia's marine and coastal environments that was developed through the collaborative efforts of State, Territory and Commonwealth marine management and research agencies. The IMCRA provides a regional framework for planning resource development and biodiversity conservation. Provincial bioregions were classified based on fish, benthic (seabed) habitat and oceanographic data at a scale that is useful for regional conservation planning and management.

IMCRA v. 4.0 identifies eight provincial bioregions in the Region. These are described in Chapter 2. (Note: The terms provincial bioregion and bioregion are used interchangeably throughout the North-west Bioregional Profile to refer to the provincial bioregions identified by IMCRA v. 4.0).

The Northwest Shelf Transition
(area 305 463 km²; max depth 330 m).

This provincial bioregion straddles the North and North-west Marine Regions, extending from the Tiwi Islands in the Northern Territory to Cape Leveque in Western Australia. The Indonesian Throughflow is the dominant oceanographic feature and dominates the majority of the water column. The strength of the Throughflow and its influence in the bioregion varies seasonally in association with the North-west Monsoon.

The vast majority of the provincial bioregion is located on the continental shelf with water depths generally in the range 10–100 m. The provincial bioregion has a complex seafloor topography with a diversity of features including submerged terraces, carbonate banks, pinnacles, reefs and sand banks. The carbonate banks and pinnacles of the Joseph Bonaparte Gulf are distinctly different in morphology and character to other parts of the Region, and are believed to support a high diversity of marine species.

The biological communities of the North-west Shelf Transition are typical of Indo-west Pacific tropical flora and fauna, and occur across a range of soft-bottom and harder substrate habitats. The inshore waters off the Kimberley are where the Western Australian population of humpback whales mate and give birth. The Northwest Shelf Transition is important for commercial fisheries, defence, and the petroleum industry.

The Timor Province
(area 156 669 km²; max depth 5920 m)

This provincial bioregion covers almost 15 per cent of the North-west Marine Region, predominantly covering the continental slope and abyss between Broome and Cape Bougainville. Water depth ranges from about 200 m near the shelf break to 5920 m over the Argo Abyssal Plain. In addition to the Argo Abyssal Plain, the major geomorphic features are the Scott Plateau, the Ashmore Terrace, part of the Rowley Terrace and the Bowers Canyon. Ashmore Reef, Cartier Island, Seringapatam Reef and Scott Reef are important features of the provincial bioregion.

The bioregion is dominated by the warm, oligotrophic waters of the Indonesian Throughflow. The thermocline in the water column in this bioregion is particularly pronounced and is associated with the generation of

internal tides, an important oceanographic feature of this bioregion. The variety of geomorphic features in the Timor Province, together with the variation in bathymetry, results in several distinct habitats and biological communities, many of which are in close proximity to each other. The reefs and islands of the bioregion are regarded as particular hotspots for biodiversity. A high level of endemicity exists in demersal fish communities of the continental slope in the Timor Province and two distinct communities have been identified – one associated with the upper slope, the other with the mid slope. The bioregion is important for the petroleum industry, and commercial fisheries operate within it.

The Northwest Shelf Province
(area 238 759 km²; max depth 200 m)

This provincial bioregion is located primarily on the continental shelf between North West Cape and Cape Bougainville. It varies in width from about 50 km at Exmouth Gulf to more than 250 km off Cape Leveque. About half the bioregion has water depths of only 50–100 m. The bioregion is a dynamic oceanographic environment, influenced by strong tides, cyclonic storms, long-period swells and internal tides. Its waters derive from the Indonesian Throughflow, are warm and oligotrophic, and circulate throughout the bioregion via branches of the South Equatorial and Eastern Gyral Currents.

Fish communities are diverse and both benthic and pelagic fish communities appear to be closely associated with different depth ranges. Humpback whales migrate through the bioregion and Exmouth Gulf is an important resting area, particularly for mothers and calves on their southern migration. A number of important seabird breeding sites are located in the bioregion (but adjacent to Commonwealth waters), including Eighty Mile Beach, the Lacepede Islands, and Montebello and Barrow islands. The bioregion is important for the petroleum industry and the location of commercial fishing operations. The nationally significant ports of Dampier and Port Hedland operate in this bioregion.

The Northwest Transition
(area 184 424 km²; max depth 5980 m)

This provincial bioregion includes shelf break and continental slope and the majority of the Argo Abyssal Plain included in the North-west Marine Region. Key topographic features include the Mermaid, Clerke and Imperieuse Reefs, all of which are marine reserves and together constitute the Rowley Shoals. Surface circulation of Indonesian Throughflow waters occurs both via direct southward movement of the Throughflow itself, and recirculation of Throughflow waters via the South Equatorial Current. Cyclone incidence is high in this bioregion during summer months.

Little is known about benthic biological communities in the deeper parts of the provincial bioregion, although high levels of species diversity and endemism have been identified among demersal fish communities on the continental slope. The Rowley Shoals are biodiversity hotspots in the bioregion and the steep change in slope around them attracts a range of pelagic migratory species including billfish, sharks, tuna and cetaceans. Commercial fishers operate within the bioregion and it may increase in importance for the petroleum industry in the future.

The Northwest Province
(area 178 651 km²; max depth 5170 m)

This provincial bioregion occurs offshore between Exmouth and Port Hedland and consists entirely of continental slope. Water depths generally range between 1000–3000 m. The dominant geomorphic feature is the Exmouth Plateau, while the Montebello Trough and Swan Canyon are also important features. It contains the steepest shelf break in the Marine Region along the Cape Range Peninsula near Ningaloo Reef. Circulation and recirculation (via the South Equatorial Current) of Indonesian Throughflow waters comprise the dominant surface flow. The predominantly southward moving surface waters consolidate along the narrow shelf break adjacent to Cape Range Peninsula to form the Leeuwin Current, a significant feature of this bioregion and those further south.

The canyons in this bioregion probably channel currents onto the Exmouth Plateau and certainly onto the shelf along Ningaloo Reef, resulting in enhanced localised biological production. The Northwest Province represents the beginning of a transition between tropical and temperate marine species. High endemism in demersal fish communities on the slope is also evident in this provincial bioregion. Commercial fishing and petroleum are important industries in some parts of the bioregion.

Central Western Shelf Transition
(area 9698 km²; max depth 100 m)

This is the smallest provincial bioregion in the North-west Marine Region and is located entirely on the continental shelf between North West Cape and Coral Bay. Although both the Leeuwin Current and the Leeuwin Undercurrent occur on the adjacent slope, this bioregion is strongly influenced by the interactions between these currents and the nearshore, northward flowing Ningaloo Current.

The bioregion is located within a significant biogeographic transition between tropical and temperate species. A large proportion of the bioregion is covered by the Ningaloo Marine Park, and Ningaloo Reef is an area of high biodiversity with over 200 species of coral and more than 460 species of reef fish. Marine turtles, dugongs and dolphins frequently visit the reef lagoon and whale sharks and manta rays visit the outer reef. Commercial fishing and petroleum are the major industries in the bioregion.

Central Western Transition
(area 162 891 km²; max depth 5330 m)

This provincial bioregion covers the continental slope and abyss between Shark Bay and North West Cape. The major geomorphic features of the bioregion are the Wallaby Saddle, Carnarvon Terrace, the Cuvier Abyssal Plain and the Cloates and Cape Range Canyons. Almost half the bioregion has water depths of more than 4000 m and the proximity of deep ocean areas to the continental slope and shelf may have resulted in distinctive biological communities.

The Leeuwin Current, flowing south along the slope, is the dominant oceanographic feature. Interactions between the Leeuwin Current, Leeuwin Undercurrent and the nearshore Ningaloo Current facilitate vertical mixing of water layers and are believed to be associated with sporadic bursts in productivity (particularly during summer). The level of endemism within demersal fish communities on the slope is less than in the bioregions further north. This bioregion is also within the biogeographic transition between tropical and temperate marine species. The major industries in the bioregion are commercial fishing and petroleum.

Central Western Shelf Province
(area 50 516 km²; max depth 100 m)

This bioregion consists of the continental shelf between Kalbarri and Coral Bay. Most of the bioregion varies in depth between 50–100 m and has a predominantly flat, sandy substrate. The main currents are the Leeuwin (centred on the shelf break), the Ningaloo (which originates around the mouth of Shark Bay and flows north, and the northern extreme of the wind-driven Capes Current. In addition, during summer seepage out of Shark Bay of hypersaline water occurs and is known as the Shark Bay Outflow.

The bioregion abuts the Shark Bay World Heritage Area, a globally important area for dugongs. Commercial fishing and petroleum are the main industries in the bioregion.

Divers at Mermaid Reef. Photo: Naomi Wolfe, Department of the Environment, Water, Heritage and the Arts.

Conservation values of the North-west Marine Region

Conservation values of the Region include protected species and protected places, as well as a number of key ecological features in the Commonwealth marine environment identified as part of this planning process.

A total of 151 species that are known to occur in the Region are protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), as either threatened, migratory, cetacean or listed marine species. Of these, 17 species are listed as threatened, including four endangered and 13 vulnerable species.

This Bioregional Profile identifies a number of key ecological features that are of conservation value because of the role they are thought to play in the marine environment of the Region. They are given this value on the basis that they are:

- a species, group of species or a community with a regionally important ecological role (e.g. a predator, prey that affects a large biomass or number of other marine species); or
- a species, group of species or a community that is nationally or regionally important for biodiversity; or
- an area or habitat that is nationally or regionally important for:

  a) enhanced or high biological productivity (such as predictable upwellings),

  b) aggregations of marine life (such as feeding, resting, breeding or nursery areas),

  c) biodiversity and endemism; or
- a unique seafloor feature with known or presumed ecological properties of regional significance.

Key ecological features of the Region include:

Regionally significant geomorphic features:

- Carbonate banks in the Joseph Bonaparte Gulf (Unique seafloor feature);
- Limestone pinnacles in the Bonaparte Depression (Unique seafloor feature);
- Canyons on the slope between Agro Abyssal Plain and Scott Plateau (Unique seafloor feature; enhanced biological productivity; aggregations of marine life);
- Ancient coastline at 125 m contour (Unique seafloor feature; enhanced biological productivity);
- Exmouth Plateau (Unique seafloor feature);
- Canyons and slope between Cuvier Abyssal Plain and Cape Range Peninsula (Unique seafloor feature; enhanced biological productivity; aggregations of marine life);
- Wallaby Saddle (Unique seafloor feature).

Regionally important communities and habitats:

- Commonwealth waters surrounding Ashmore Reef and Cartier Island (Enhanced biological activity; feeding and breeding aggregations of marine life; high biodiversity);
- Commonwealth waters surrounding Scott and Seringapatam reefs (Enhanced biological productivity; feeding and breeding aggregations of marine life; high biodiversity);
- Demersal slope fish communities (Communities with high species diversity and endemism);
- Commonwealth waters adjacent to Quondong Point (Enhanced biological productivity; feeding aggregations of marine life);
- Glomar shoals (Unique seafloor feature; high biodiversity);
- Commonwealth waters surrounding Rowley Shoals (Enhanced productivity; aggregations of marine life; high biodiversity);
- Commonwealth waters surrounding Ningaloo Reef (Unique seafloor feature; high biodiversity; feeding and breeding aggregations of marine life).

There are no listed heritage sites within the Region. There are four historic shipwrecks in the Region, although many more are in State waters.

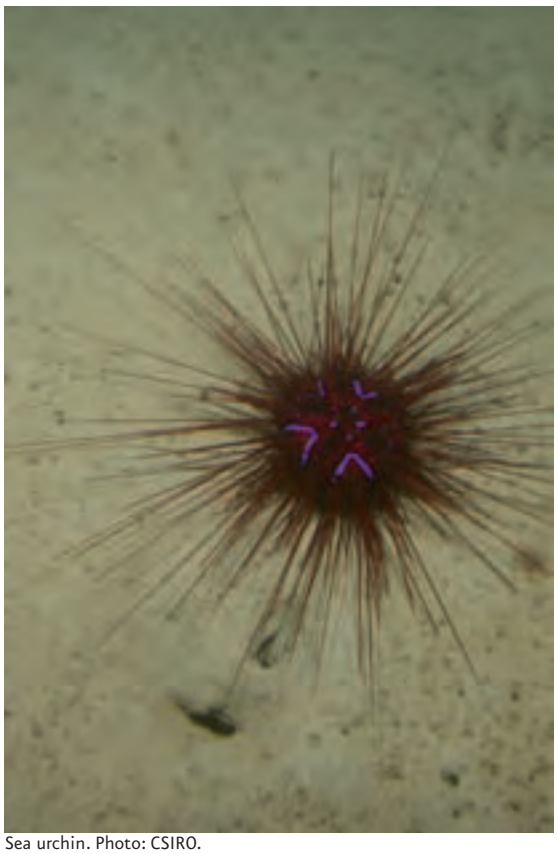
A description of the conservation values and key ecological features of the Region is given in Chapter 3.

Marine Protected Areas in the North-west

There are four existing Commonwealth MPAs in the Region:

- Ashmore Reef National Nature Reserve
- Cartier Island Marine Reserve
- Mermaid Reef Marine National Nature Reserve
- Ningaloo Marine Park (Commonwealth Waters).

New MPAs will be established to meet national guidelines under which all Australian governments are developing a comprehensive, adequate and representative reserve system. The Australian Government's goals for establishing the MPA network are described in Chapter 4, along with information about the principles guiding the identification, selection, design and zoning of representative MPAs. Consideration of the socio-economic implications of potential MPAs will inform the Government's decision about a final regional MPA network.



Sea urchin. Photo: CSIRO.

Human activities and the marine environment

The Region has been a focus for coastal Indigenous communities for many thousands of years. Indigenous coastal communities, particularly in the Kimberley, continue to maintain special links with their sea country through occupation, resource utilisation, and cultural practice. Indigenous people in the Kimberley were trading with fishers from Makassar in South Sulawesi from the early 1700s.

The Region was one of the sites of first contact in the seventeenth century between Europeans and Aboriginal people. British colonisation began on the Pilbara coast in the early 1860s. Pastoralism was the first industry but by the late nineteenth century a pearling industry had been established in Broome. Pearling is now an industry worth about $122 million a year to the Region.

Sixteen commercial fisheries currently operate in the North-west Marine Region with a further 15 active in State waters adjacent to the Region. In 2005–06 the total catch of finfish, prawns and crab in the Region was about 7000 tonnes valued at approximately $42 million.

The resource industries in and adjacent to the Region, as well as the communities dependent on them, are undergoing rapid growth fuelled by demand for minerals and petroleum products in east Asia. Australia's two largest ports (in terms of tonnage), Dampier and Port Hedland, are adjacent to the Region and both are undergoing major expansion.

The value of petroleum production in Western Australia in 2006–07 was $16.4 billion, the vast majority produced in the North-west Marine Region. This was an 11 per cent increase on production in the previous year. While exploration and production continues to expand in the Carnarvon Basin on the North West Shelf, attention is turning increasingly to development of the petroleum reserves (predominantly natural gas) in the Browse and Bonaparte basins in the Region's north.

Chapter 5 describes human activities in and adjacent to the Region.

Blue-spotted fantail ray, Mermaid Reef. Photo: Naomi Wolfe, Department of the Environment, Water, Heritage and the Arts.

Next steps

This Bioregional Profile will guide development of a Draft Marine Bioregional Plan for the Region. The Draft Plan will be released for a period of formal public comment, as required under the EPBC Act. Conservation measures and potential implications for people and industries will be considered and resolved through a process involving consultation with stakeholders and the wider public. A final Marine Bioregional Plan will then be developed for consideration and approval by the Minister for the Environment, Heritage and the Arts. Once finalised, the Minister will be guided by the Marine Bioregional Plan in all decisions made under the EPBC Act for which the Plan has relevance.

Although marine bioregional planning is an Australian Government program undertaken under Commonwealth legislation, the planning process occurs in consultation with State and Territory governments. This consultation is important because the Western Australian Government is also undertaking planning and MPA development processes in its waters.

Chapter 6 describes the next steps in the marine bioregional planning process for the North Marine Region.

Anemone fish, Scott Reef. Photo: Australian Institute of Marine Science.

Chapter 1 Introduction

Marine bioregional planning is designed to better protect marine environments, conserve biodiversity and deliver certainty to resource users and decision makers. The Minister for the Environment, Heritage and the Arts must have regard to a Marine Bioregional Plan when making decisions under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) for which the plan has relevance.

Marine bioregional planning is also the process through which the Australian Government identifies areas within Commonwealth waters for inclusion in the National Representative System of Marine Protected Areas (MPAs). The guidelines the Government is using to develop the National Representative System of MPAs have been agreed upon with the States and the Northern Territory. See <www.environment.gov.au/coasts/mpa/publications/nrsmpa-guidelines.html>.

Marine Bioregional Plans guide government decision-makers and marine users by:

- describing the conservation values of each Marine Region, including identifying sites of importance for protected species, protected communities and ecological processes;
- identifying regional priorities for action, based on an assessment of threats to conservation values and long-term policy goals; and
- developing strategic guidance for proponents and decision-makers. For example, Marine Bioregional Plans may provide a regional context for national guidelines to help proponents to consider whether their action might result in a significant impact (see Appendix B). Plans may also include guidance on the type of information that should be included with referrals under the EPBC Act, or the monitoring requirements that may be required for certain activities or locations within a Region.

There are five Marine Regions for planning, as shown in Figure 1.1.

Figure 1.1 Australia's Marine Regions

Each of Australia's Marine Regions has been divided into provincial bioregions based on ecological similarities, species distribution and oceanographic and seafloor characteristics. The North-west Marine Region has eight provincial bioregions, which are described in Chapter 2. These bioregions reflect our understanding of the ecology of the Region and underpin the planning process.

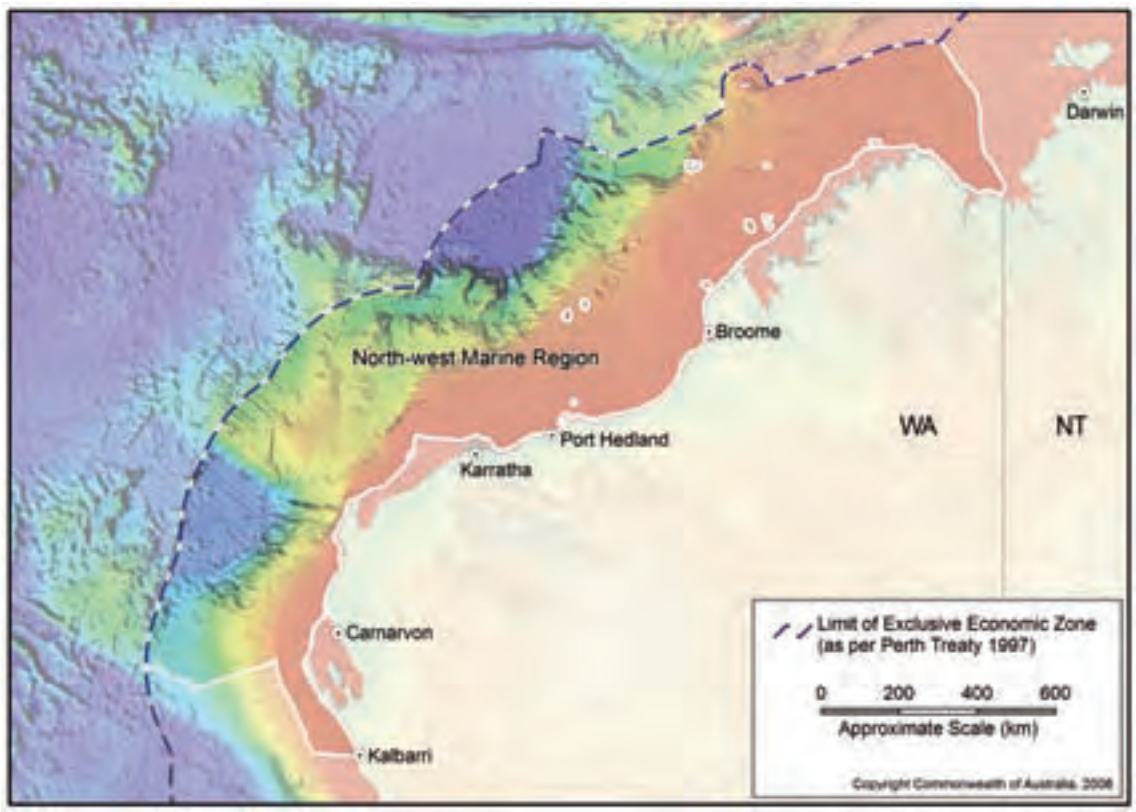
Concurrent with the marine bioregional planning process, the Australian and Western Australian governments are undertaking a strategic assessment of the west Kimberley, under Section 146 of the EPBC Act. This strategic assessment is being undertaken to ensure development is sustainable and that the Kimberley's unique natural and cultural values are preserved. The strategic assessment will be undertaken in two parts. The first relates to the site selection and management of a common-user liquefied natural gas (LNG) hub to service the Browse Basin gas reserves. This will provide certainty for industry, and reduce the cultural and environmental impacts that might otherwise result if piecemeal development of onshore LNG processing facilities were to occur along the Kimberley coastline. The second part will be a wider assessment of the cultural and environmental values of the Kimberley, to formally identify the Kimberley's national and international heritage values and to inform land use development.

1.1 The Bioregional Profile of the North-west Marine Region

The North-west Marine Region encompasses Commonwealth waters from the Western Australia/ Northern Territory border, south to Kalbarri (Figure 1.2). It covers 1.07 million km² of ocean and includes the airspace above and the seabed below. The physical, ecological and biological characteristics of the Region are described in more detail in Chapter 2. In this Bioregional Profile, the terms *the Region* and *the North-west Marine Region* are used interchangeably to refer to the Commonwealth waters defined above.

Figure 1.2 The North-west Marine Region

(Note: the seaward boundary depicted for the Region does not necessarily show the full extent of Australian jurisdiction and is without prejudice to Australia's maritime claims).



The objectives of the North-west Bioregional Profile are to describe:

1. the ecological and biophysical features and characteristics of the Region – including major ecosystems, marine species, communities and places already specifically protected under legislation, and those identified as key ecological features;
2. the considerations and information that will guide the identification of MPAs; and
3. human activities in the Region.

In addition to this introduction, the North-west Bioregional Profile includes five other chapters and four appendices:

Chapter 2 – *The Marine Environment of the North-west Marine Region* describes the biophysical and ecological characteristics of the Region, with particular focus on ecosystem structure and functioning.

Chapter 3 – *Conservation Values of the North-west Marine Region* describes and summarises the biodiversity and heritage features of the Region.

Chapter 4 – *Establishing New Marine Protected Areas in the North-west Marine Region* introduces the goals and principles the Australian Government is using to establish the Commonwealth component of the National Representative System of MPAs and explains their application to the North-west Marine Region.

Chapter 5 – *Human Activities and the North-west Marine Region* outlines the human activities that take place in the Region. It also provides a short overview of the population and the historical development of the Western Australian economy adjacent to the Region.

Chapter 6 – *Developing a North-west Marine Bioregional Plan: Next Steps* describes the stages of marine bioregional planning beyond the Bioregional Profile, and opportunities for stakeholder participation.

Appendix A – *International Conventions and Agreements on the Marine Environment* describes Australia's international commitments to manage the marine environment.

Appendix B – *An Overview of the Legislative Framework for Environmental Protection and Biodiversity Conservation in Commonwealth Waters* explains Australia's national legislation for managing its marine areas.

Appendix C – *Nationally Protected Species in the North-west Marine Region* lists all species that are known to occur, and those which may occur in the Region that are protected under the EPBC Act.

Appendix D – The *Protected Species Group Report Cards* provide detailed information about species in the Region protected under the EPBC Act. Each report card outlines the ecology of a particular species group, describes areas of particular importance, interactions with human activities, threats to their survival and mitigation measures currently in place for that group.

1.2 Supporting information

A number of reports were commissioned to consolidate existing information to support the development of this Bioregional Profile. These reports contain further details on the natural environment and human uses of the Region, and are available online at <www.environment.gov.au/coasts/mbp/north-west>.

Marine bioregional planning has a strong focus on understanding the natural environment of the Region. In September 2007, the Department of the Environment, Water, Heritage and the Arts facilitated a scientific workshop in Perth to bring together marine scientists with specific experience and expertise in the Region. The aim was to compile current knowledge and theory about the way marine ecosystems function in the Region. The workshop also helped to ensure that the Bioregional Profile and subsequent Marine Bioregional Plan are based on the most comprehensive understanding possible, with an explicit recognition of the uncertainties due to gaps in the information base. The outcomes of the workshop are available at <www.environment.gov.au/coasts/mbp/north-west>.

The Bioregional Profile is intended to help stakeholders and the public to participate in the development of the North-west Marine Bioregional Plan. The Department of the Environment, Water, Heritage and the Arts welcomes any contribution from the public about information that may be relevant to bioregional planning within the North-west Marine Region. The Department will consult with stakeholders to discuss the contents of the Bioregional Profile and explain subsequent steps in the planning process.

1.3 Flagship species of the North-west Marine Region

Flagship species have been identified in the North-west Marine Region on the basis of their strong association with the Region and its habitats. The concept of flagship species is not legislative, and does not change the conservation status the species may have, nor does it change associated provisions under the EPBC Act. Identifying flagship species for a Region is useful for education purposes and to raise awareness about marine conservation among the public. Flagship species of the North-west Marine Region are the humpback whale (Western Australian population), whale shark, flatback turtle, olive seasnake, lesser frigatebird, manta ray and trochus shell.

Humpback whale (Western Australian Population)
Megaptera novaeangliae

Humpback whale breaching. Photo: Mark Farrell.

Humpback whales are found throughout the world, although several genetically distinct populations are recognised. Six separate populations occur in the Southern Hemisphere, one of which, known as the Group IV population, is strongly associated with the North-west Marine Region. There appears to be little exchange of individuals between the Group IV population and the Group V population that migrates to the east coast of Australia (Chittleborough 1965). The Group IV population migrates every winter from its summer feeding grounds in the Antarctic, along the West Australian coast, to the tropical waters of Camden Sound and other parts of the Kimberly coast to mate and give birth. Shark Bay and Exmouth Gulf are important resting areas for the migrating whales, especially mothers and calves undertaking the southerly return migration for the first time. The current population of Western Australian humpbacks is thought to be between 8000 and 14 000 individuals (DEH 2005a). Prior to exploitation, it is estimated that the population was between 16 000 and 30 000 (DEH 2005a).

Humpbacks were hunted extensively throughout the world's oceans during the 19th and 20th centuries and it is thought that the Western Australian population may have been reduced to as few as 500 individuals (Chittleborough 1965). A ban on humpback whaling in the Southern Hemisphere was imposed by the International Whaling Commission in 1963, and an international moratorium on commercial whaling came into effect in 1985–86. Since then, the rate of population recovery has been estimated to be up to 10 per cent annually. The humpback whale is listed under the EPBC Act as vulnerable and migratory. Further information on cetaceans listed under the EPBC Act that occur in the North-west Marine Region can be found in Appendix D.

Whale shark
Rhincodon typus

The whale shark is the world's largest fish, growing to lengths of up to 12 m. Whale sharks are found worldwide in all tropical and warm temperate seas, except the Mediterranean. In Australia, whale sharks are regularly observed in Queensland, the Northern Territory and Western Australia, and have also been occasionally recorded in New South Wales, South Australia and Victoria.

Ningaloo Marine Park is one of the few places in the world where whale sharks are known to aggregate regularly. Whale sharks are filter-feeders and their diet includes krill, crab larvae, copepods, small fish, phytoplankton and macroalgae (Colman 1997). The aggregations at Ningaloo coincide with the seasonal intensification of the Leeuwin Current and mass synchronous coral spawning events in March and April (Taylor 1996). However, it is not clear whether whale sharks feed on the coral spawn or take advantage of an associated increase in krill and other zooplankton (Taylor 2007).

The seasonal aggregation of whale sharks at Ningaloo Reef has been estimated at between 300–500 individuals and appears to mainly consist of immature males (Meekan *et al*. 2006). Although widely distributed, whale sharks are generally infrequently recorded and little is known of their biology or ecology. It is estimated

that they may live to over 100 years of age and reach sexual maturity at about 30 years (DEH 2005b).

Whale shark gulp feeding at surface. Photo: Paradise Ink.

Whale shark meat is highly sought after in Taiwan and there are concerns that fishing pressure is causing severe declines in the local population (Colman 1997). The highly migratory nature of whale sharks means that local population declines are likely to have global implications and vice versa. An increasing frequency of smaller individuals at Ningaloo Reef may indicate changes in population structure as a result of overfishing outside Australian waters (Meekan 2005).

Whale sharks are listed under the EPBC Act as vulnerable and migratory. Further information on whale sharks and other sharks listed under the EPBC Act that occur in the North-west Marine Region can be found in Appendix D.

Flatback turtle

Natator depressus

Flatback turtles are endemic to the Australian-New Guinea continental shelf and are the only marine turtle that does not have a global distribution (EA 2003). Flatback turtles are the second most common marine turtle species in the North-west Marine Region (after green turtles), and nesting is widespread on offshore islands and coastal areas adjacent to the Region. The Region supports two genetically distinct breeding populations of flatback turtles: the North West Shelf population, and a small population from Cape Dommett in the Kimberley that is considered part of the western Northern Territory breeding unit (Limpus 2004). It is thought that hundreds to thousands of individuals breed on the North West Shelf annually. Flatback turtles differ from other species of marine turtle in that they do not have a pelagic phase to their life cycle (Walker & Parmenter 1990). Instead, it is thought that hatchlings grow to maturity in shallow coastal waters close to the beaches where they hatched (Musick & Limpus 1997).

As adults, flatbacks may undertake long-distance migrations between their feeding and breeding grounds. It is thought that flatback turtles nesting in the Pilbara may migrate to feeding grounds as far away as the Tiwi Islands in the Northern Territory. They feed on jellyfish and soft-bodied benthic invertebrates such as sea cucumbers, crustaceans, molluscs and sea-pens (Limpus 2004). All marine turtles are vulnerable to capture in trawl fisheries, and the flatback turtle is the most commonly caught species in the Northern Prawn Fishery, which operates within the Region in the Joseph Bonaparte Gulf (DEH 2003). The use of turtle exclusion devices has reduced the capture and death of marine turtles in trawl operations but by-catch in trawl fisheries is still considered a key threatening process for marine turtles.

Flatback turtles are listed as vulnerable and as a marine and migratory species under the EPBC Act. Further information on flatback turtles and other marine turtles listed under the EPBC Act that occur in the North-west Marine Region can be found in Appendix D.

Flatback turtle returning to the sea from her nesting beach. Photo: Tim Harvey.

Olive seasnake

Aipysurus laevis

The olive seasnake is the most common sea snake found on coral reefs around Australia. Its distribution extends from Exmouth Gulf in Western Australia to Moreton Bay in Queensland, and through the Coral Sea to New Caledonia and north to New Guinea. Olive seasnakes are sedentary, occupying small home ranges on coral reefs throughout the year. They are generalist and opportunistic predators with a diet including fish, fish eggs, shrimp and crabs. They also feed on dead fish and have been known to take fish from baited hooks, and to feed on trawl discards (Guinea 2007). Like other species of sea snake, olive seasnakes are potentially threatened by trawling operations. Olive seasnakes live for more than 15 years, and take longer to reach sexual maturity than other sea snake species, which may make them particularly vulnerable to the impacts of trawling (Guinea 2007). They appear to have declined throughout their range in the last 10–30 years and are one of the many species that have severely declined at Ashmore Reef (Guinea 2007), an area previously acknowledged as internationally significant for its abundance and diversity of sea snakes.

Olive seasnakes are listed as a marine species under the EPBC Act. Further information on the olive seasnake and other sea snakes listed under the EPBC Act that occur in the North-west Marine Region can be found in Appendix D.

Olive seasnake. Photo: Great Barrier Reef Marine Park Authority.

Lesser frigatebird

Fregata ariel

The lesser frigatebird is the most common and widespread frigatebird in Australian seas (Lindsey 1986). It is common in tropical waters of the Indian and western and central Pacific oceans, and breeds

Lesser frigatebird. Photo: Tom and Marie Tarrant.

on remote offshore islands. Significant rookeries of lesser frigatebirds occur in and adjacent to the North-west Marine Region on Adele Island, Bedout Island, the Lacepede Islands and Ashmore Reef (DEC 2007). Frigatebirds have the largest wingspan in proportion to their body size of any bird and spend most of their time in flight. Their diet consists of fish and squid, taken on the wing by scooping prey from the surface of the water. They are well known for harassing less agile birds returning from foraging trips, forcing them to drop their catch and stealing the food for themselves. Frigatebirds are also known as 'man-o'-war' birds in reference to these piratical tendencies (Lindsey 1986). Frigatebirds can travel over vast expanses of ocean. Some banded birds have been recorded thousands of kilometres from where they were first caught and individuals are often seen more than 300 km from the nearest land.

The lesser frigatebird is listed as a marine and migratory species under the EPBC Act. Further information on the lesser frigatebird and other seabirds listed under the EPBC Act that occur in the North-west Marine Region can be found in Appendix D.

Manta ray

Manta birostris

Manta rays are large, plankton feeding rays that occur in temperate and tropical waters around the world. They are the largest species of ray and one of the largest living fish, growing to up to 9 m wide. They are primarily observed in continental shelf areas, around upwellings and near seamounts (Marshall *et al*. 2006). Little is known of the ecology and biology of this species, however, large feeding and mating aggregations of manta rays occur around Ningaloo Reef every autumn. Significant numbers also occur in Shark Bay in winter (Preen *et al*. 1997). Manta rays are the target of fisheries in the Philippines, Mexico, Mozambique, Madagascar,

India, Sri Lanka, Brazil, Tanzania and Indonesia (Marshall *et al*. 2006). So little is known of this species that it is unclear how manta rays may respond to fishing pressure. However, it is expected that, like other shark and ray species, life-history traits such as being long-lived and having a low reproductive rate may make them vulnerable to overfishing. The manta ray is not listed under the EPBC Act.

Manta ray. Photo: Great Barrier Reef Marine Park Authority.

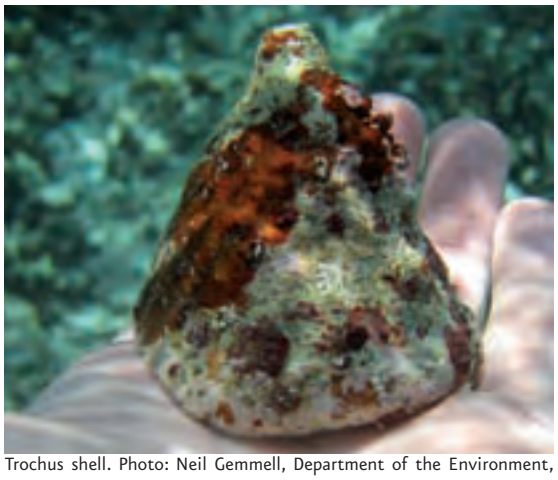
Trochus shell

Trochus niloticus

Trochus niloticus is commonly known as trochus shell or top shell, and is a relatively large (about 12 cm wide), conical marine gastropod found on shallow tropical reefs in the Indo–Pacific. They inhabit intertidal and shallow areas of reefs that receive strong wave or tidal action. In the North-west Marine Region, trochus are found on the coral reefs of the Buccaneer and Bonaparte archipelagos, the Rowley Shoals, Browse Island, Scott Reef, Seringapatam Reef, Ashmore Reef and Cartier Island. Trochus shells have a thick inner layer of mother-of-pearl, or nacre, which has been used for centuries by indigenous people of the Pacific to make ornaments and jewellery. Trochus shell is sought after in the western world for the manufacture of buttons.

In the 1990s, Australia harvested more trochus than any other single country, although the Pacific island nations combined produced approximately 59 per cent of the global trochus harvest (ICECON 1997). The increasing demand for trochus shell has led to many trochus populations being overexploited, which has in turn led to research on mass production of juveniles in hatcheries, and restocking techniques that aim to provide methods for stock enhancement. A trochus hatchery has been developed at the Bardi Aboriginal community at One Arm Point on the Kimberley coast adjacent to the Region, focusing on ornamental species. The export of the shell provides a valuable income for the Bardi Aboriginal community, while the meat is eaten locally.

On the remote offshore reefs of Western Australia, trochus are taken by Indonesian fishers under a Memorandum of Understanding signed between Australia and Indonesia in 1974. However, only the Buccaneer Archipelago region possesses commercial quantities of trochus (Stutterd & Williams 2003) and Indonesian fishers have been caught illegally poaching trochus in this area and other parts of the Kimberley. In 2006, Indonesian poachers were caught with approximately 4.5 tonnes of trochus, almost the entire annual quota allocated to the Bardi Aboriginal community (The Australian 2006). Indonesian fishers have also been apprehended at Ashmore Reef for offences relating to trochus. The total catch from poachers is unknown. The trochus shell is not listed under the EPBC Act.



Trochus shell. Photo: Neil Gemmell, Department of the Environment, Water, Heritage and the Arts.

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Legislation

Available from the Commonwealth of Australia Law website <www.comlaw.gov.au>.

Environment Protection and Biodiversity Conservation Act 1999, <www.environment.gov.au/epbc/about>, accessed 28/04/2008.

Map Data

Figure 1.1 Australia's Marine Regions

Department of the Environment, Water, Heritage and the Arts (2004): Collaborative Australian Protected Areas Database – CAPAD

Department of the Environment, Water, Heritage and the Arts (2006):

Commonwealth Marine Planning Regions

Geoscience Australia (1998): Australia, Coastline and State Borders 1:100,000

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Projection: Geographics, Datum: GDA94

Produced by the Environmental Resources Information Network (ERIN) Australian Government Department of the Environment, Water, Heritage and the Arts COPYRIGHT Commonwealth of Australia, 2008

Figure 1.2 The North-west Marine Region

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2006):

Commonwealth Marine Planning Regions

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Projection: Geographics, Datum: GDA94

Produced by the Environmental Resources Information Network (ERIN)

Australian Government Department of the Environment, Water, Heritage and the Arts

Dugongs. Photo: Lochman Transparencies.

Chapter 2 The Marine Environment of the North-west Marine Region

The North-west Marine Region comprises Commonwealth waters from the Western Australian–Northern Territory border to Kalbarri, south of Shark Bay. The Region covers an area of some 1.07 million km², and includes the airspace above and the seabed below. The Region is bounded inshore by the outer limit of the Western Australian State waters boundary, which generally extends out to three nautical miles from the territorial sea baseline. While the territorial sea baseline is usually at the low water mark, the baseline extends across the openings of bays and rivers (e.g. Shark Bay) and extends around some coastal islands. As such, the Region is adjacent to, but does not cover, the State waters of Western Australia. It is bounded offshore by the edge of the Australian Exclusive Economic Zone (EEZ), which is generally 200 nautical miles from the low water mark. See Figure 2.1 for a description of maritime zones. The Region is bordered by two adjacent Marine Regions: to the east by the North Marine Region and to the south by the South-west Marine Region.

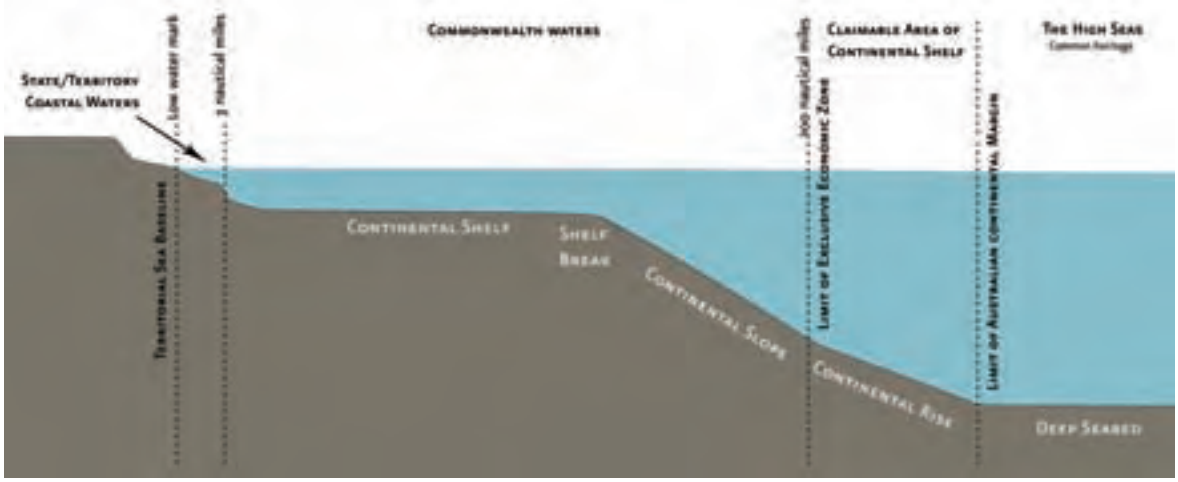
Chapter 2 focuses primarily on the biophysical features and ecological processes in Commonwealth waters of the North-west Marine Region. However, in some instances, biophysical features and ecological processes occurring in State waters are identified because:

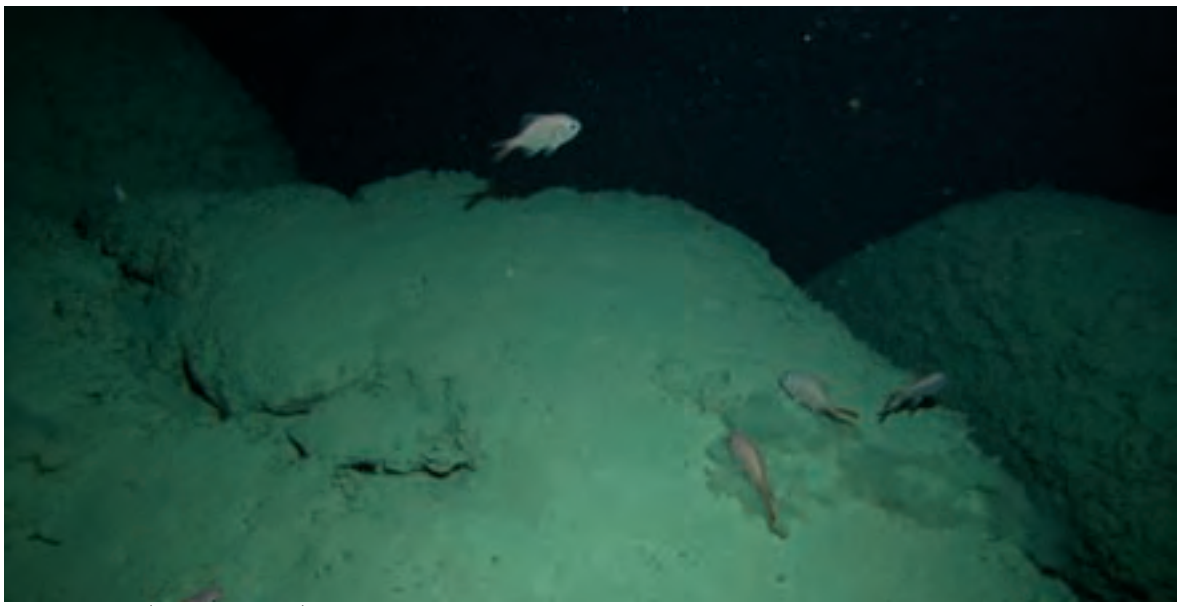
- they are important to species listed as threatened or migratory under the *Environmental Protection and Biodiversity Conservation Act* 1999 (EPBC Act), which are protected as matters of national environmental significance (see Chapter 3 and Appendix B for further information on matters of national environmental significance); or
- there is connectivity between biophysical and ecological processes that link State and Commonwealth waters.

There are a number of unique features of the North-west Marine Region that differentiate it from other Marine Regions around Australia. The first is the large area of continental shelf and continental slope across the Region. Secondly, the Region experiences highly variable tidal regimes, and also has a very high cyclone incidence. The Region is influenced by a complex system of ocean currents that change between seasons and between years, which generally result in its surface waters being warm and nutrient-poor, and of low salinity.

The Region has high species richness but relatively low endemicity. In other words, although the Region is home to a large number of different species, the number of species that are found only in the Region and nowhere else (i.e. endemic species) is small compared with many other parts of Australia's marine jurisdiction, particularly Australia's southern marine areas. The majority of the Region's species are tropical and are found in other parts of the Indian Ocean and western Pacific Ocean. As such, the Region shares many species with the North Marine Region. The southern part of the Region is a transition zone between tropical and temperate species and corresponds with the northern extent of the range of some temperate species that are more typical of the South-west Marine Region.

Figure 2.1 Australia's maritime zones





Yelloweye Redfish (*Centroberyx australis*) around silt covered high relief outcrops in 293 m water depth off Kalbarri. Photo: CSIRO.

The geomorphology of the Region – The seafloor of the Region consists of four general feature types: continental shelf; continental slope; continental rise; and abyssal plain (or deep ocean floor). The majority of the Region consists of either continental slope (61 per cent) or continental shelf (28 per cent). The large areas of continental slope in the Region are significant because they constitute a considerable portion (16 per cent) of this type of feature across all Australian Marine Regions. In contrast, only nine per cent of the Region's seafloor consists of abyssal plain and only one per cent is continental rise – far lower proportions than in any other Marine Region (except the North).

The seafloor across the Region is distinguished by a range of features such as canyons, plateaux, terraces, ridges, reefs, banks and shoals (Figure 2.2). Over half of the total area of banks and shoals across all of Australia's marine jurisdiction occurs in the North-west Marine Region, as well as 39 per cent of terraces and 56 per cent of deeps, holes and valleys.

The geomorphology and seafloor features of the Region reflect its long and complex geological history. This has included periods of continental break-up, the movement of the Australian tectonic plate relative to adjacent plates, extensive faulting and volcanic activity, periods of subsidence (i.e. the dropping of the Earth's surface) and erosion.

An important characteristic of the Region is the significant narrowing of the continental shelf around North West Cape from the broad continental shelf in the north of the Region. For example, in the Joseph Bonaparte Gulf, the continental shelf is around 400 km wide, whereas at North West Cape in the south of the Region the shelf is only 7 km wide – the narrowest of anywhere on the Australian continental margin.

The area formed part of the northern margin of Gondwana during the Palaeozoic-Early Mesozoic (approximately 550–160 million years ago). During the late Palaeozoic (approximately 300 million years ago), crustal stretching, rifting and breakup initiated development of an extensive basin (the Westralian Superbasin) that became the site for deposition of Permian, Triassic and Jurassic sediments prior to final continental break-up (separation of greater India and Australia) in the early Cretaceous (approximately 135 million years ago). Ocean spreading associated with the continental break-up resulted in the creation of the Argo and Cuvier abyssal plains in the early Cretaceous. Early Cretaceous subsidence of the rifted margin resulted in the formation of the Exmouth and Scott plateaux and the Rowley Terrace. The narrow shelf south of North West Cape was formed approximately 130 million years ago as a result of the separation of India and seafloor spreading (Baker *et al*. 2008).

The continental shelf in the northernmost part of the Region (north of Cape Leveque) is described as a rimmed ramp, as the waters over the outer margins of the shelf are shallower than the middle portions. The ramp is a unique feature of the Australian margin in this Region. The rim at its outer edge is the site of a number of coral reefs including Ashmore, Cartier, Scott and Seringapatam.

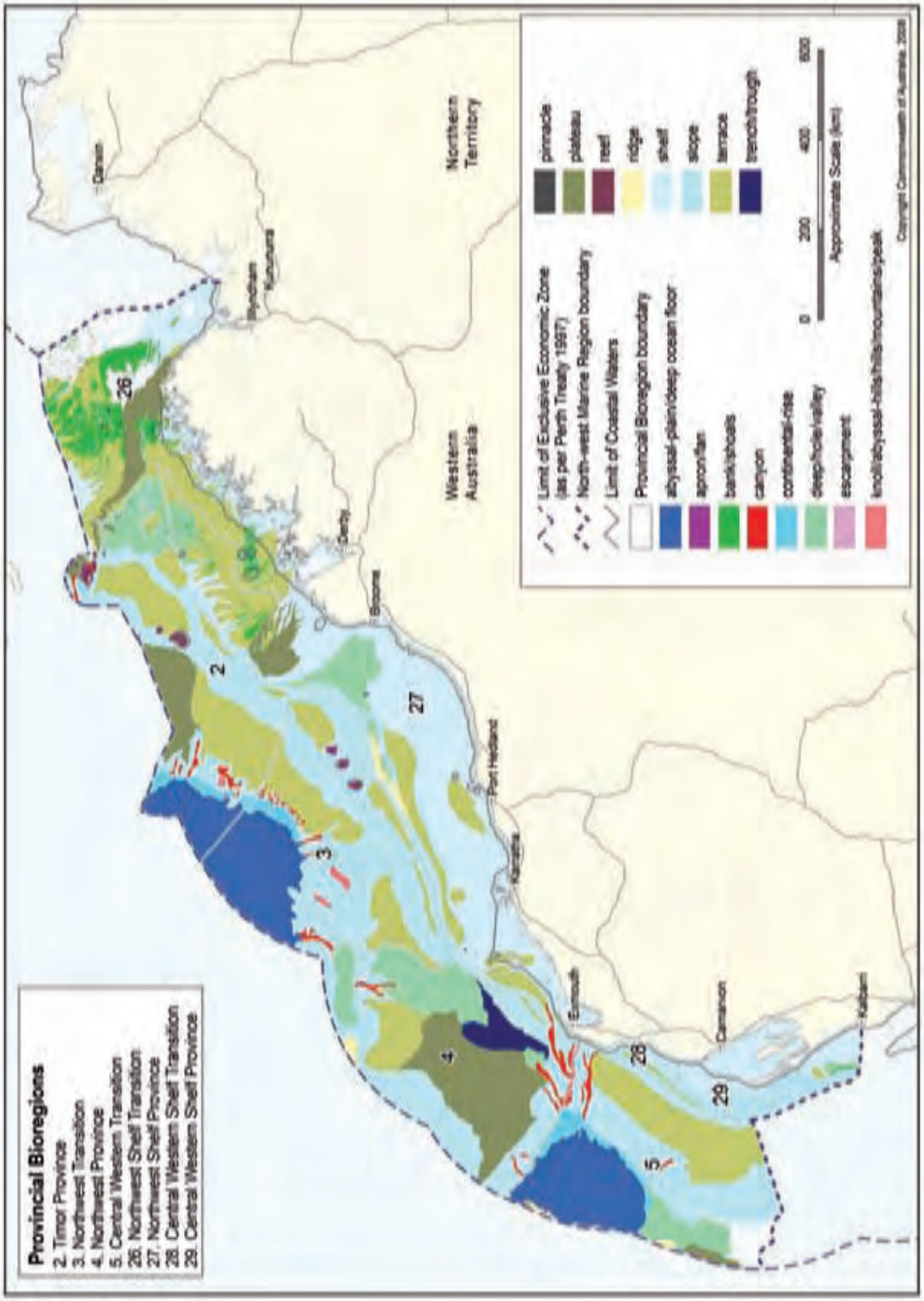


Figure 2.2 Geomorphic/seafloor features of the North-west Marine Region

Coral reefs have a long history in the Region. The earliest formation of coral reefs began on what are now the Exmouth and Scott plateaux and Rowley Terrace in the late Triassic (about 210 million years ago). Reefs are an important feature of the Region, and over the last 10 000 years reef development has kept pace with fluctuations in sea level. Rises in sea level during the last 10 000 years have also resulted in a number of drowned terraces and steps along the outer shelf. The most prominent of these drowned terraces, which is at 125 m water depth, is referred to as the 'ancient coastline' in subsequent sections of this chapter.

The geological history of the Region, as well as its geomorphology and oceanography, has influenced the composition and distribution of sediments. Throughout most of the Region's recent geological evolution, sediments have been deposited at relatively slow and uniform rates. Thicker accumulations of sediment on the mid-shelf reflect the Region's history of sea level rises over the last 10 000 years.

Terrestrial environments are not a major source of sediment in the Region and therefore terrigenous sediments tend to be confined to the inner shelf, particularly in areas adjacent to rivers. Most sediments that occur on the shelf have been derived from the *in-situ* breakdown of marine material and are either relic or recent carbonate deposits. Approximately 60 per cent of the sediments in the Region are carbonate derived.

Sediments in the Region generally become finer with increasing water depth, ranging from sand and gravels on the shelf to mud on the slope and abyssal plain. Joseph Bonaparte Gulf is an exception to this pattern, as sediments with high mud content extend across the inner and mid shelf of the Gulf, graduating to sands and gravels in the Bonaparte Depression. The higher mud content of inner to mid shelf sediments here is reflective of modern deposition processes, whereas the carbonate sands and gravels of the Bonaparte Depression reflect a mix of both modern and relict sedimentation processes.

The distribution and resuspension of sediments on the inner shelf is strongly influenced by the strength of tides across the continental shelf as well as episodic events such as cyclones. Further offshore, on the mid to outer shelf and on the slope itself, sediment movement is primarily influenced by ocean currents and internal tides, the latter causing resuspension and net down-slope deposition of sediments on the North West Shelf.

Oceanography and other ecological drivers – Ocean currents, temperature, salinity and other water column properties are major drivers of marine ecosystems. Oceanography influences the transport and distribution of sediment and nutrients, as well as turbidity and light penetration. These factors affect the ability of marine plants, the ecosystem's 'primary producers', to photosynthesise. This primary production is the vital first step in the food-web in the marine environment. Ocean currents also have a strong influence on species distribution and recruitment.

Overall, the Region is relatively shallow, with water depths of less than 200 m over more than 40 per cent of its area. More than 50 per cent of the Region has depths of less than 500 m, which is reflective of the Region's large areas of continental shelf and continental slope (Baker *et al*. 2008). Partially as a result of the relatively shallow nature of much of the Region, surface currents exert a strong influence over the Region's biophysical and ecological processes.

The major surface currents in the Region flow polewards, away from the equator. Their waters are warm, have low salinity and are oligotrophic (low in nutrients). The major surface currents influencing the Region include the Indonesian Throughflow, the Leeuwin Current, the South Equatorial Current and the Eastern Gyral Current (Figure 2.3). In addition, the Ningaloo Current, the Holloway Current, the Shark Bay Outflow and Capes Current are seasonal surface currents in the Region. The effect of these currents is described in subsequent sections of this chapter.

Below the Region's surface currents, there are a number of subsurface currents, the most important of which are the Leeuwin Undercurrent and the West Australian Current (Figure 2.4). These subsurface currents flow towards the equator, in the opposite direction to surface currents. The Leeuwin Undercurrent and the West Australian Current are derived from waters in the seas to the south of Australia, known as the Subantarctic Mode Water Body. These waters are characterised by high oxygen concentration, high salinity and cooler temperatures.

Figure 2.3 *Surface currents in the North-west Marine Region*

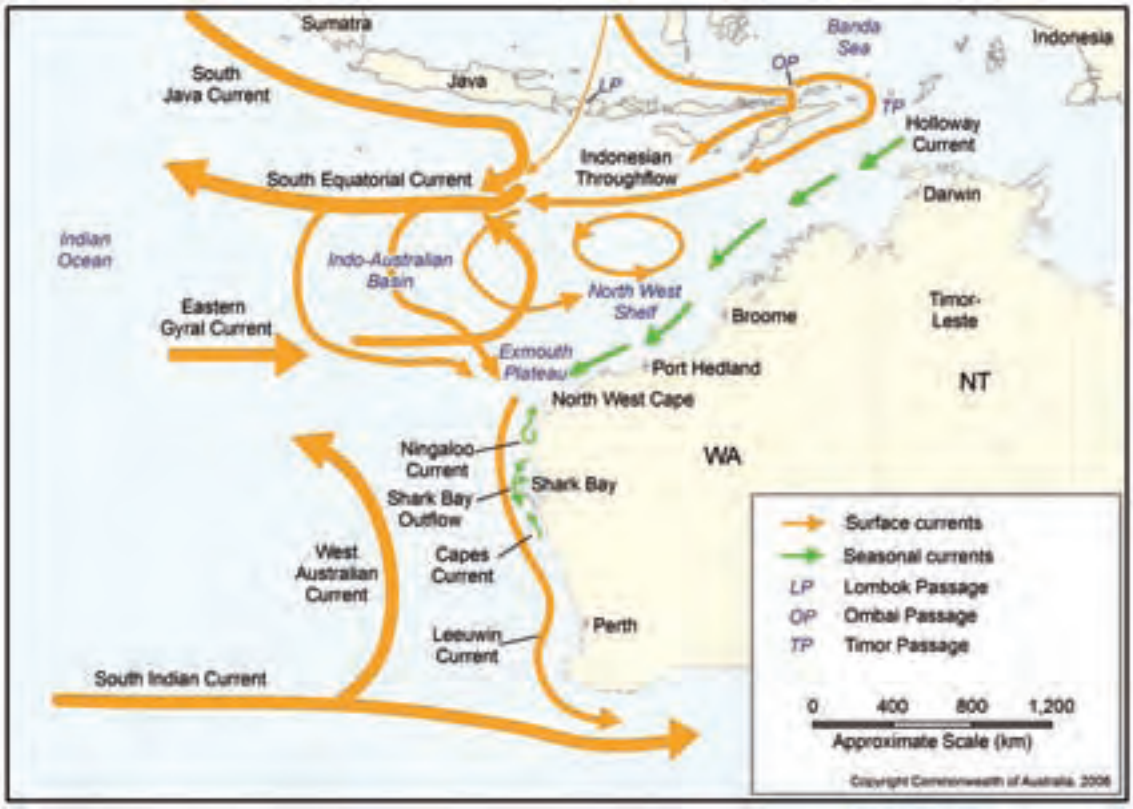
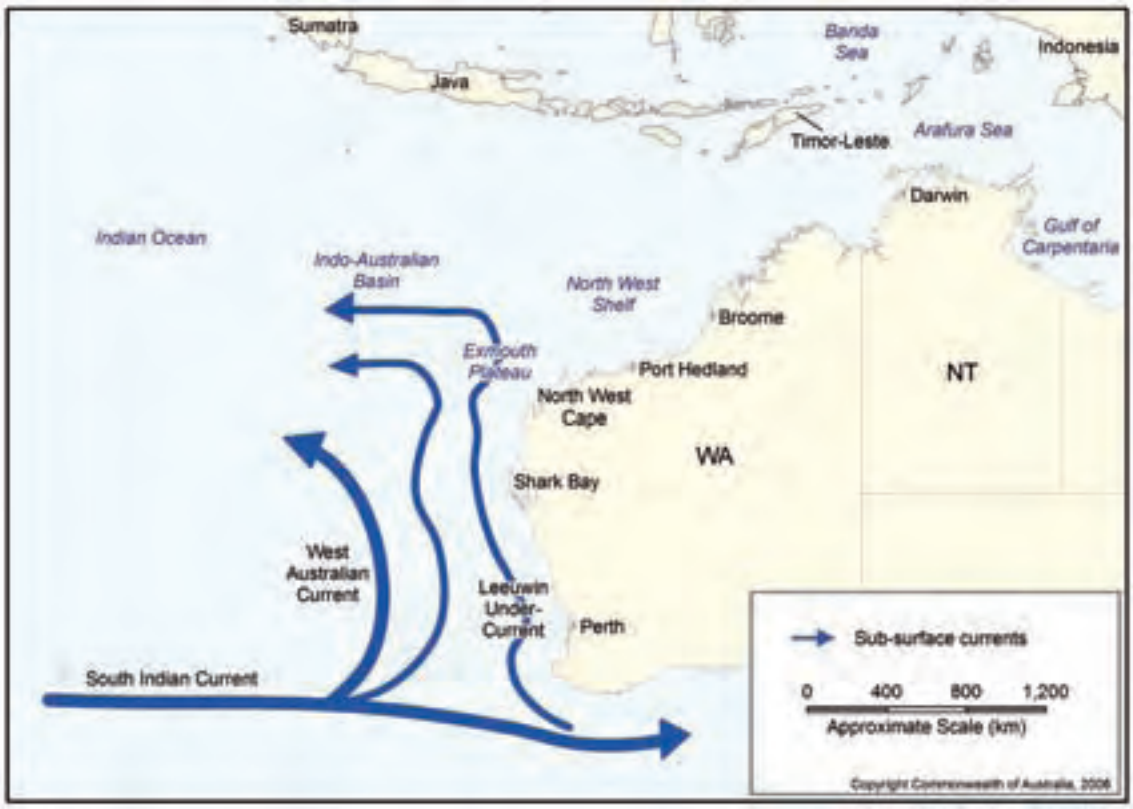


Figure 2.4 *Subsurface currents in the North-west Marine Region*



The Indonesian Throughflow and the Leeuwin Current are the signature currents of the North-west Marine Region because of their influence on the Region's ecology. The Indonesian Throughflow is a system of surface currents that transport waters from the Pacific Ocean into the Indian Ocean through the Indonesian Seas. The Throughflow is one of the primary links in the global exchange of water and heat between ocean basins and an essential element in the global climatic system (Meyers *et al*. 1995).

The Pacific Ocean is the primary source of the Indonesian Throughflow waters. However, before these waters reach the Region they are modified in their passage through the Indonesian Seas by freshwater inputs and run-off from high rainfall over Indonesia. This modification causes these waters to become increasingly warm, oligotrophic and of low salinity. The Throughflow exits into the Indo-Australian Basin (the ocean region between the northwest coast of Australia and the Indonesian islands of Java and Sumatra) via three main outflow straits: the Lombok and Ombai straits and Timor Passage. These filaments of flow come together in the Indo-Australian Basin to form the westward flowing South Equatorial Current, which is further augmented by South Indian Ocean currents as it crosses the basin (Domingues 2006) (Figure 2.3).

Indonesian Throughflow waters, or waters derived from the Throughflow, are thought to occupy the upper surface water layers over almost the entire North-west Marine Region, including over the slope and abyss. Recirculation of Indonesian Throughflow waters into the Region is believed to occur via two pathways:

- through the Eastern Gyral Current, which transports waters eastward over the Argo Abyssal Plain and associated slope; and/or
- through a southward flow across the shallow Timor Shelf from the Banda and Arafura seas, which is known as the Holloway Current.

The Holloway Current is thought to be closely associated with the Northwest Monsoon. Evidence indicates that on the termination of the Northwest Monsoon in March, Throughflow waters within the Banda and Arafura seas flow southward over the shelf from around Darwin to as far south as Ningaloo Reef. This is thought to be an 'extended Leeuwin Current' (DEWHA 2008) (see Figure 2.3).

The present understanding of the Holloway Current and the origin of shelf waters throughout the North-west Marine Region is generally poor. However, the flooding of Indonesian Throughflow waters onto the continental shelf is likely to be assisted by local eddies which facilitate cross-shelf transport. Along with internal tides, these local eddies probably modify water characteristics on the shelf by facilitating vertical mixing. The waters flowing back into the Region via the Eastern Gyral Current appear to diverge over the slope, with some moving south and others completing an anti-clockwise circulation by moving north before turning west again to rejoin the waters of the Throughflow (see Figure 2.3).

As one of the dominant currents in the North-west Marine Region, the Leeuwin Current is broadly recognised as a distinct current at North West Cape where waters flowing south across the shelf and along the slope converge with those of the Eastern Gyral Current. It is a warm, shallow and narrow current (50-100 km wide) that is centred along the shelf break. Its water properties demonstrate its links with the Indonesian Throughflow and Eastern Gyral Current, as it is warmer and fresher than the salty, cool subtropical waters further offshore. The formation of meanders and eddies is also a feature of the Leeuwin Current (Domingues *et al*. 2006; Waite *et al*. 2007), and a number of eddies occur south of Shark Bay.

The Leeuwin Current contributes to the maintenance of generally low levels of biological productivity in the south of the Region and into the adjacent South-west Marine Region, as well as playing a crucial role in transporting tropical and sub-tropical species to areas further south than they would otherwise occur.

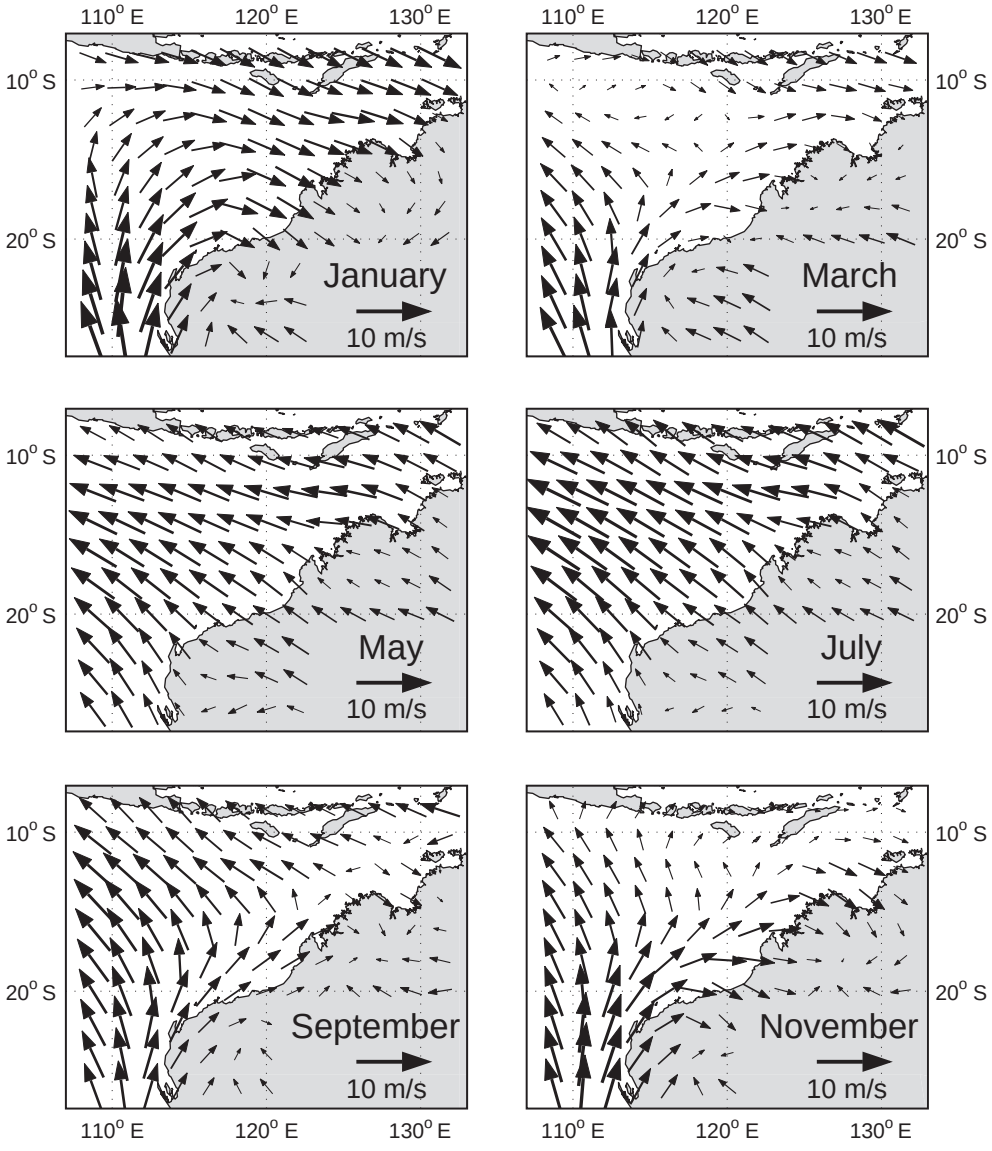
The poleward flow of the Indonesian Throughflow and the Leeuwin Current is globally unique, as other currents on the eastern boundaries of oceans (such as the Humboldt Current off the west coast of South America) flow towards the equator (Domingues 2006). The force behind the poleward flow results from a pressure gradient that is created between the lower density (warmer, lower salinity) equatorial waters and the higher density (cooler and more saline) waters of the Southern Ocean. This difference in water density causes a difference in sea level height between the Pacific and Indian Oceans which, combined with the Earth's rotation, results in the flow of waters through Indonesia and down the coast of Western Australia (Pearce & Walker 1991). The pressure gradient may be further reinforced through surface cooling of the waters as they move southwards and the rate of flow accelerates with

the formation of the Leeuwin Current and the narrowing of the continental shelf around North West Cape.

The characteristics of the Indonesian Throughflow and the Leeuwin Current differ between seasons and between years. Variability in the strength of the Indonesian Throughflow and the Leeuwin Current is influenced by seasonal variability in the pressure gradient. During the Northwest Monsoon (December to March), the pressure gradient between the Pacific and Indian oceans is reduced, resulting in a weakening of the Indonesian Throughflow and Leeuwin Current. In addition, onshore winds in the north of the Region work against the general westerly flow of the Indonesian Throughflow, while in the south of the Region, strong southerly winds along the coast south of North West Cape, oppose the southward-flowing Leeuwin Current.

During the Southeast Monsoon (April to September), the pressure gradient between the Pacific and Indian oceans is more intense, strengthening the South Equatorial Current and the Eastern Gyral Current. Lower rainfall and humidity are typically associated with the Southeast Monsoon, in contrast to the high levels of rainfall and humidity associated with the Northwest Monsoon. These effects are reinforced by south-easterly winds blowing offshore in the north of the Region and the weakening of the southerlies in the south of the Region (Figure 2.5). The Leeuwin Current also surges between autumn and early winter and this surge is thought to be partly associated with the seasonal Holloway Current flowing south along the shelf. Variability in current strength and direction plays an important role in driving seasonal biological productivity and species distributions, which will be discussed further in subsequent sections of this chapter.

Figure 2.5 Seasonally averaged winds in the North-west Marine Region
(at 10 m above mean sea level) during January, March, May, July, September, and November



Source: Condie *et al.* 2006

Surface current strength is also affected by inter-annual variability, particularly evident between El Niño/Southern Oscillation and La Niña events. Wind changes associated with El Niño/Southern Oscillation events modulate the depth of the thermocline (a steep temperature gradient in the ocean where the layer above is a different temperature from the layer below) in the western Pacific Ocean, which in turn influences the thermocline depth in the Indonesian Seas and into the Region. During El Niño, the thermocline rises, sea level differentials drop, sea surface temperatures fall and the strength of the Indonesian Throughflow and Leeuwin Current weakens. Conversely, during La Niña years, higher sea level differentials, warmer sea surface temperatures in the North-west and deeper thermoclines result in a stronger Indonesian Throughflow and Leeuwin Current.

Another feature of the Region's oceanography is the occurrence of localised currents during summer (between December and March) when the Indonesian Throughflow and Leeuwin Current are weakest. The most prominent of these is the Ningaloo Current, which is evident on the shelf inshore of the 50 m depth contour and flows north from Shark Bay to possibly as far as Barrow Island (Hanson *et al*. 2005). The strong southerly winds at this time overcome the alongshore pressure gradient, resulting in the surface waters moving offshore, and colder, more nutrient-rich water upwelling onto the continental shelf as the Leeuwin Current weakens and moves offshore.

The North-west Marine Region has some of the largest tides along a coastline adjoining an open ocean in the world. Tides increase in amplitude from south to north, corresponding with the increasing width of the shelf (Holloway 1983). Tides in the Region can be broadly categorised as semi-diurnal (i.e. two high tides and two low tides per day) with a spring/neap cycle[1]. In the Kimberley, the daily tidal range is up to 10 m during spring tides and less than 3 m during some neap tides. Tides and winds strongly influence water flow in the coastal zone and over the inner to mid-shelf, whereas flows over the outer-shelf, slope, rise and deeper waters are influenced by large scale regional circulation.

As well as influencing the dispersal of bottom sediments, tides also play an important role in the dispersal of turbid waters in coastal areas of the Region. Generally, turbid waters occur in areas that receive high volumes of river run-off, as well as areas with high levels of tidal mixing of water layers.

Tidal fronts have been observed on the North West Shelf. These fronts separate areas of vertically mixed waters from stratified areas of the water column. Tidal fronts are generally associated with higher biological productivity (C. Pattiaratchi, pers. comm. 2007). They are evident in satellite imagery from the North West Shelf as lines of higher biological productivity parallel to the coast, and appear to be controlled by depth contours. Their occurrence in summer coincides with the weakening of the Leeuwin Current. However, current understanding of their role in the trophic dynamics of the North-west Marine Region is poor.

Perhaps one of the most dynamic and unique features of the interaction between regional oceanography and seafloor topography in the North-west Marine Region is the occurrence of internal waves. Internal waves are dynamic, episodic events, which are strongly influenced by topography and generated by internal tides. Internal tides, also known as barotropic tides, occur at the delineation between water bodies with marked differences in density. They are large in scale, frequently occurring across an ocean basin and, in common with normal tides, forced by the gravitational pull of the moon and sun. The internal tide can rise and fall at a different rate to the surface tide, but they most commonly have a semi-diurnal (twice daily) frequency (Holloway *et al*. 1997) and may travel either towards the shore, or away from the shore across the shelf and out into deeper water. Internal tides are particularly pronounced in the North-west Marine Region. They occur at the thermocline, where the warm, low salinity waters of the Indonesian Throughflow overlay colder, more saline, deeper ocean waters.

When water moving along the thermocline as a result of the internal tide intersects seafloor topography, internal waves may be generated. For internal waves to form, the seafloor topography must have a significant change in water depth over a relatively short distance, such as over the continental slope or shelf break (G. Ivey, pers. comm. 2007). Internal waves can be tens of kilometres long (Holloway *et al*. 1997) with a crest of up to 75 m (M. Furnas, pers. comm. 2007). Areas such as Exmouth Plateau and the slope adjacent to the North West Shelf

1 The spring/neap tide cycle has an approximately seven day interval between spring tides. During spring tides, high tides are higher than average and low tides are lower than average. At neap tides the tidal range is at its minimum, with relatively high low tides, and relatively low high tides.

are known sites of internal wave activity (Holloway 1988). Changes in topography at 125 m and 200 m water depths on the North West Shelf and at depths of between 400–1000 m on the Exmouth Plateau have been identified as critical points for the generation of internal waves (Holloway *et al*. 2001).

Internal tides and the internal waves they generate are thought to occur more frequently and to be stronger during summer, when the Region's water column is highly stratified and temperature differentials are greatest. Internal waves can raise cooler, generally more nutrient-rich water higher in the water column, and sometimes into the photic zone – the area of the ocean reached by sufficient sunlight to allow marine plants to photosynthesise. However, the passing of an internal wave is unlikely to result in any significant impact on biological productivity. The steepening of an internal wave through interaction with seafloor features can cause the wave to break. The breaking of an internal wave causes near-bottom turbulence resulting in enhanced overall vertical mixing in the water column. If nutrients are available, breaking internal waves can generate areas of increased productivity where there are strong internal tides. Isolated topographic features that may give rise to the breaking of internal waves include Ashmore, Scott and Seringapatam reefs, the Rowley Shoals and canyon heads, but internal waves may break even over gently sloping regions as they move into shallower waters towards the shore (G. Ivey, pers. comm. 2007).

Biological productivity – Globally, the eastern sides of ocean basins tend to be highly productive ecosystems. However, the Western Australian coast is an exception. Despite having a similar wind regime to other eastern ocean margins, the Region's waters are generally low in nutrients. The upwelling of deeper more nutrient-rich waters is suppressed by the dominance of the Indonesian Throughflow and Leeuwin Current.

Seasonal changes in the Region's oceanography are the primary drivers of biological productivity in the Region. These include: weakening of the Indonesian Throughflow and Leeuwin Current; the seasonal reversal in wind direction, which supports development of currents like the Ningaloo Current; conditions more favourable for upwelling on the North West Shelf; and episodic events such as cyclones. As a result of the periodic nature of these changes, biological productivity in the North-west Marine Region follows boom and bust cycles, is sporadic and significantly geographically dispersed. Currently, our understanding of the nature and spatial distribution of biological productivity in the Region is limited.

The shelf break is an area where significant mixing of water bodies occurs, and the frequency of this mixing is influenced by a range of factors mentioned earlier. Mixing is important for biological productivity in deeper waters over the slope and abyss, as surface waters mix with deeper, more nutrient-rich waters to form a mixed water layer that covers deeper regions as a thin subsurface intrusion at about 100 m depth (Brewer *et al*. 2007).

Biological productivity over the slope and shelf is also reliant upon seasonal changes in the strength of surface and subsurface currents that influence the depth of the thermocline. Research into the shelf and slope adjacent to North West Cape has found that during El Niño years, when the strength of the Leeuwin Current declines, the thermocline occurs at much shallower depths and intrudes onto the shelf, bringing nutrients closer to the surface and increasing primary production and secondary bacterial production two to four times that of La Niña years (Furnas 2007).

Similarly, the annual weakening of the Leeuwin Current during summer is known to facilitate the movement of cold nutrient-rich slope waters from the Indian Ocean onto the shelf. These waters are subsequently mixed by the Region's strong tides, stimulating primary productivity below the shallow surface layer, but within the photic zone. The extent to which weakening of the Indonesian Throughflow influences upwelling of more nutrient-rich waters over the slope and shelf break in other parts of the Region is unknown. However, large areas of the shelf may be highly dependent on physical processes occurring on the shelf break to transport offshore nutrients into the water column and towards the coast.

Cyclones are another episodic mechanism that can enhance primary production in the North-west Marine Region. In an average summer, numerous cyclones occur on or near the north-western Australian coast. Their effect on marine ecosystems is highly variable and dependent on each cyclone's path, size, duration and intensity. Cyclones enhance oceanic mixing and upwelling and at their extreme can also have a major effect on habitats, ecological communities and individual species. Observations of Cyclone Tiffany on the North West Shelf in January 1988 demonstrated that cyclones can determine the distribution and dispersal of plankton and pelagic (open water) larvae in shallow shelf

environments. Communities of phytoplankton (small and microscopic marine plants) rapidly regenerated as a result of changed nutrient conditions, and species of zooplankton (small and microscopic marine animals) and fish were transported into areas they did not normally occupy as a result of changed current, wind and wave patterns (McKinnon *et al*. 2003).

Despite a general lack of knowledge regarding the processes that drive biological productivity throughout the North-west Marine Region, there are a number of locations where enhanced biological productivity has been recorded. The waters adjacent to the Cape Range Peninsula are regarded as a regional hotspot for primary production as a result of the upwelling and mixing between the Leeuwin and Ningaloo currents during summer, when the Leeuwin Current is weaker and the Ningaloo Current develops (Hanson *et al*. 2005). Seafloor canyons in this area, such as the Cloates Canyon and the Cape Range Canyon, are also important in enhancing biological productivity around Ningaloo (Brewer *et al*. 2007). In addition to Ningaloo, the coral reefs along the shelf edge in the north of the Region are also known to be sites of enhanced biological productivity (Brewer *et al*. 2007).

While we have some understanding of the relationship between Cloates and Cape Range canyons and Ningaloo Reef, canyons elsewhere in the Region about which we know almost nothing, could also be important sites of enhanced biological productivity. Interactions between surface and subsurface currents can cause localised flow patterns within canyons that can stimulate upwelling of cooler water and generate potential bursts of primary productivity (Brewer *et al*. 2007). However, little is known about the processes or biodiversity associated with the canyons of the North-west Marine Region. Canyons are generally thought to support rich and dynamic communities within the sides and floor of the canyon heads, and to attract species such as opportunistic deposit feeders and predators (Brewer *et al*. 2007).

Many species and communities have adapted to the sporadic boom and bust nature of biological productivity in the Region and are able to utilise food sources whenever and wherever they become available, as well as being able to conserve resources until the next event. In the water column, injections of nutrients are quickly utilised through rapid regeneration of primary consumers such as microzooplankton (e.g. protozoa) as well as macro/mesozooplankton (e.g. copepods and other filter-feeders). Gelatinous zooplankton (e.g. salps) and jellyfish also play an important role in the food web as both primary and secondary consumers (DEWHA 2008). They represent a large proportion of the marine biomass (the total mass of organisms in a given area), as they are able to respond quickly to bursts in primary productivity. They also provide a food source for many pelagic fish species, such as tuna, billfish and lutjanids, long after the initial burst in primary productivity has dissipated. Highly mobile communities such as seabirds, cetaceans, whale sharks, manta rays and large pelagic fish move throughout the North-west Marine Region, taking advantage of short-term and dispersed bursts of productivity.

Bentho-pelagic fish (those that occur in water depths of approximately 200–1000 m) are a vital link in the trophic systems of the Region (Brewer *et al*. 2007). As they migrate vertically between the pelagic and benthic (seafloor) systems they consume nutrients and aid the transfer of the nutrients between the two systems.

Other processes also transfer nutrients from pelagic systems to benthic systems. For example, many deep water benthic communities are either attached to the seafloor or have limited ranges and are heavily reliant upon nutrients in the form of detritus falling through the water column into the benthic environment.

Biodiversity in the North-west Marine Region – The flora and fauna of the North-west Marine Region is predominantly tropical, but there is a transition from tropical to subtropical and temperate species south of North West Cape. Some species groups, such as sponge communities on the shelf, display a gradual transition from tropical to temperate species. Others, such as coastal and shelf fish, show a more distinct biogeographic split in species composition between the tropical communities north of Shark Bay and the temperate communities in the far south of the Region.

The North-west Marine Region has high species diversity, but fewer endemic species than are present in cooler and more temperate waters. The Region contains more coastal and shelf fish species than anywhere else on the Western Australian coast, particularly in the Kimberley and North West Shelf (Fox & Beckley 2005). In addition, the coast between Port Hedland and North West Cape has been identified as a hotspot for species richness of coastal and shelf fish (Fox & Beckley 2005). The Region's high species richness partially reflects its strong biogeographic links with Indonesia and the west Pacific through the Indonesian Throughflow. However,

Marine turtle on Scott Reef. Photo: Australian Institute of Marine Science.

few species in the Region are endemic to Australia and even fewer are endemic to Western Australia (Fox & Beckley 2005).

The high species richness of the Region is also thought to be associated with the diversity of habitats available. These include hard seafloor areas (e.g. limestone pavements on the North West Shelf), submerged cliffs and coral reefs of the Kimberley, and atolls and reefs on the edge of the shelf. These habitats support a high diversity of benthic filter-feeders and producers. Soft-bottom substrates include areas of sandy seafloor that support seagrass habitat along the Pilbara coast, muddy substrates on the slope and in the Joseph Bonaparte Gulf, as well as the deep waters of the Cuvier Abyssal Plain and the Argo Abyssal Plain, which support sparsely distributed sessile organisms such as filter-feeding and deposit-feeding species.

The coral reefs of the Region are areas of especially high species diversity, and there is a distinct zonation in reef types across the Region. Reefs to the north of Ashmore Reef are mostly composed of coralline algae, whereas Ashmore Reef and other reefs to the south are mostly composed of scleractinian corals (i.e. hard corals) (Baker *et al*. 2008). The transition to hard corals from Ashmore Reef south is caused by the upwelling of cooler, nutrient-rich water from the Indian Ocean along the continental shelf break, which provides ideal conditions for the development of hard corals. In contrast, the occurrence of *Halimeda* reefs north of Ashmore is the result of warmer water temperatures that restrict the formation of hard corals.

Multispecific, synchronous spawning (mass spawning) of scleractinian corals has been recorded in the Dampier Archipelago (in State waters adjacent to the Region), at Ningaloo Reef, and is also believed to occur at other reefs in the Region. Mass spawning occurs around the third quarter of the moon (i.e. seven to nine nights after the full moon) on neap, nocturnal ebb tides in March and April each year. This coincides with the annual intensification of the Leeuwin Current and Indonesian Throughflow (Simpson 1991).

Recent work has suggested that there is a second period of coral spawning around Dampier, with at least two species of *Acropora* spawning in both spring and autumn. While the major spawning period around Dampier is autumn, a small proportion of the coral assemblage spawn in spring (Baird *et al*. 2007). Similarly, a study at Scott Reef found two short and distinct periods of mass spawning during spring and autumn, in contrast to the single mass spawning described on most other reefs around Australia (Gilmour *et al*. 2007)

The timing of mass spawning events is an adaptation to the regional oceanography and explains the connectivity between tropical and temperate coral reefs on the Western Australian coast and the genetic links between the tropical coral reefs of Indonesia and the North-west Marine Region. Such connectivity has been demonstrated between the reefs of the Montebello and Barrow islands and Ningaloo Reef, and some genetic exchange also occurs between Ashmore Reef and Scott Reef (CSIRO 2007).

Fish communities play an important ecological role in the North-west Marine Region. In particular, small pelagic fish (e.g. members of the family Myctophidae – lantern fish) are believed to comprise a significant proportion of the fish biomass throughout the Region. On the North West Shelf, small pelagic fish comprise a third of the total fish biomass (Bulman 2006). They inhabit a range of marine environments, including inshore and continental shelf waters, and form a vital link in many of the Region's trophic systems, feeding on pelagic phytoplankton and zooplankton and providing a food source for a wide variety of predators including large pelagic fish, sharks, seabirds and marine mammals (Mackie *et al*. 2007).

Large pelagic fish such as tuna, mackerel, swordfish and marlin, are another important component of the ecosystems of the North-west Marine Region. They are found mainly in oceanic waters and occasionally on the shelf. Both adult and juvenile large pelagic fish are highly mobile and have a wide geographic distribution, although juveniles more frequently inhabit warmer or coastal waters. In particular, southern bluefin tuna are highly migratory and can be found in the North-west Marine Region on their migration between the southern oceans and spawning grounds in the tropical oceanic waters off Java. The oceanic waters of the Region are also believed to provide important spawning and nursery grounds for a number of large pelagic fish species.

Sharks, skates and rays (collectively known as chondrichthyan fish) are typically higher order predators and perform an important ecological role in the North-west Marine Region through the regulation of prey species (Heupel & McAuley 2007). The Region contains a rich chondrichthyan fauna – 157 species are believed to occur in the Region, 18 of which are endemic. Ninety four shark species occur in the Region, many of which are found in other parts of Australia. However, sharks that occur within the North-west Marine Region represent approximately 19 per cent of the world's shark species (Heupel & McAuley 2007). Sharks, skates and rays occupy a broad range of shallow and deep water habitats, as well as being distributed throughout the water column, with some species preferring pelagic waters, while others are demersal (associated with the seafloor).

High order predators, including sharks and large pelagic fish, prey upon a wide variety of fish, octopus, squid and crustaceans. The Region is thought to contain a high diversity of crustaceans across a range of habitats, from intertidal sites to the deeper waters of the slope and the abyss. Dominant species groups include copepods, prawns, scampi and crabs. These groups display a strong biogeographic affinity with the Indo-west Pacific, with few endemic species present. As well as being preyed upon by large pelagic fish, crustaceans are also a significant food for cephalopods (squid and octopus species).

Approximately 81 different species of cephalopod are believed to occur in the North-west Marine Region, five of which may be endemic as they have only been recorded from one location or are thought to have a very restricted distribution (Semeniuk 2007). The area between Kalbarri and the Dampier Archipelago appears to be particularly significant for octopus, dumpling squids and several species of cuttlefish (Semeniuk 2007). Squid are an important food item for a number of species in the Region. Sperm whales, for example, feed exclusively on the squids *Todarodes pacificus* and *Ancistrocheirus lesueurii*, while seabirds (such as black noddies and red-footed boobies) feed on the squid *Sthenoteuthis oualaniensis*.

The North-west Marine Region also supports internationally significant breeding and feeding grounds for a number of threatened and migratory marine animals. Thousands of humpback whales migrate through the Region each year to mate and give birth in the tropical waters of the Kimberley coast, especially around Camden Sound. This coast is the only known breeding ground for the Western Australian population of humpback whales.

Coastal beaches and offshore islands in and adjacent to the Region support significant rookeries of endangered and vulnerable marine turtles, including one of the largest breeding populations of hawksbill turtles in the world. The Region also marks the end point of the East Asian-Australasian Flyway for millions of shorebirds that migrate every year from breeding grounds in the Northern Hemisphere. Shark Bay supports one of the largest remaining dugong populations in the world with up to 14 000 individuals present in the bay (Gales *et al*. 2004). Annual aggregations of whale sharks at Ningaloo Reef every autumn are also internationally significant as they are the largest density of whale sharks per kilometre in the world (Martin 2007).

2.1 The provincial bioregions of the North-west Marine Region

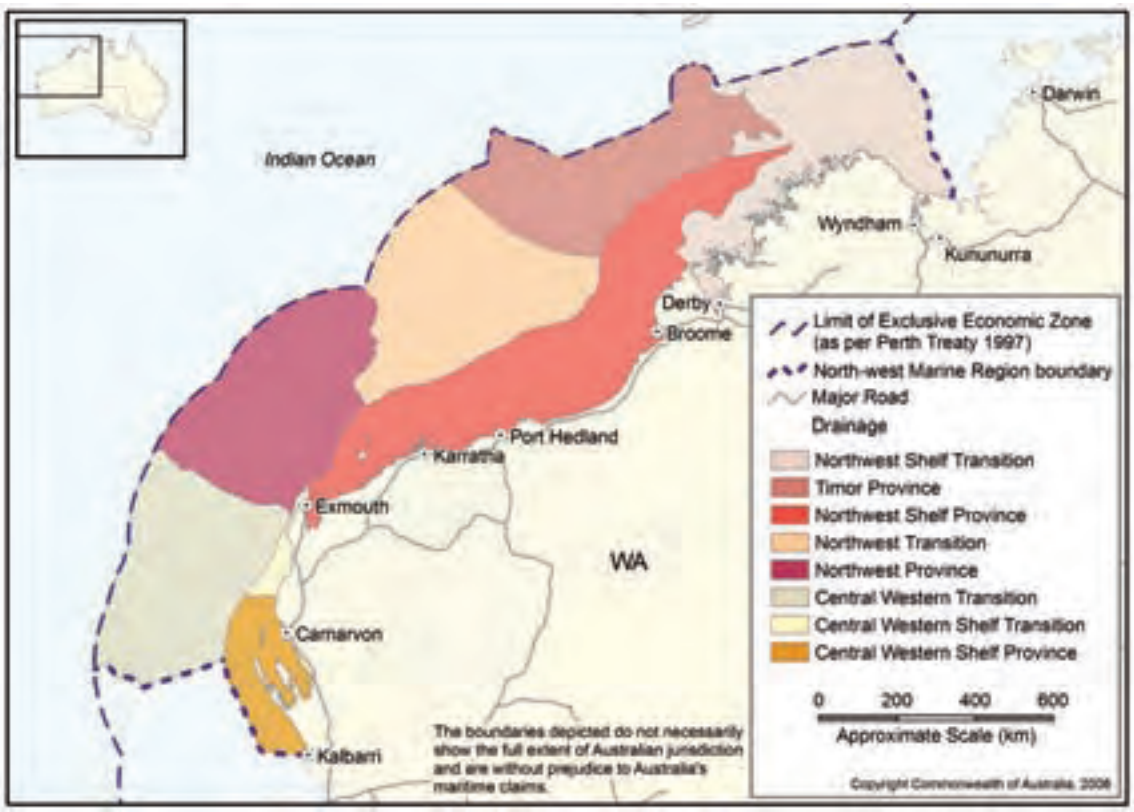
The *Integrated Marine and Coastal Regionalisation of Australia Version 4.0* (IMCRA v.4.0) identifies eight provincial bioregions in the North-west Marine Region, one of which extends into the neighbouring North Marine Region (Figure 2.6). The regionalisation represents the distribution patterns of marine life in the Region at a broad scale. In this Bioregional Profile the terms *provincial bioregion* and *bioregion* are used interchangeably to refer to provincial bioregions as defined in IMCRA v.4.0.

The provincial bioregions described in this Bioregional Profile are:

- Northwest Shelf Transition;
- Timor Province;
- Northwest Shelf Province;
- Northwest Transition;
- Northwest Province;
- Central Western Shelf Transition;
- Central Western Transition; and
- Central Western Shelf Province.

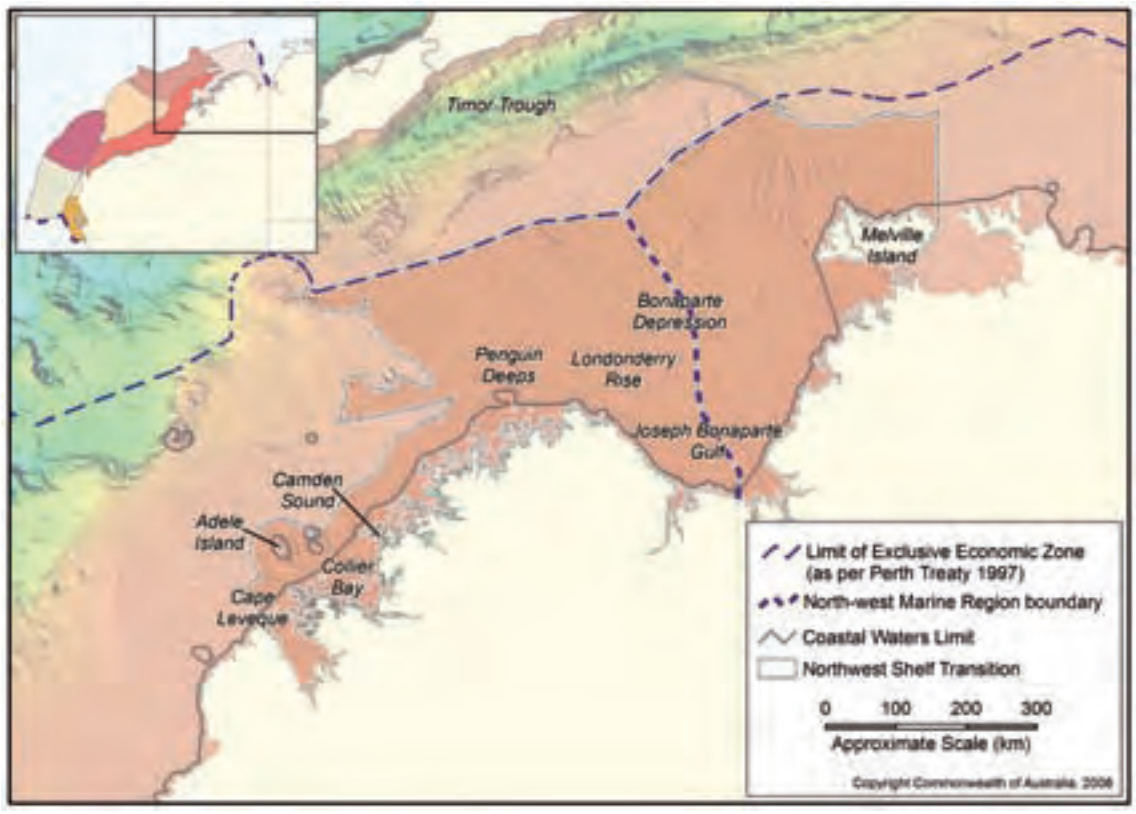
Each provincial bioregion is described below in terms of the characteristics of its marine environment, including physical structure, biological communities and ecological processes. Chapter 4 discusses the provincial bioregions in relation to the identification of areas suitable for inclusion in the National Representative System of Marine Protected Areas.

Figure 2.6 Provincial bioregions of the North-west Marine Region (IMCRA v.4.0)



2.1.1 Northwest Shelf Transition

Figure 2.7 The Northwest Shelf Transition



The Northwest Shelf Transition extends from Cape Leveque to the eastern end of Melville Island (in the North Marine Region). The bioregion is divided between the North and North-west Marine Regions through the centre of the Joseph Bonaparte Gulf, along the seaward extent of the Western Australian–Northern Territory border. The bioregion as a whole (including Commonwealth, State and Territory waters) has an area of 305 463 km², of which 136 663 km² or 44.7 per cent occurs in the North-west Marine Region. The following information relates to the bioregion as a whole, although with an emphasis on describing the geomorphology, oceanography and biodiversity of those areas that occur within the North-west Marine Region.

Geomorphology – The majority of the Northwest Shelf Transition is located on the continental shelf, with only a small area extending onto the continental slope. Consequently, water depths throughout the bioregion are shallow, ranging between 0–330 m, but the majority of the bioregion has water depths of 10–100 m (Baker *et al*. 2008). The shelf includes a diversity of topographic features, such as submerged terraces, plateaux, sand banks, canyons and reefs.

The Northwest Shelf Transition contains a number of geomorphic features that are largely absent from other areas of the North-west Marine Region. In particular, this bioregion contains 90 per cent of the Region's carbonate banks/shoals (Baker *et al*. 2008). Carbonate banks and shoals occur predominantly in the Joseph Bonaparte Gulf, and consist of a hard substrate with flat tops and steep sides that rise from water depths of between 150 and 300 m (Baker *et al*. 2008). Each bank generally occupies an area less than 10 km² and is separated from the next by narrow channels, one of which is known as Penguin Deeps.

Adjacent to the carbonate banks in the Joseph Bonaparte Gulf is the Bonaparte Depression. This is a 45 000 km² geomorphic basin and is the only occurrence of this type of feature in the North-west Marine Region (Baker *et al*. 2008). It is a relatively flat feature containing a higher content of mud and gravel than is found in sediments elsewhere on the shelf in the North-west Marine Region. The depression is punctuated by numerous pinnacles and subaqueous banks, which are believed to be the remnants of calcareous shelf and coastal deposits that have been eroded to their present elevations. The pinnacles can be up to 50 m high and 50–100 km long

and are an important feature of this bioregion, not only because of their predominance in this area (60 per cent of pinnacles in the North-west Marine Region are found here), but also because they represent 9 per cent of the pinnacles found in the entire Australian EEZ (Baker *et al*. 2008). The bioregion also contains the majority of the tidal sandwaves/sandbanks of the North-west Marine Region, as well as the Londonderry Rise, which is a large elongated plateau that extends offshore from Cape Londonderry.

The complex seafloor topography of the Northwest Shelf Transition is reflected in its sedimentology. Sediments in this bioregion are characteristically different from other areas of the Region, as they tend to be dominated by soft muds, which are the result of relict mud deposition as well as modern carbonate and terrigenous mud deposition (DEWHA 2008). Elsewhere in the Region, muddy sediments tend to occur in deeper oceanic waters and the shelf mostly comprises sandy sediments. The different sedimentology on the shelf in the bioregion is likely to be indicative of seabed environments not found elsewhere in the North-west Marine Region (Baker *et al*. 2008).

Oceanography – The generally shallow nature of the Northwest Shelf Transition means that the Indonesian Throughflow is the dominant oceanographic feature in the bioregion, and dominates the majority of the water column. The Throughflow generally flows westward through the Timor Trench and reconstitutes as the South Equatorial Current south of Java. However, while the general path of the Indonesian Throughflow is reasonably well understood, very little is known of the exact pathways and movements of Throughflow waters through the Northwest Shelf Transition.

The strength of the Throughflow, and its influence in the bioregion, varies seasonally in association with the Northwest Monsoon. In the wet season (December to March), monsoonal winds push some of the waters of the Throughflow eastward, building a pressure gradient in the Banda and Arafura seas that may extend as far as the Gulf of Carpentaria (in the North Marine Region). At the end of the Northwest Monsoon (March–April), this pressure gradient is released, releasing a south-westerly flow of water across the shelf during autumn and winter. This is known as the Holloway Current (DEWHA 2008). Our understanding of the Holloway Current and its influence on other aspects of the oceanographic system is rudimentary.

The extent to which deeper, cooler and more nutrient-rich waters occur beneath the Indonesian Throughflow, particularly in the mid and outer shelf areas of this bioregion, is also largely unknown. Intrusions of cooler water onto the shelf may occur during summer when the Throughflow is weaker and water layers are more highly stratified and some seepage of cooler waters onto the shelf from mixing and upwelling processes occurring around the shelf break in the Timor Trench may occur. These water layers may be mixed by wind, external and internal wave action, or by cyclones that also episodically resuspend sediments.

The coastal waters of the bioregion are highly turbid, particularly during summer, because of the interaction of high tides with increased terrestrial inputs of sediments, organic material and freshwater from summer rains, in addition to the influence of cyclones. Tidal ranges are very high along the Kimberley coast section of this bioregion, but decrease significantly in the Joseph Bonaparte Gulf. Coastal waters therefore are a fairly distinct feature within the bioregion and may extend out as far as the 100 m depth contour during high rainfall events, particularly around the mouths of the Fitzroy, Ord and other major rivers (DEWHA 2008).

Biological communities – The biological communities of the Northwest Shelf Transition are typical of Indo–west Pacific tropical flora and fauna, and occur across a range of soft-bottom and harder substrate habitats. The softer, muddy substrates are thought to be sparsely covered by sessile filter-feeding organisms, such as gorgonians, sponges, ascidians and bryozoans, and mobile invertebrates, such as echinoderms, prawns and detritus feeding crabs. The harder substrates are believed to have a more diverse range of sessile benthos, such as hard and soft corals, gorgonians, encrusting sponges and macroalgae, and consequently, a more reef-associated fish and shark fauna.

Pinnacles and carbonate banks, particularly in the Joseph Bonaparte Gulf, are believed to support a high diversity of marine species. This is thought to be because of the channelling of water around these features, which stimulates enhanced local biological productivity through the stirring of nutrients. In addition, the hard substrates are suitable for the formation of filter-feeding coral and sponge communities.

The formation of carbonate banks in the bioregion is thought to be associated with seafloor hydrocarbon seeps (vents in the seafloor though which hydrocarbons and frequently other chemicals enter the water column).

Microbial utilisation of the hydrocarbons is thought to create carbonate by-products, which precipitate to form the basis of the banks. The hard substrate is then colonised by reef-building organisms that thrive on passing nutrients. Demersal catch records from the Northern Prawn Fishery in the Joseph Bonaparte Gulf indicate that the bioregion's demersal communities have a relatively high biomass and further suggest that the bioregion is an area of high species diversity. There are occasional reports of very large catches of some species such as the cornflake or swimming crab (*Charybdis callianassa*), which are believed to be because of spawning aggregations of this species (Brewer *et al*. 2007).

The Northwest Shelf Transition supports a number of protected marine species. A distinct genetic stock of flatback turtles is known to inhabit the Joseph Bonaparte Gulf and adjacent areas of the North Marine Region, and is likely to nest and feed in and adjacent to this bioregion (Limpus 2004). Marine turtles are also believed to feed in the reef habitat of this bioregion, and pinnacles on the mid-shelf may be important feeding sites for green, loggerhead, flatback and olive ridley turtles (Brewer et al. 2007; Donovan et al. 2008). Dugongs are also known to feed on seagrass communities in coastal waters of the Joseph Bonaparte Gulf adjacent to the Region.

Predator species in the bioregion include rays, sawfish, sharks and sea snakes. Sea snakes are regularly caught as by-catch in the Northern Prawn Fishery. A number of sites along the Kimberley coastline adjacent to the Region are also important for seabirds and cetaceans, including the Indo-Pacific humpback dolphin and the Australian snubfin dolphin, which may be endemic to Australian waters. The Kimberly coast, but particularly the area around Camden Sound is an important calving area for the West Australian population of humpback whales, from July to November. Humpback whales are also regularly seen up to 50 km offshore between Camden Sound and the Joseph Bonaparte Gulf during winter months. Adele Island is an important breeding area for brown boobies, lesser frigatebirds and small numbers of red-footed boobies, masked boobies and lesser crested terns.

A number of other areas also provide important habitat for marine species and contribute to the biological productivity of the Northwest Shelf Transition. In particular, deep embayments and islands along the Kimberley coast support extensive tall mangrove forests, tidal mud and sand flats and some rocky shorelines, which provide important nursery habitat for fish and crustaceans. Embayments and estuaries along the Kimberley coastline, including Deception Bay, Talbot Bay, Cape Londonderry, King Sound, Yampi Sound and Cambridge Gulf also support resident populations of inshore dolphins including the Australian snubfin dolphin (Thiele 2008). The importance of coastal habitat for adjacent Commonwealth waters requires further investigation. However, it is likely that many marine species use coastal waters at varying stages of their life cycle and that coastal species are an important food source for marine species.

Coastal mangroves, seagrasses and algal mats also provide important habitat for many marine fish, dugongs and marine turtles. They are also important for nitrogen fixation and nutrient recycling, providing nutrients in shallower waters that may be transported via currents and tides into adjacent Commonwealth waters. Reefs around the coastal islands of the Kimberley, including Montgomery Reef in Collier Bay, contain a high biomass of corals and coralline algae, which are important contributors to biological productivity in this bioregion.

Ecosystem processes – Within the Northwest Shelf Transition, water depth and distance from the coast strongly influence productivity pathways, and there is connectivity between biophysical and ecological processes in both State and Commonwealth waters. In coastal areas and on the inner shelf, biological productivity is generated from terrestrially derived nutrients in river run-off, which are well mixed with oceanic water through tidal action. The trophic system in these areas is largely based on bacteria and other micro-organisms, and mangrove communities play a key role in primary production. The waters are believed to be relatively productive and to support an abundant array of consumer organisms. Although the composition of these communities is poorly understood, primary and secondary consumers are likely to include species such as the small cornflake or swimming crab, and the detritivorous threadfinned scat (*Rhinoprenes pentanemus*).

In Commonwealth waters further offshore, upwelling of cooler water onto the shelf probably occurs to the north of the bioregion, in association with the Timor Trough. However, it is unclear whether nutrients associated with these upwellings extend into the bioregion itself. Cross-shelf channels may be one mechanism for the movement of cooler waters into the bioregion, and may support a benthic fauna of suspension feeders and a variety of

small and large secondary and tertiary consumers such as serranid and lutjanid fish species.

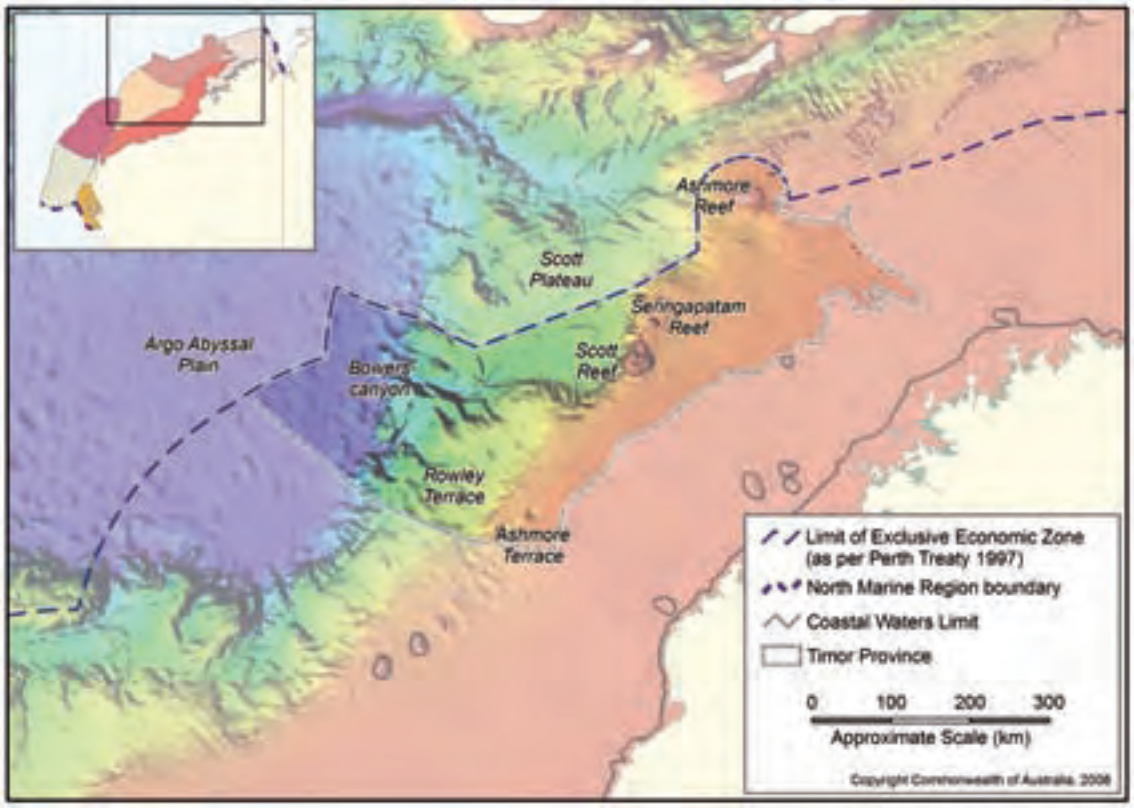
Primary productivity in the deeper Commonwealth waters of the bioregion is generally thought to be low, as these areas are nutrient-limited and reliant upon physical drivers such as seasonal winds to resuspend benthic deposits in the water column. Primary productivity is likely to be influenced by the transfer of nutrients from the coastal zone. While the mechanisms for the transfer of nutrients between the coastal and mid-shelf regions are not well known, it is presumed that migration of demersal species between the coast and mid-shelf may enhance nutrient transfer. Tertiary consumers in Commonwealth waters are likely to include small sharks, tunas and dolphins. The Northern Demersal Scalefish Fishery operates in 30–200 m water depths within this bioregion and targets deep-water snappers (*Pristipomoides* spp.) and emperors (*Lethrinus* spp.).

Table 2.1 Features and areas of ecological importance in the Northwest Shelf Transition

Feature or area	Rationale
The Kimberley coastline (between Cape Leveque and the WA/NT border) and surrounding waters	The Kimberley coastline and adjacent waters provide a range of important habitats for species in the North-west Marine Region, including reefs, rocky headlands, mudflats, sandflats and mangroves. Many marine species use these areas as nursery and feeding grounds. The Kimberley is particularly important for the Western Australian or Group IV population of humpback whales which breed in the area, and Australian snubfin dolphins, which may be endemic to Australian waters. The rugged coastline, numerous islands and reefs and surrounding Commonwealth waters support a high diversity of tropical species including marine turtles, dugongs and seabirds. Connectivity between biophysical and ecological processes occurring in state and Commonwealth waters are another important link of this area. In particular, the following sites are noted for their ecological importance: • Montgomery Reef in Collier Bay – an inshore reef that includes a high biomass of coral and is an area of high biological productivity that attracts aggregations of many marine species including turtles. • Tidal creeks around Yampi Sound and between Kuri Bay and Cambridge Gulf are important year-round habitat for Indo-Pacific humpback dolphins and Australian snubfin dolphins. • Waters between Cape Leveque and Cape Londonderry are regarded as the core of the Group IV humpback whale calving area. Large aggregations of humpbacks concentrate in Camden Sound between July and November. • Adele Island supports large breeding populations of brown boobies and lesser frigatebirds as well as smaller populations of red-footed boobies, masked boobies and lesser crested terns. • King Sound and the adjacent Fitzroy River support a significant population of freshwater sawfish, and are likely to be a significant stronghold for this species worldwide. These waters are also thought to be the only nursery area for freshwater sawfish in the Region.
Carbonate banks in Joseph Bonaparte Gulf and surrounding waters	Over 90 per cent of the carbonate banks in the North-west Marine Region are located within this bioregion, and they represent more than 70 per cent of carbonate banks in Australia's entire EEZ. It is thought that the formation of these banks is associated with hydrocarbon seeps and the hard carbonate substrate is ideal for reef-building organisms. The carbonate banks are thought to be sites of enhanced biological productivity that may support many tropical reef species. The banks, and the channels between them (e.g. Penguin Deeps), are also known foraging areas for flatback and loggerhead turtles. A distinct genetic population of flatback turtles inhabit Joseph Bonaparte Gulf and areas of the adjacent North Marine Region.
Pinnacles in the Bonaparte Depression and surrounding waters	The Bonaparte Depression contains 60 per cent of pinnacles in the North-west Marine Region and nine per cent of pinnacles in the entire EEZ. The pinnacles are up to 50 m high and 50–100 km long and are believed to be associated with enhanced local biological productivity and diverse species assemblages. The pinnacles are also important foraging areas for green, flatback, loggerhead and olive ridley turtles.

2.1.2 Timor Province

Figure 2.8 The Timor Province



The Commonwealth waters of the Timor Province cover 14.6 per cent of the total area of the North-west Marine Region. The bioregion occupies the slope between Broome and Cape Bouganville and has an area of 156 669 km², of which 155 899 km² or 99.5 per cent is in Commonwealth waters. Water depth in this bioregion ranges from 200 m near the shelf break to 5920 m on the Argo Abyssal Plain.

Geomorphology – The Timor Province is located on the continental slope and includes topographic features such as the Scott Plateau, the Ashmore Terrace, and part of the Rowley Terrace, as well as a portion of the Argo Abyssal Plain. The Scott Plateau is a significant geomorphic feature. It occurs in water depths of 2000–3000 m and is fringed by numerous spurs and valleys. It is separated from the Rowley Terrace by canyons including the Bowers Canyon. These canyons are believed to be up to 50 million years old and were excavated by sediment and water movements during the long evolution of the Region (DEWHA 2008).

Almost half of the reefs in the North-west Marine Region occur in the Timor Province, including Scott, Seringapatam and Ashmore reefs and Cartier Island. Ashmore Reef is the most northern reef of the bioregion and rises from water depths of about 300 m on the slope adjacent to the Sahul Shelf.

Ashmore Reef National Nature Reserve is a Commonwealth marine reserve and is composed of islands that are more robustly developed on their southern margins than their northern margins as a result of their exposure to an energetic southeast wind and swell regime (Baker *et al*. 2008). Cartier Island lies about 45 km to the south-east of Ashmore Reef and covers approximately 167 km². Cartier Island Marine Reserve is also a Commonwealth marine reserve and both reserves include the seabed and substrate to a depth of 1000 m.

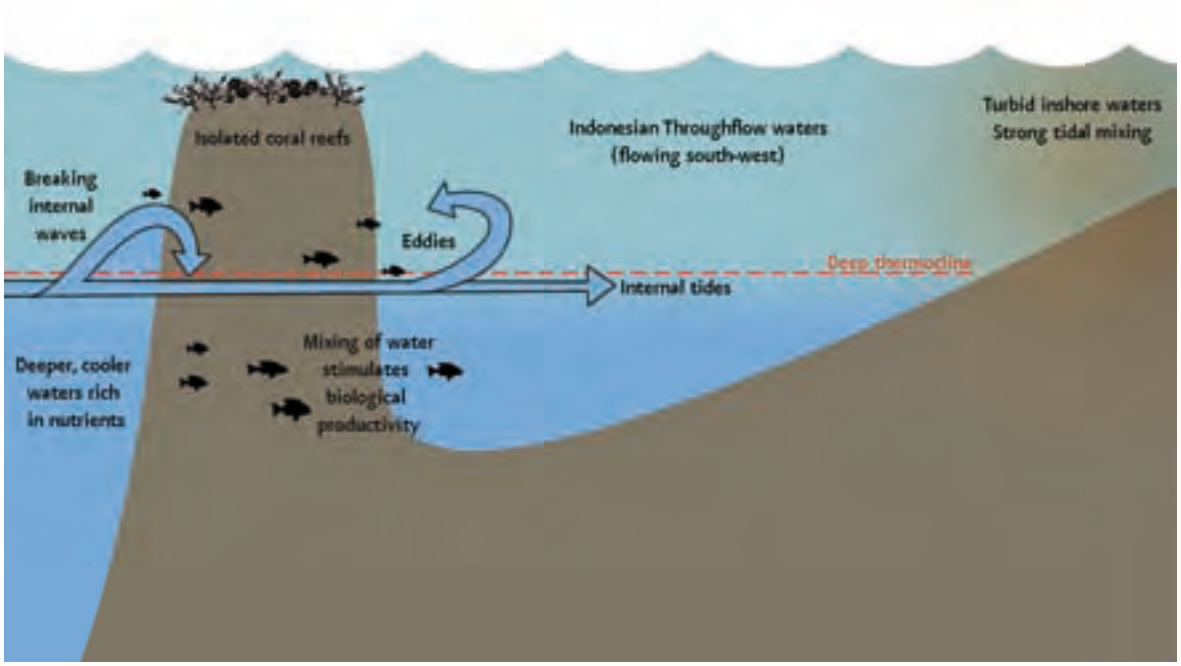
Seringapatam Reef lies to the south of Ashmore Reef in water depths of about 400 m. Scott Reef is a further 23 km south of Seringapatam Reef and rises from water depths of approximately 450 m on the slope to the east of the Scott Plateau. It has an area of 800 km² and consists of two separate atolls (North Scott Reef and South Scott Reef) that are separated by a channel of water that is about 400 m deep. One of the most significant aspects of the reefs of the Timor Province is that they reflect a transition in reef type from algal-dominated reefs north of Ashmore Reef to hard-coral-dominated reefs south of, and including, Ashmore Reef.

Oceanography – The surface waters of this bioregion are again dominated by the Indonesian Throughflow and are warm and oligotrophic (low in nutrients). Throughflow waters are believed to be circulated throughout the bioregion via offshoots of the South Equatorial Current (as described in Section 2.1.1 for the Northwest Shelf Transition), but also by flows from the Eastern Gyral Current (see Figure 2.3). As previously described, there is a strong south and westerly flow of surface waters during winter. However, during the summer Northwest Monsoon when the Throughflow weakens, the recirculation of surface waters back into the Region via the Eastern Gyral Current may give rise to anti-clockwise circulations resulting in a northward movement of water over the continental slope in this bioregion. Some scientists have suggested that this seasonal northward surface flow of the Eastern Gyral Current may be used by humpback, blue and sperm whales to assist their northward migrations (DEWHA 2008). Cooler, more nutrient-rich waters beneath the Throughflow are believed to be associated with the northward-flowing West Australian Current and possibly the Leeuwin Undercurrent.

Because of the bathymetry of the Timor Province, and its position on the continental slope, stratification of the water column is more pronounced than in most other bioregions. Internal tides associated with highly stratified water bodies are a feature of the Timor Province. The depth of the overlying surface waters, and hence the depth of the thermocline in this bioregion, is modified by seasonal and interannual variability in current strengths.

Oceanographic processes that mix surface waters with deeper water layers are concentrated around the shelf break. The shelf break is generally a dynamic zone where vertical mixing results in a mixed water mass that intrudes offshore from the shelf break across the slope at approximately the 100 m depth contour (Brewer *et al.* 2007), as well as inshore across the continental shelf into the adjacent Northwest Shelf Province (see Section 2.1.3). It is possible that eddies form on the inshore side of emergent reefs and islands in the bioregion and could be an important mechanism for mixing the water column. Similarly, the action of internal waves on the shelf break and around islands in the bioregion is an important physical process that may enhance vertical mixing and therefore may play an important role in stimulating seasonal biological productivity (Figure 2.9). Internal waves around Scott Reef have been recorded at heights of around 60 m from peak to trough (Wolanski & Delasalle 1995).

Figure 2.9 ***Oceanographic processes around offshore coral reefs in the Timor Province***



Biological communities – The variety of geomorphic features in the Timor Province, together with its varying bathymetry, results in several distinct habitats and biological communities, many of which occur in close proximity. For example, shallow reefs on the shelf break occur in close proximity to adjacent deep water muddy seabeds on the slope (Brewer *et al*. 2007). The reefs and islands of the bioregion are regarded as biodiversity hotspots and include a range of important pelagic and benthic ecological communities.

Ashmore Reef is characterised as a scleractinian coral reef. It is a significant breeding area for green turtles and has a high coverage of seagrass that supports a small dugong population. Ashmore is also internationally recognised for its abundance and diversity of sea snakes (Guinea 2007). Both Ashmore Reef and Cartier Island are important staging posts for migratory shorebirds and support some of the most important seabird rookeries in the North-west Marine Region. Further information on Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve is contained in Chapter 3.

Scott and Seringapatam reefs are also scleractinian coral reefs and are regionally important for their high biodiversity. They represent the limit of the geographic range of many fish species, including Indonesian species that are not found anywhere else in Australia. In addition, the reefs are the only known habitat in Western Australia for many fish, molluscs and echinoderms. Scott Reef also supports a small but genetically distinct breeding population of green turtles and is an important staging post for migratory shorebirds. It is also thought to be a foraging area for seabirds including roseate terns, lesser frigatebirds, brown boobies and wedge-tailed shearwaters (Donovan *et al*. 2008). There are thought to be highly diverse deep coral water habitats around Scott Reef that are not found elsewhere in Australian waters.

The species composition of all the hard coral reefs in the bioregion is very similar and reflects strong links with Indo–west Pacific fauna, largely as a result of the dispersal of coral spawn via regional currents. The reefs and islands in this bioregion are thought to be important biological stepping-stones between centres of biodiversity in the Indo–Pacific and reef ecosystems further south. There is no significant endemism among the corals of the eastern and western coasts of northern Australia. However, there is a greater level of endemism in biological communities, such as sponges and molluscs, whose larvae are generally not transported long distances by ocean currents. For example, a large component of the sponge fauna of Scott Reef is unique to Scott Reef and does not occur at Seringapatam, despite the close proximity of the two reefs and their connection via regional currents.

Coral reefs in this bioregion support a high biomass of fish species, including tropical reef fish, small pelagic fish, parrotfish and groupers as well as larger species such as trevally, coral trout, emperors, snappers, dolphinfish, marlin and sailfish. These reefs and their surrounding waters are also important habitats for cetaceans and seabirds.

The biological communities of Ashmore, Cartier, Scott and Seringapatam reefs are well understood compared with those of the slope and abyssal plain. Despite their ecological importance, reefs represent only a small proportion of the habitat types that occur in the Timor Province. Based on an understanding of the oceanographic processes that give rise to bursts in biological productivity, it is likely that important demersal communities also occur in the canyons, banks and deep holes of the bioregion, as well as on the Ashmore and Rowley terraces and Scott Plateau.

The North West Slope Trawl Fishery targets scampi in the Region. Data from the fishery suggests that muddy sediments in the Timor Province support significant populations of crustaceans (Brewer *et al* 2007). In addition, research into the demersal fish communities of the continental slope has identified the Timor Province as an important bioregion because of the presence of a number of endemic fish species, and two distinct demersal community types associated with the upper slope (water depths of 225–500 m) and mid-slope (water depths of 750–1000 m) (Last *et al*. 2005). This research suggests this bioregion may be distinctive because of the absence of a discrete mid-upper slope habitat, which has been identified in other Australian continental slope bioregions. However, the current understanding of the relationship between demersal fish communities and benthic environments on the continental slope, as well as the trophic relationships of this area, is rudimentary.

A number of migratory species occur in the Timor Province. It is likely that southern bluefin tuna travel through the bioregion on their way to and from spawning grounds between Java and Australia. Migrating whales, including humpback, sperm and blue whales, may 'ride' the northward flows of the Eastern Gyral Current and South Equatorial Current enroute to breeding grounds off the Kimberley (DEWHA 2008).

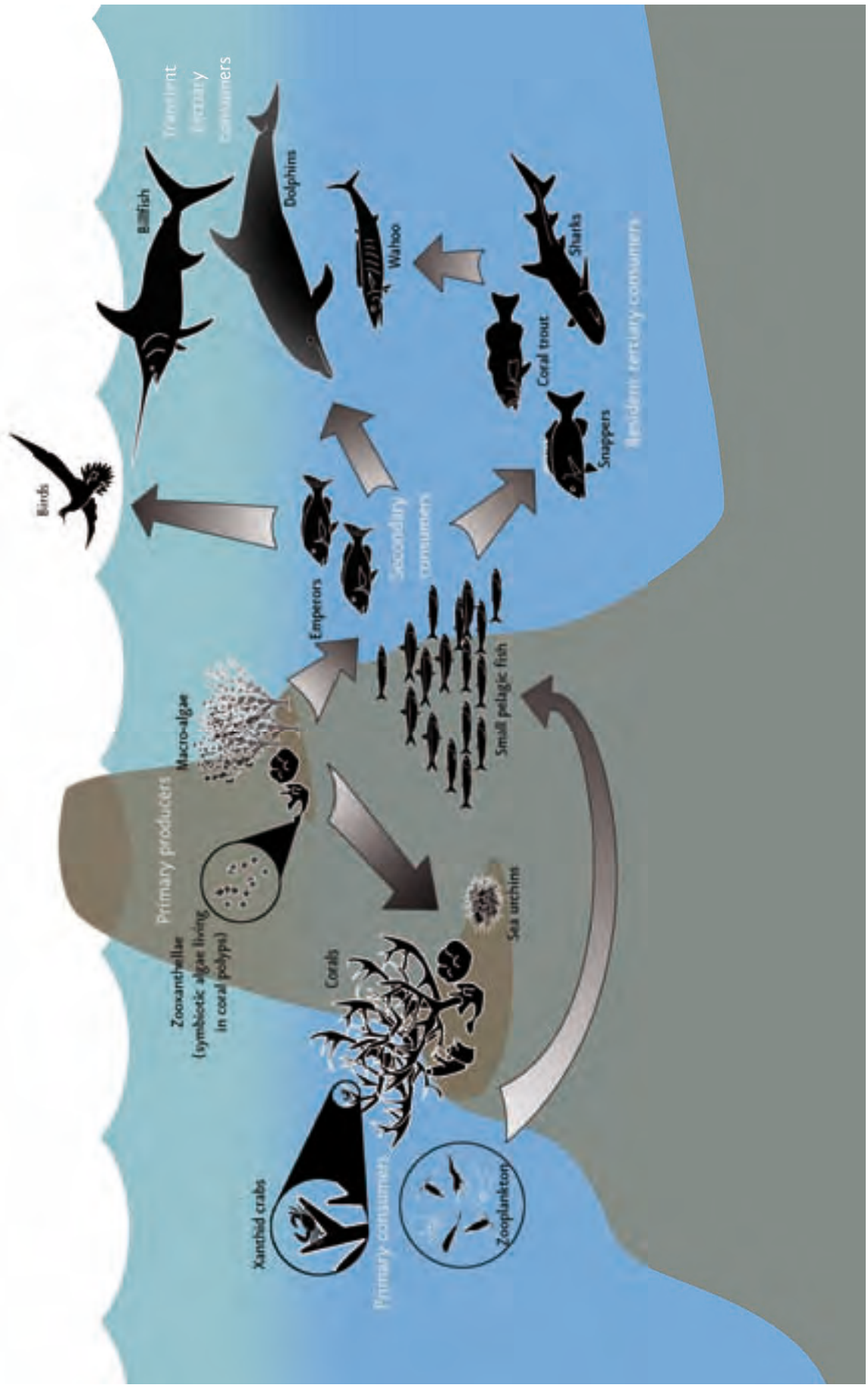


Figure 2.10 Trophic structures of the Timor Province

Blue whales reportedly move between Scott Reef and Browse Island during July (northern migration) and again during October–November as part of their southern migration (DEWHA 2008). Whaling records from the 19th century indicate that historically the number of sperm whales was high in this bioregion. Although their numbers today are unknown, it is possible that they congregate around canyon heads adjacent to the Scott Plateau, attracted high levels of biological productivity which support aggregations of prey species.

Ecosystem processes – The layer of water derived from the Indonesian Throughflow that comprises the top part of the water column has a direct impact upon biological productivity in this bioregion. Nitrate and phosphate concentrations are low at the surface, but are high at water depths of around 500 m and deeper (Brewer *et al*. 2007). Enhanced biological productivity in the bioregion is likely to be associated with ephemeral events such as topographically induced water movement through canyons and around geomorphic features, which cause mixing of the water column and provide the stimulus for productivity bursts when the thermocline is lifted into the photic zone. The action of internal waves, particularly in canyons, around islands and reefs, and on the shelf break, may be another important influence on biological productivity in this bioregion. Therefore, the canyons on the slope between the Argo Abyssal Plain and Scott Plateau, as well as to the north of Scott Reef are thought to be associated with small, periodic upwellings and are sites of locally enhanced biological productivity.

The trophic system in the pelagic zone is based on phytoplankton, and organisms like copepods are thought to be the dominant primary consumers. Secondary consumers include a larger range of planktonic taxa such as larval fish (including herring, sardines, anchovies and jack mackerel), small pelagic fish species and invertebrates including cephalopods. These in turn are preyed upon by large pelagic fish, sharks and mammals (Brewer *et al*. 2007).

The trophic dynamics of the benthic and demersal system throughout most of the Timor Province are detritus based and reliant upon deposit-feeding infauna and epifauna (animals that live on the seafloor or burrow into its sediments, e.g. nematodes, polychaete worms, shelled molluscs and a variety of crustaceans). These feed on bacteria and are preyed upon by secondary consumers such as fish, larger molluscs and crustaceans (Brewer *et al*. 2007). Tertiary consumers in deeper waters are likely to include carnivorous fish (e.g. angler fish), deep water sharks (e.g. six-gill shark), large squids and toothed whales.

As productivity hotspots, the reefs and coral atolls of the Timor Province have distinctive trophic structures. Internal waves recorded around Scott Reef are thought to bring nutrients from below the thermocline (located at about 100 m depth) to within 40 m of the surface and into the photic zone (Brewer *et al*. 2007). These nutrients are then concentrated around channels in the reefs, making them available to primary consumers near the surface (Brewer *et al*. 2007). The mixing of warm surface waters with deeper waters that are higher in nutrients stimulates phytoplankton production and zooplankton blooms that attract planktivorous squid and fish such as anchovies (Engraulidae), small pelagic fish and predators such as dolphins, striped marlin (*Tetrapturus audax*), tunas and wahoo (*Acanthocybium solandri*) (Brewer *et al*. 2007).

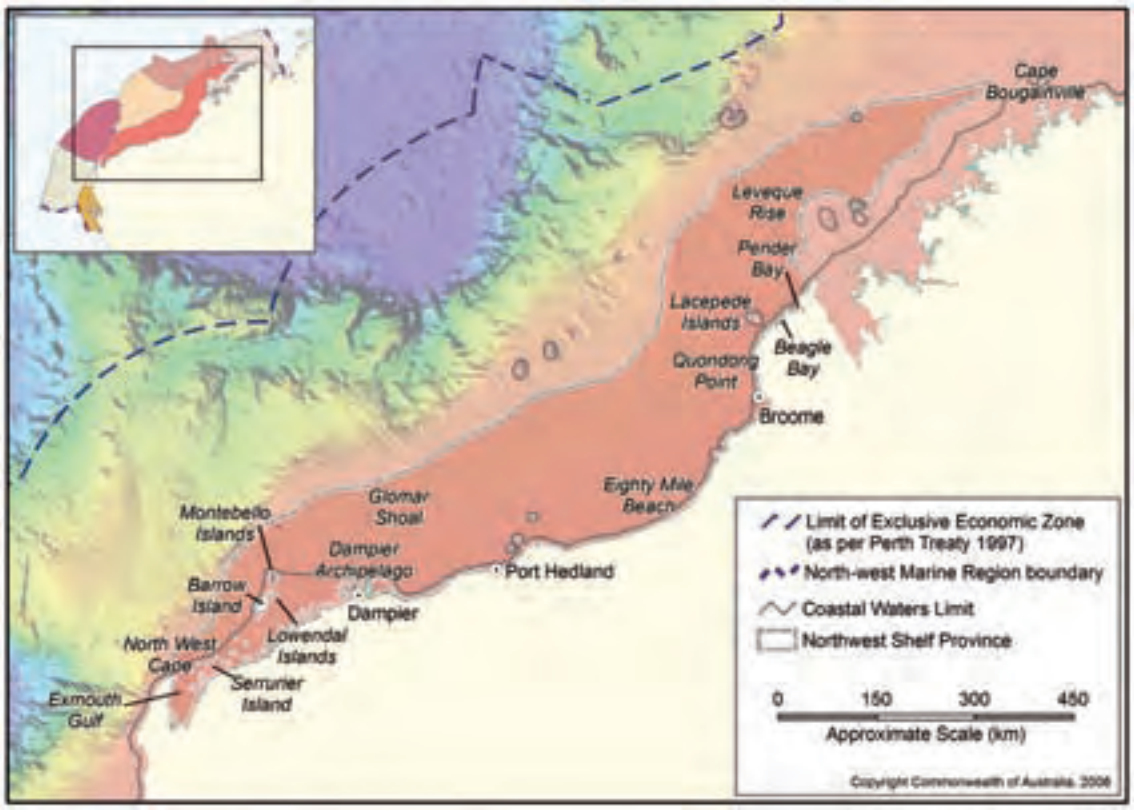
Bigeye trevally. Photo: Photolibrary.

Table 2.2 Features and areas of ecological importance in the Timor Province

Feature or area	Rationale
Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve and surrounding waters	The Commonwealth waters within and adjacent to Ashmore Reef and Cartier Island are sites of enhanced local biological productivity, within an area of relatively unproductive waters. Localised upwelling and turbulent mixing around the reefs deliver nutrients to the system. The reefs provide varied structural habitat that attracts a diverse range of primary and secondary consumers including sea cucumbers, small pelagic fish, parrot fish, and groupers. These, in turn, attract higher order consumers such as trevally, coral trout, emperors, snappers, dolphinfish, marlin and sailfish, as well as cetaceans and seabirds. The islands are important areas for the following protected species: • Ashmore Reef is internationally significant for its abundance and diversity of sea snakes. • Both Ashmore Reef and Cartier Island have been identified as critical nesting and internesting habitat for green turtles, supporting one of three genetically distinct breeding populations in the North-west Marine Region. Low level nesting activity by loggerhead turtles has also been recorded. • Large and significant feeding populations of green, hawksbill and loggerhead turtles occur around the reefs. It is estimated that approximately 11 000 marine turtles feed in the area throughout the year. • Ashmore Reef supports a small dugong population of less than 50 individuals that breeds and feeds around the reef. This population is thought to be genetically distinct from other Australian populations. • The islands support some of the most important seabird rookeries on the North West Shelf including colonies of bridled terns, common noddies, brown boobies, eastern reef egrets, frigatebirds, tropicbirds, red-footed boobies, roseate terns, crested terns and lesser crested terns. • Ashmore Reef and Cartier Island are important staging points/feeding areas for many migratory shorebirds.
Scott Reef and Seringapatam Reef and surrounding waters	Commonwealth waters surrounding Scott and Seringapatam reefs are areas of enhanced localised biological productivity and provide a variety of habitats for a diverse range of marine species. Scott Reef is an important staging area for migratory shorebirds and a foraging area for seabirds including roseate terns, lesser frigatebirds, brown boobies and wedge-tailed shearwaters. Scott Reef also supports a small but genetically distinct breeding population of green turtles, and both Scott and Seringapatam reefs are important areas for sea snakes. The reefs themselves are biogeographically important for their links with fauna of the Indo–Pacific and support many species of fish, molluscs and echinoderms that are found nowhere else in Western Australia. Each reef has diverse but distinct sponge communities.
Demersal fish communities associated with the upper and mid-slope	The upper slope (225–500 m depth) and mid slope (750–1000 m depth) habitats of the continental slope of this bioregion and the neighbouring Northwest Transition support rich and diverse demersal fish communities with a high level of endemism (64 species).
Canyons in the slope between the Argo Abyssal Plain and Scott Plateau and the north of Scott Reef	The canyons in the slope between the Argo Abyssal Plain and Scott Plateau and the north of Scott Reef are believed to be up to 50 million years old and are associated with small, periodic upwellings that result in localised higher levels of biological productivity. Anecdotal evidence of the processes occurring in canyon heads suggests that they support fish aggregations that attract larger predatory fish, sharks and cetaceans. Historical whaling records indicate that aggregations of sperm whales occurred on the Scott Plateau. There is also anecdotal evidence that the Scott Plateau may be a breeding ground for sperm whales and beaked whales.

2.1.3 Northwest Shelf Province

Figure 2.11 The Northwest Shelf Province



The Northwest Shelf Province is located primarily on the shelf between North West Cape and Cape Bougainville, and encompasses much of the area more commonly known as the North West Shelf. It covers an area of 238 759 km², of which 209 743 km² or 87.8 per cent is within the Region. The Commonwealth waters of the bioregion represent 19.6 per cent of the total area of the North-west Marine Region. The bioregion varies in width from around 50 km at Exmouth Gulf to greater than 250 km off Cape Leveque and includes water depths of 0–200 m, with more than 45 per cent of the bioregion having a depth of 50–100 m.

Geomorphology – The Northwest Shelf Province is located almost entirely on the continental shelf, except for a small area to the north of Cape Leveque that extends onto the continental slope. This bioregion includes more than 60 per cent of the continental shelf in the North-west Marine Region (Baker *et al*. 2008). The shelf gradually slopes from the coast to the shelf break, but displays a number of seafloor features such as banks/shoals and holes/valleys. These are thought to be morphologically distinct from other features of these types found elsewhere in the North-west Marine Region, and have a different sedimentology (Baker *et al*. 2008). For example, the Glomar Shoals occur approximately 30–40 km offshore of Dampier in water depths of between 26–70 m and are distinguished by highly fractured molluscan debris, coralline rubble and coarse carbonate sand (Baker *et al*. 2008).

The Leveque Rise, a large plateau, is one of only two shelf plateaux within the North-west Marine Region. Significant areas of tidal sandwaves/sandbanks, ranging in height between 5–10 m, occur on the inner-most reaches of Exmouth Gulf and are one of only three major occurrences of this type of feature in the Region. The shelf also contains several terraces and steps that extend into adjacent bioregions and reflect ancient coastlines from when the sea level in the Region was lower than it is today. The most prominent of these occurs at a water depth of approximately 125 m and is believed to be an important migratory pathway for cetaceans and other pelagic species such as the whale shark (DEWHA 2008).

Sediment differentiation within the Northwest Shelf Province occurs on a north-south gradient. South of Broome, sediment texture is relatively homogenous and dominated by sands, with a small proportion of gravels. Mud increases slightly within 100 km of the coast and within 100 km of the shelf break but is mostly absent from areas in between (Baker *et al*. 2008). North of

Broome, sediment texture is highly variable; sand dominates in some areas and gravel dominates in others, with no discernible spatial pattern.

The dynamic oceanic environment influences sediment distribution throughout the bioregion. The seafloor of this bioregion is particularly strongly affected by cyclonic storms, long-period swells and large internal tides, which can resuspend sediments within the water column as well as move sediment across the shelf (Margvelashvili *et al*. 2006).

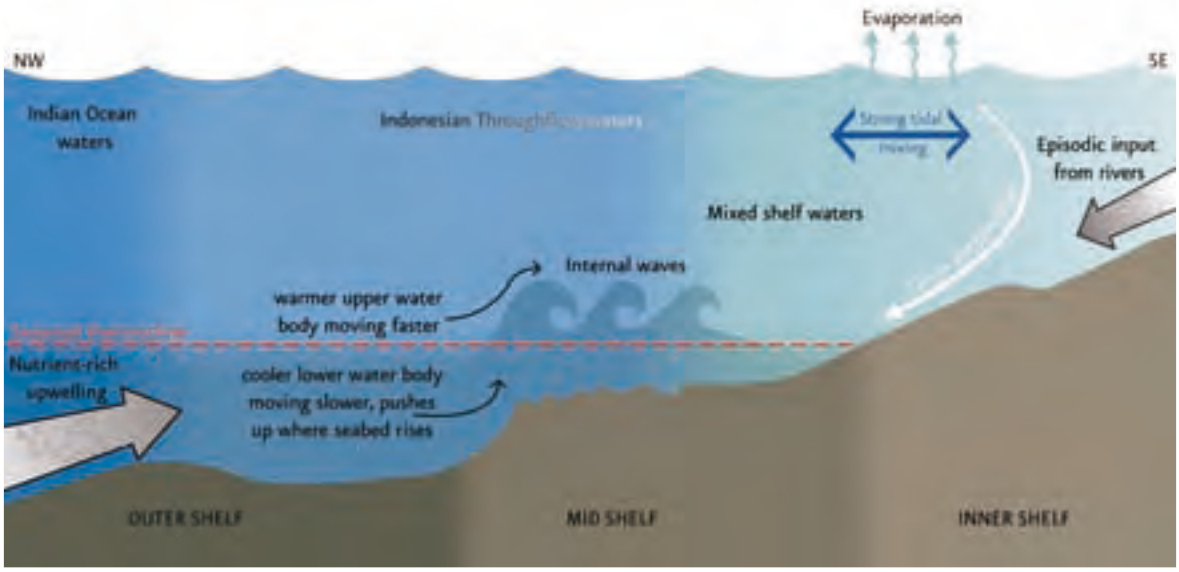
Oceanography – The Northwest Shelf Province extends across both State and Commonwealth waters and is located in a transitional climatic region between the dry tropics to the south and the humid tropics to the north (average rainfall in Broome is twice that of Port Hedland). The surface waters of the bioregion are tropical year-round, with summer sea surface temperatures around 26°C, and winter temperatures around 22°C. The surface water layers of this bioregion are highly stratified during summer months, with the thermocline occurring at water depths of 30–60 m. In winter surface waters are well mixed, with the thermocline occurring at 120 m depth (James *et al*. 2004).

The oceanography of this bioregion is dominated by the movement of surface currents derived from waters of the Indonesian Throughflow. Throughflow waters are circulated through the North-west Marine Region by branches of the South Equatorial and Eastern Gyral Currents. In addition, the Holloway Current moving southwards along the shelf brings waters from the Banda and Arafura seas and perhaps the Gulf of Carpentaria at the conclusion of the Northwest Monsoon in March–April (see Figure 2.3).

Water circulation in the Northwest Shelf Province is highly seasonal. During winter, when the southern flow of the Throughflow is greatest, it dominates the water column. During summer when the Throughflow is weaker, strong winds from the southwest cause intermittent reversals of the currents, which may be associated with occasional weak upwellings of colder, deeper water onto the shelf (Condie *et al*. 2006). The Ningaloo Current is also thought to intrude into the southern part of this bioregion during summer, flowing towards the north as far as Barrow Island.

Crystal crabs (*Chaceon* sp) feeding on a squid carcass at 701 m water depth. Photo: CSIRO.

Figure 2.12 *Major geomorphic and oceanographic features of the North West Shelf*



Adapted from James *et al*. 2004.

Tidal activity is a significant factor in the oceanography of the Northwest Shelf Province. Tides are large and increase in magnitude from south to north, from amplitudes of about 1 m near Exmouth to over 3 m near Broome (Brewer *et al*. 2007). Tides contribute to vertical mixing of surface water layers and sediments, mostly in shallower waters, although tidal effects are likely to be evident across the shelf. High evaporation rates in the shallower coastal waters result in the slow offshore movement of denser, more saline waters across the North West Shelf as a bottom layer from coastal waters out as far as the 200 m depth contour, i.e. the edge of this bioregion (James *et al*. 2004).

Internal tides, although generated primarily around the shelf break, may have an influence in this bioregion as the crests of internal waves radiate onshore from the shelf break as far as the stratification of the water layer extends. As discussed previously, when internal waves break they can cause mixing of more nutrient-rich water within the photic zone, which may in turn result in a burst of biological productivity. Figure 2.12 depicts the major aspects of regional oceanography on the North West Shelf.

Cyclones are another significant physical driver in this bioregion. The North West Shelf experiences an average of four cyclones each year, two of which make landfall. Hurricane-force winds associated with cyclones can reach speeds of up to 240 km/h (James *et al*. 2004) and cyclone-generated storm currents can cause significant sediment movement on the seafloor as well as vertical mixing of the water column. While cyclones can be very influential at the local scale, the overall contribution of cyclones to regional biological productivity is considered to be low (Holloway *et al*. 1985).

Biological communities – The sandy substrates on the shelf within this bioregion are thought to support low density benthic communities of bryozoans, molluscs and echinoids. Sponge communities are also sparsely distributed on the shelf, but are found only in areas of hard substrate. The region between Dampier and Port Hedland has been described as a hotspot for sponge biodiversity (Hooper & Ekins 2004). This biodiversity may reflect the tendency of sponge larvae to settle out of the water column very quickly, resulting in minimal larval exchange and high population differentiation between sponge communities. Other benthic and demersal species in this bioregion include sea cucumbers, urchins, prawns and squid.

The benthic and pelagic fish communities of the Northwest Shelf Province are strongly depth-related, indicative of a close association between fish communities and benthic habitats (Brewer *et al*. 2007). The fish communities are also highly diverse and a number of fish biodiversity hotspots have been identified between Port Hedland and North West Cape (Fox & Beckley 2005). Fish species of the inner shelf include lizardfish, goatfish, trevally, anglefish and tuskfish. Deep goatfish, deep lizardfish, ponyfish, deep threadfin bream, adult trevally, billfish and tuna are found in areas with water depths of between 100–200 m. Spanish mackerel spawn in this area between August and November.

The Glomar Shoals appear to be a particularly important site for fish species within the bioregion, probably

because of increased biological productivity associated with localised upwelling at this location (Brewer *et al*. 2007). A number of commercial fish species are caught in high numbers in this area, including Rankin cod, brownstripe snapper, red emperor, crimson snapper and the frypan bream.

Numerous migratory species travel through this bioregion. The northerly humpback whale migration pathway approaches the Kimberley coast near Quondong Point, before moving further offshore to pass to the west of the Lacepede Islands. The southern humpback migration follows the coastline between Cape Leveque and Pender Bay before again diverting west around the Lacepede Islands and then south, paralleling the coast on the 20–30 m depth contour, approximately 20 nautical miles west of Broome (Jenner *et al*. 2001). Exmouth Gulf (in State waters) is an important resting area for migrating humpbacks, particularly for cows and calves on the southern migration. Sharks, including whale sharks, feed and migrate through this bioregion, as do dugongs.

The Northwest Shelf Province supports several resident populations of common bottlenose dolphins and Indo-Pacific humpback dolphins including around the Montebello Islands and in the bays of the Dampier Peninsula. Roebuck Bay supports a significant population of Australian snubfin dolphins (Thiele 2008) and waters around Browse Island support the highest diversity of cetacean species in Western Australia including large numbers of oceanic dolphins (Jenner & Jenner 2008). Numerous nesting sites for green, hawksbill, flatback and loggerhead turtles occur along the coast and on offshore islands in and adjacent to the Region, and the waters of the bioregion provide extensive developmental habitat for juveniles and foraging areas for resident adults. The bioregion supports significant breeding populations of several seabird species including wedge-tailed shearwaters, crested, bridled and sooty terns, brown boobies and lesser frigatebirds. A number of important seabird breeding sites are located in areas adjacent to the North-west Marine Region including the Lacepede Islands, Eighty Mile Beach, Roebuck Bay, Serrurier Island and Montebello, Lowendal and Barrow islands.

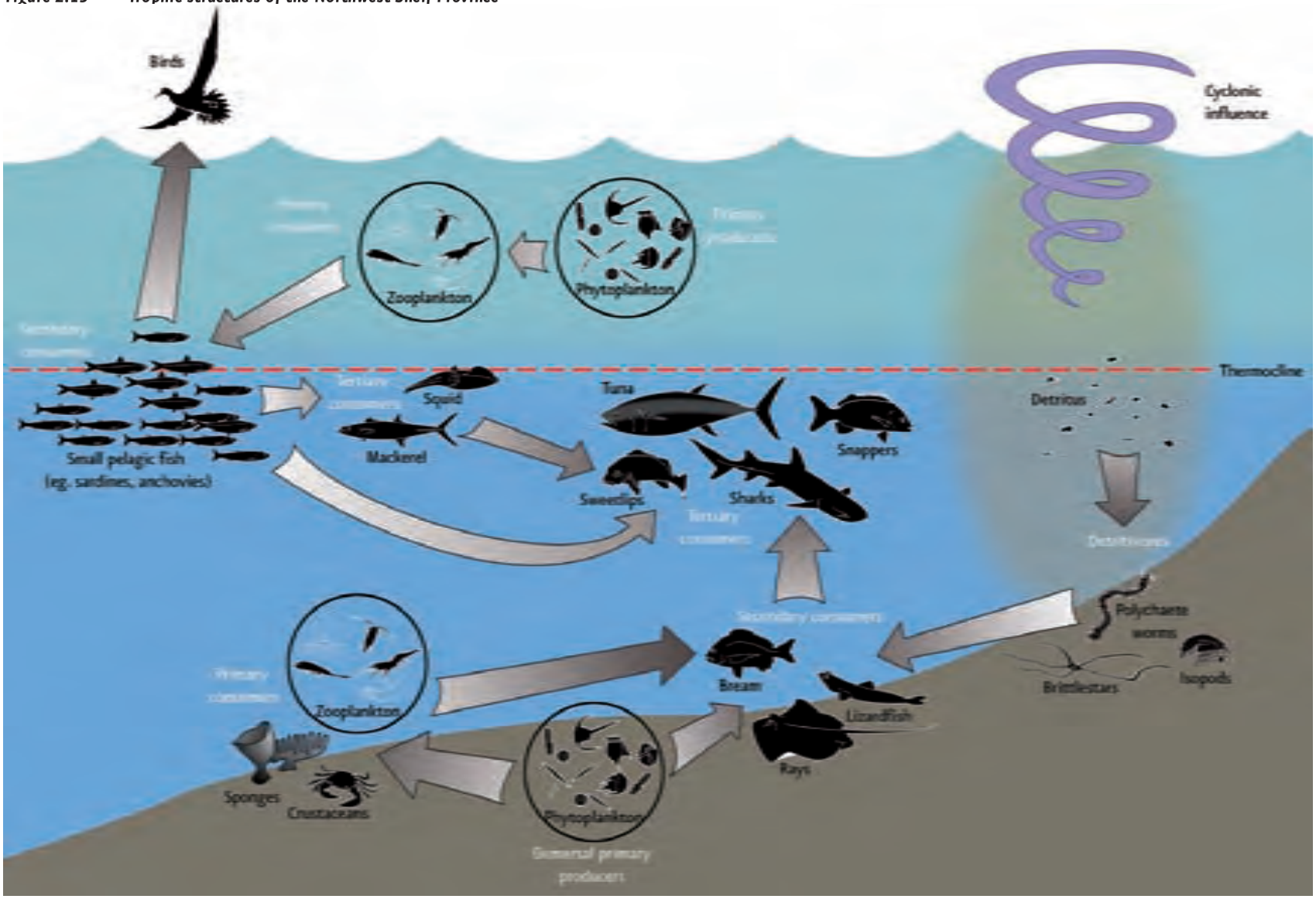
Coastal habitats are important for many of the Region's marine species. Areas of mangrove along the Pilbara coast provide important nursery habitat for many marine fish species and support prawn and crab (e.g. coral, blue and swimmer crab) fisheries. Coastal seagrasses and algal mats also provide important habitat for fish and dugongs through the length of the bioregion. The sheltered embayments along the west coast of Dampier Peninsula adjacent to the Region, particularly Carnot Bay, Beagle Bay and Pender Bay support extensive mangrove systems (Kenneally 1982). Coastal mangrove and algal mats are sites of nitrogen fixation and nutrient recycling, providing nutrients in shallower waters that are transported across the shelf via currents and tides.

The shallower waters also contain an extensive array of small barrier and fringing reefs, including important sites such as Dampier Archipelago, which is thought to be the richest area of marine biodiversity in Western Australia. The relationship between coastal habitats and adjacent Commonwealth waters is poorly understood. However, because of their higher biological productivity, these areas are likely to be aggregation sites for many marine species that move throughout the bioregion.

Ecosystem processes – The warm, low salinity waters of the Indonesian Throughflow generally suppress upwellings in the Northwest Shelf Province. However, biological productivity in the bioregion is thought to be stimulated through the action of physical drivers such as internal waves, tidal stirring and cyclones. Broadly, the inner shelf experiences oligotrophic conditions, with episodic injections of nutrients during storm events when run-off from terrestrial sources occurs and when sediments are resuspended as a result of cyclonic or tidal activity. Quondong Point and Browse Island, adjacent to the Region, are thought to be areas of enhanced biological productivity (DEWHA 2008), but the processes underlying this productivity are unclear. Waters surrounding Quondong Point attract large numbers of cetaceans, turtles, fish, dugongs and seabirds. Productivity in this area may be associated with a unique combination of bathymetry and oceanography where a strong current running along the coastline interacts with the 50 metre contour line which runs perpendicular to the coast. This interaction is likely to cause mixing of deeper, more nutrient-rich waters with surface waters, resulting in increased productivity. Localised upwellings are thought to occur around Browse Island, similarly enhancing productivity and attracting aggregations of marine species including large numbers of cetaceans.

The mid-shelf is also generally oligotrophic with sporadic availability of higher levels of nutrients associated with vertical mixing and internal wave activity occurring around the shelf break and extending onto the shelf. While not as pronounced as for the inner shelf, cyclones

Figure 2.13 *Trophic structures of the Northwest Shelf Province*



and strong tides mix water layers and nutrients and induce pulses of increased biological productivity over the mid shelf.

Enhanced pelagic production occurs on the outer shelf as a result of the interaction of surface and deeper water masses on the adjacent shelf break, via vertical mixing and possibly internal wave action. The mixed water masses travel towards shore and can stimulate biological productivity when the deeper nutrient-rich waters move into the photic zone where light allows phytoplankton to take up the influx of nutrients. However, such upwelling events are likely to be sporadic and short-lived. The most favourable conditions for upwelling are associated with a weakening of the Throughflow during summer, although some upwelling may still occur during winter. The spatial distribution and seasonal cycles of biological productivity in the area are poorly understood, but higher productivity is likely to be associated with topographic features such as escarpments along the ancient coastline and the Glomar Shoals.

Primary productivity in the Northwest Shelf Province is thought to occur predominantly in pelagic environments, where phytoplankton play an important primary producer role. Phytoplankton species rapidly multiply in response to bursts in nutrient availability and are subsequently consumed by zooplankton, that are in turn consumed by small pelagic fish. Higher order tertiary consumers, including squid, mackerel and seabirds, feed on small pelagic fish. Scavengers such as crabs, shrimps and demersal sharks, and fish species such as queenfish, mackerel, king salmon and barramundi may also be common (Brewer *et al*. 2007). Transient tertiary consumers such as tuna, snapper species and toothed cetaceans provide a link between the pelagic and benthic systems, as they prey on demersal and pelagic species. Small amounts of detritus falling to the seafloor provide another link between the pelagic and demersal systems and are utilised by sparse benthic communities of sponges and sessile filter-feeders.

Table 2.3 Features and areas of ecological importance in the Northwest Shelf Province

Feature or area	Rationale
Browse Island and surrounding waters	Browse Island is a major rookery for green turtles and flatback turtles also nest here. Localised upwellings occur around the island and may be associated with concentrations of tropical krill, a potential source of food for blue whales in the Region. Waters surrounding Browse Island support a larger number of cetacean species than anywhere else in Western Australia.
Lacepede Islands and surrounding waters	The Lacepede Islands provide critical nesting and internesting habitat for green turtles and are the site of the largest green turtle rookery in Western Australia. The Commonwealth waters surrounding the islands are important for migrating marine turtles as they move between nesting and feeding sites in this bioregion and beyond. The Lacepede Islands also support some of the largest brown booby colonies in Western Australia. Other seabirds also breed in the area, including lesser frigatebirds, bridled terns, roseate terns and common noddies. The surrounding waters are likely to provide food for seabird species.
Quondong Point, north of Broome and surrounding waters	Quondong Point, adjacent to the Region, is an area of enhanced localised biological productivity, which supports large numbers of baitfish that in turn attract aggregations of seabirds and other marine life including turtles, dugongs and possibly sawfish. This area reflects the important linkages between biophysical and ecological processes occurring in both State and Commonwealth waters. Large numbers of humpback whales, as well as other cetaceans such as false killer whales, pygmy blue whales and dolphins have been recorded in the waters around Quondong Point. Flatback turtles, which are known to nest at Barrow Island, have been regularly reported in waters here and appear to travel to Quondong Point from Barrow Island to feed. The processes that give rise to these aggregations are not yet fully understood but may be associated with a unique combination of bathymetry and oceanography.

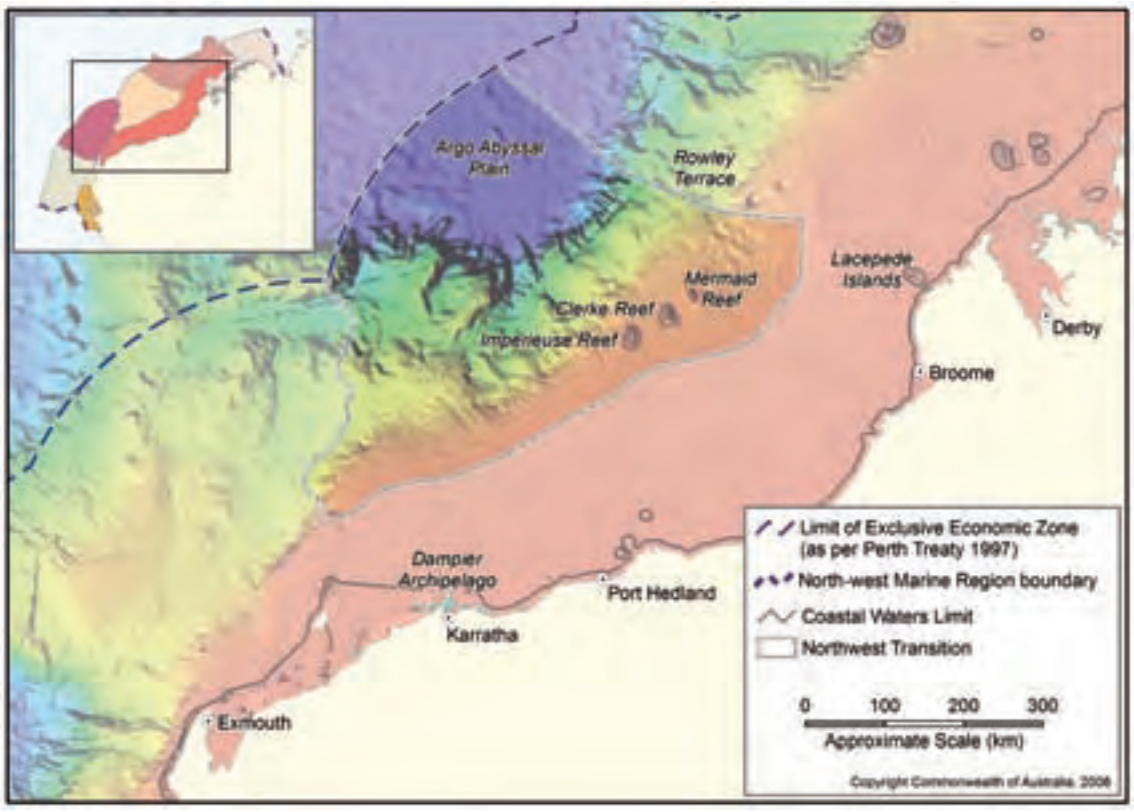
West coast of the Dampier Peninsula, including Beagle and Pender bays and surrounding waters	The sheltered embayments along the west coast of Dampier Peninsula adjacent to the Region, particularly Carnot Bay, Beagle Bay and Pender Bay support extensive mangrove systems which play a key role in primary productivity in inshore waters, mainly driven by tidal movement and terrestrial run-off. The biophysical and ecological processes occurring in the coastal areas have important links with Commonwealth waters, as the higher productivity attracts aggregations of fish species, which in turn attract a number of higher order marine predators. Beagle Bay and Pender Bay are also important for bottlenose dolphins, Indo-Pacific humpback dolphins and Australian snubfin dolphins. Small concentrations of dugongs have been observed in seagrass between Cape Bossut and King Sound. These species regularly use adjacent Commonwealth waters.
Pilbara coast (between Exmouth and Broome) and surrounding waters	The Pilbara coastline and adjacent waters encompass a number of sites of ecological importance that demonstrate the connectivity between biophysical and ecological processes occurring in State and Commonwealth waters. The Pilbara coast supports a complex range of habitats including rocky coastlines, sandy substrates with mangroves and seagrass, and a number of islands and associated reefs, including the Dampier Archipelago. These habitats support a high diversity of marine species, including significant populations of a number of protected species. These species are likely to move through and feed in Commonwealth waters. Montebello, Lowendal and Barrow islands are resting areas for migrating humpback whales and support resident populations of common bottlenose dolphins and Indo-Pacific humpback dolphins, while Roebuck Bay is a significant area for Australian snub-fin dolphins. The Pilbara coast and offshore islands also provide important habitat for protected marine turtle species: • Eighty Mile Beach is a major rookery for flatback turtles. • Serrurier Island is a major nesting area for green turtles and may also be a foraging area for this species. • Thevenard Island supports a significant flatback turtle rookery, along with small numbers of green turtles and is a known feeding area for green turtles. • Many areas in the Montebello, Lowendal and Barrow islands complex have been identified as critical nesting and internesting habitat for green, flatback and hawksbill turtles. Occasional nesting by loggerhead turtles has also been recorded on Barrow Island. • Summer mating aggregations of green turtles occur to the west of Barrow Island and within the Montebello Island group. • Possible green turtle foraging grounds occur over the Barrow Shoals off the south-east coast of Barrow Island. Hawksbill turtle feeding grounds occur in the Mary Anne and Great Sandy Island groups to the south of the Barrow Shoals. • Rosemary Island and the Dampier Archipelago provide critical nesting and internesting habitat for flatback turtles, and support the most significant hawksbill turtle rookery in Western Australia. This rookery is also one of the largest in the Indian Ocean. Dampier Archipelago also supports major green and flatback turtle nesting sites. • Port Hedland and Cape Thouin are important rookeries for flatback turtles. Critical nesting and internesting habitat for flatback turtles has also been identified at Mundabullangana Beach. This area also supports important seabird populations and habitats: • Eighty Mile Beach and Roebuck Bay are both among the most important feeding areas/staging points in Australia for migratory shorebirds. They regularly support over 500 000 birds at a time with over 850 000 birds using the area annually. Both sites support more than one per cent of the East Asian–Australasian Flyway population of 20 migratory shorebird species and, consistent with international criteria, are recognised as being internationally significant sites. • Caspian terns, little terns, wedge-tailed shearwaters and ospreys breed on Serrurier Island and nearby Airlie Islands. • Montebello, Lowendal and Barrow islands support significant rookeries of wedge-tailed shearwaters and bridled terns. The Montebello Islands support the largest breeding population of roseate terns in Western Australia. Ospreys, white-bellied sea-eagles, eastern reef egrets, Caspian terns, crested terns and lesser crested terns also breed in this area.

Pilbara coast (between Exmouth and Broome) and surrounding waters cont'd.	• Waters to the west of the Montebello Islands may be a minor upwelling zone, supporting large feeding aggregations of terns. • Barrow Island is ranked equal tenth among 147 sites in Australia that are important for migratory shorebirds (feeding area/staging post). • Barrow, Lowendal and Montebello islands are internationally significant sites for six species of migratory shorebirds, supporting more than one per cent of the East Asian–Australasian Flyway population of these species. • Bedout Island supports one of the largest colonies of brown boobies in Western Australia. Masked boobies, lesser frigatebirds, roseate terns and common noddies also breed in the area.
Exmouth Gulf – Muiron Islands and surrounding waters	This area and its surrounding waters provide important habitat for a number of protected marine species. Exmouth Gulf is an important resting area for migrating humpbacks, particularly for females and calves on their southern migration. Large numbers of dugongs also occur in the Gulf and feed on seagrass beds. The surrounding Commonwealth waters are therefore thought to include large numbers of humpbacks and dugongs at different times of the year as they travel between resting and feeding grounds. The Muiron Islands are critical nesting and internesting habitat for loggerhead turtles and also support a major green turtle rookery. North West Cape is also a major green turtle nesting area. Turtles are thought to regularly travel through surrounding Commonwealth waters on their way to feeding and breeding grounds to the north and south.
Ancient coastline at 125 m depth contour	The ancient coastline along the 125 m depth contour in Commonwealth waters is thought to be an important seafloor feature that acts as a migratory pathway for cetaceans and other pelagic marine species such as whale sharks, as they move north and south between feeding and breeding grounds. The topographic variation created by the ancient coastline is also thought to aid minor upwelling, as a result of internal wave activity. These upwellings may initiate seasonal bursts in biological productivity that provide food for migrating marine species.
Glomar Shoals	The Glomar Shoals are an important seafloor feature in Commonwealth waters within this bioregion, as they are a raised feature on a relatively featureless continental shelf. They are characterised as a high energy environment because of current action, thereby resulting in local enhancements in productivity. Enhanced biological productivity supports significant populations of a number of commercially important fish species such as Rankin cod, brownstripe snapper, red emperor, crimson snapper and frypan bream.

Red-tailed tropicbird. Photo: Nadeena Beck, Department of the Environment, Water, Heritage and the Arts.

2.1.4 Northwest Transition

Figure 2.14 The Northwest Transition



The Northwest Transition is located off the shelf between the Dampier Archipelago and Lacepede Islands and has a total area of 184 424 km². Commonwealth waters, which comprise 99.5 per cent of the bioregion, represent 17 per cent of the total area of the North-west Marine Region and encompass a range of water depths, from the shelf break (200 m depth) over the continental slope, to depths of more than 1000 m (James *et al*. 2004). At their deepest, waters within the Northwest Transition reach depths of around 5980 m over the Argo Abyssal Plain.

Geomorphology – The majority (52 per cent) of the Northwest Transition bioregion occurs on the continental slope, with smaller areas in the north-west of the bioregion located on the Argo Abyssal Plain and continental rise. The sediments of the slope are dominated by sands, whereas the sediments of the abyssal plain/deep ocean floor are dominated by muds.

Areas of continental slope in this bioregion are believed to have different physical attributes to areas of continental slope in adjacent bioregions, because so much of the Northwest transition occurs in water over 4000 m deep (Baker *et al*. 2008). More than 60 per cent of the Argo Abyssal Plain occurs within this bioregion, the remainder being located within the Timor Province. The Argo Abyssal Plain is believed to have a different morphology and geological history to other areas of abyssal plain/deep ocean floor in the North-west Marine Region (Baker *et al*. 2008). Its surface gently slopes to the north and contains a number of swales in the south-western regions and small hills on the western margin.

Other topographic features within the bioregion include areas of rise, ridges, canyons and apron/fans. The bioregion also has reefs such as Mermaid, Clerke and Imperieuse reefs, which are collectively known as the Rowley Shoals. The Rowley Shoals are a series of isolated, reef-rimmed platforms along a north-south orientation that rise vertically to the surface from water depths of about 400 m on the continental slope. The reef basements are believed to be of Pleistocene age (a period that spanned from 1.8 million to about 10 000 years ago) and are overlain by thick, coral-rich Holocene deposits (from the last 10 000 years) that have kept pace with rising sea levels. Mermaid Reef is a Commonwealth marine reserve that covers an area of 5.4 km², including the seabed and substrate to a depth of 1000 m.

Oceanography – Surface circulation of Indonesian Throughflow waters via direct southward pressure-driven flow and recirculation through the South Equatorial Current are again the dominant oceanographic features of this bioregion (see Figure 2.3). The Throughflow waters form a deep overlying surface layer throughout the entire bioregion, particularly when the Throughflow is at its strongest in winter. In deeper waters over the Argo Abyssal Plain, the influence of the Throughflow may extend to a depth of approximately 1200 m (DEWHA 2008). During summer, the southern flow of surface waters weakens and a northerly return of Throughflow waters via the Eastern Gyral current develops. This current is thought to be used by migrating humpback whales and other cetaceans.

Because of the depth of the Indonesian Throughflow, wind stress has little influence on vertical mixing of the water column in the Northwest Transition throughout most of the year. However, cyclone incidence is high in this bioregion during summer months and contributes to mixing of surface layers of the water column as cyclones track across the slope. Another driver of oceanic mixing may be the interaction of internal waves with topographic features, such as the Rowley Shoals and canyons on the continental slope between the Argo Abyssal Plain and the Rowley Terrace.

Biological communities – The benthos of the deep ocean areas of the Northwest Transition is likely to support meiofauna (minute animals living between grains of sediment on the seabed, e.g. nematodes), larger infauna (that burrow into sediments, e.g. polychaete worms and isopods) and sparsely distributed epibenthic communities (that live on the surface of the seabed, e.g. seapens) (Brewer *et al*. 2007). Mobile benthic species, such as deepwater sea cucumbers, crabs and polychaetes are likely to be associated with the seafloor, and the bioregion may support sparse populations of bentho-pelagic fish and cephalopods in low densities. Pelagic fish species likely to be present include grenadiers and hatchetfish (*Argyropelecus* spp.) as well as transient populations of highly mobile pelagic species, such as sharks and schools of small pelagic fish. Adult and juvenile southern bluefin tuna are thought to migrate through this bioregion on their way to and from spawning grounds in the north-eastern Indian Ocean. However, the timing of these migrations and the use of regional currents to assist their migration is still unclear. Seabirds are likely to feed on small pelagic fish in this bioregion.

The slope habitat of this bioregion is associated with important populations of demersal fish species. A national bioregionalisation of slope fish communities identified the North West Slope (which occurs in this bioregion as well as the adjacent Timor Province) as supporting the second richest demersal fish assemblage nationally (Last *et al*. 2005). Over 508 fish species have been identified on the slope in this area, and 64 of these species are endemic. Demersal slope fish species in this bioregion are distributed across a number of distinct depth ranges on the slope, specifically areas of the upper slope (225–500 m) and mid slope (750–1000 m). The high diversity and endemism of the demersal fish fauna indicates important interactions between physical processes and trophic structures in this bioregion.

The Rowley Shoals are a hotspot for biodiversity in this bioregion and contain intertidal and subtidal coral reefs. These reefs support a diverse marine fauna typical of oceanic coral reef communities of the Indo–west Pacific. The reefs are important stepping stones in the maintenance of gene flow among the north-west Australian coral reefs. Biological surveys of the reefs have identified 184 species of corals, 264 species of molluscs, 82 species of echinoderms and 389 species of finfish (DEC 2007).

Mermaid Reef Marine National Nature Reserve consists of a reef flat 500–800 m wide, that shelves into shallow back-reefs rich in corals and a large lagoon up to 20 m deep (see Chapter 3 for more information on the Mermaid Reef Marine National Nature Reserve). Clerke and Imperieuse reefs also contain lagoons, but they are much shallower and generally more structurally complex as a result of erosion channels cutting through the surface of the terrace (Brewer *et al*. 2007). The steep change in slope around the reefs attracts a range of migratory pelagic species, including cetaceans, tuna, billfish and sharks. Mermaid Reef supports a variety of shark species, particularly large deep water sharks (e.g. grey reef shark *Carcharhinus amblyrhynchos* and silvertip whaler shark *Carcharhinus albimarginatus*) which have been adversely affected through overfishing at other reef locations in the North-west Marine Region (Meekan *et al*. 2005).

Ecosystem processes – Biological productivity within the Northwest Transition is characteristic of the North-west Marine Region generally. Surface productivity is suppressed as a result of the dominance of warm and oligotrophic surface water layers, derived from the Indonesian Throughflow. Biological productivity occurs

episodically at depth and is associated with seasonally reversing surface currents and mixing associated with the shelf break and perhaps through interactions between internal waves and topographic features on the slope, such as canyons and reefs.

In this generally low productivity environment, the dominant primary consumers are pelagic, vertically migrating zooplankton, such as crustaceans, larval molluscs and larval fish. These are preyed upon by jellyfish, salps, transient schools of small pelagic fish and squid (Brewer *et al*. 2007). Higher order consumers in the deep waters of this bioregion include migratory pelagic species, such as juvenile southern bluefin tuna, billfish, dolphins and sharks.

The trophic dynamics of the demersal communities of the deeper abyssal plain are heavily reliant upon energy inputs in the form of falling detritus, organic matter, nutrients in sediments that move down the continental slope, and, occasionally, carcasses of large pelagic species including whales (Brewer *et al*. 2007). Bacteria perform an important role in the trophic system of the abyss, aiding in the breakdown of detritus and regenerating nutrients. Primary consumers include copepods, nematodes and crustaceans, which in turn are fed upon by larger crustaceans and squid.

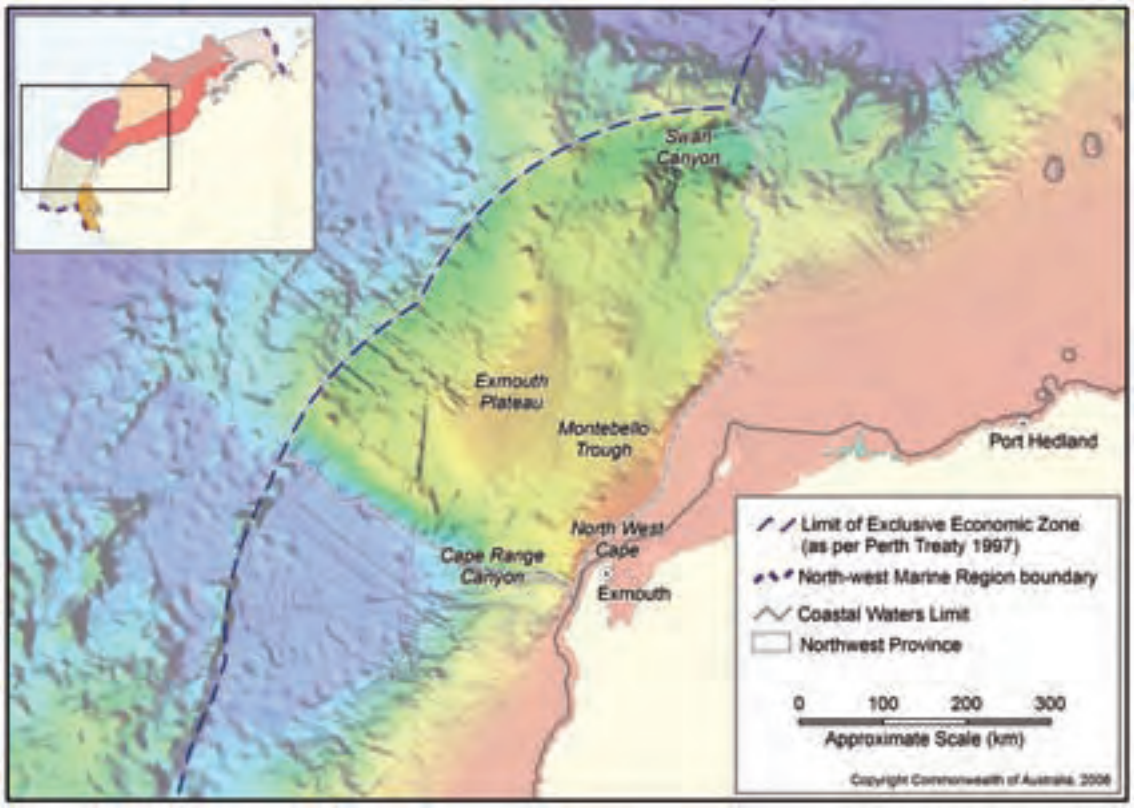
The trophic dynamics of the Rowley Shoals are centred around the flow of nutrients from primary consumers, such as zooxanthellae, phytoplankton and filter feeders, to secondary consumers, including a variety of tropical reef fish species (e.g. damselfish). In turn, these are preyed upon by a variety of resident tertiary consumers, such as snappers, trevally and serranids, as well as transient tertiary consumers such as pelagic fish, dolphins, sharks and other dominant predators.

Table 2.4 Features and areas of ecological importance in the Northwest Transition

Feature or area	Rationale
Rowley Shoals: Mermaid Reef Marine National Nature Reserve, Clerke and Imperieuse reefs and surrounding waters	The Rowley Shoals are a collection of three atoll reefs. The reefs themselves and their surrounding waters are associated with enhanced biological productivity, and support a high diversity of marine species. Unique sponge faunal assemblages are also associated with each of the reefs. Because of the predominantly southward flow of currents past the Rowley Shoals and beyond, they are also thought to provide a source of invertebrate and fish recruits for reefs further south. High order predators, such as sharks, are an important component of the marine ecosystems around the Rowley Shoals. Surveys around Mermaid Reef have confirmed that there is a diverse shark fauna here. Sharks are found in considerable numbers on the Rowley Shoals, compared with the low abundance of sharks on Scott and Ashmore reefs, which have been affected by overfishing. The Rowley Shoals also provide important habitat for a number of protected marine species: • Red-tailed tropicbirds, white-tailed tropicbirds and little terns breed in this area. • Sand cays of the Rowley Shoals are important resting and feeding sites for migratory shorebirds.
Fish communities associated with the slope	The upper and mid-slope areas of the continental slope of this bioregion and the neighbouring Timor Province support rich and diverse demersal fish communities with a high level of endemism (64 species). There are two distinct demersal community types associated with the upper slope (water depths of 225–500 m) and the mid-slope (water depths of 750–1000 m).

2.1.5 Northwest Province

Figure 2.15 The Northwest Province



The Northwest Province is located offshore between Exmouth and Port Hedland, and covers an area of 178 651 km^2, all of which is Commonwealth waters. The bioregion covers 16.7 per cent of the total area of the North-west Marine Region and occurs entirely on the continental slope. Water depths in the bioregion are predominantly between 1000–3000 m and reach a maximum depth of over 5170 m in the Exmouth Plateau.

Geomorphology – The bioregion occurs entirely on the continental slope and is comprised of muddy sediments. It is distinguished by a number of topographic features, such as the Exmouth Plateau, terraces and canyons (including the Swan and Cape Range canyons), as well as deep holes and valleys on the inner slope. The Montebello Trough occurs on the eastern side of the Exmouth Plateau and represents more than 90 per cent of the area of troughs in the North-west Marine Region (Baker *et al*. 2008). Significantly, this bioregion contains the steepest shelf break of the North-west Marine Region, along the Cape Range Peninsula near Ningaloo Reef.

The largest topographic feature of this bioregion (in terms of area) is the Exmouth Plateau, which covers an area of approximately 50 000 km^2, or 26 per cent of the bioregion (Baker *et al*. 2008). The surface of the plateau is generally rough and undulating with water depths of approximately 500–5000 m, and is thought to be dotted with pinnacles. It is an important geomorphic feature of the North-west Marine Region that modifies the flow of deep waters. It has been identified as contributing to the generation of internal waves and the potential uplifting of deeper, more nutrient-rich waters, closer to the surface (Brewer *et al*. 2007).

Oceanography – As with many other bioregions, circulation of Indonesian Throughflow waters into the Northwest Province (via the South Equatorial Current and Eastern Gyral Current) comprises the dominant surface flow. This circulation is subject to seasonal variation as well as inter-annual variation (as described earlier). It can take up to a year for Throughflow waters to recirculate via these pathways into the bioregion. As a result, the properties of these waters are modified by the time they reach the Northwest Province, but retain their overriding oligotrophic characteristics.

The most distinguishing feature of the oceanography of the Northwest Province, compared with bioregions further north, is the result of the narrowing of the continental shelf at North West Cape. The generally

southward moving surface waters consolidate along the narrow shelf break and become the Leeuwin Current. The Leeuwin Current is often described as the 'signature current' of Western Australia, owing to its extent and significant impact on biodiversity and the biological productivity of ecosystems. The Leeuwin Current flows south along the shelf break and is shallow (less than 300 m deep) and narrow (50–100 km wide). The Leeuwin Undercurrent is also a feature of this bioregion and flows northward beneath the Leeuwin Current, between 250–450 m water depth on the continental slope. It transports higher salinity, oxygen-rich but nutrient-depleted water, characteristic of subantarctic water masses, northwards (Thompson 1984).

The Leeuwin Current is strongest during autumn and winter. During summer, strengthening south-westerly winds counter the alongshore pressure gradient and weaken the southward flow of the Leeuwin Current, allowing the generation of the northward flowing Ningaloo Current. The Ningaloo Current intrudes into this bioregion inshore of the 50 m depth contour along Cape Range Peninsula. The narrowness of the shelf in this bioregion brings the opposing flows of the Leeuwin and Ningaloo currents into close proximity, creating an area of enhanced mixing.

Other seasonal influences on the oceanography of the Northwest Province include an increase in cyclone incidence and intensity during summer, as well as in increase in internal wave activity around Exmouth Plateau and its associated canyons. The increase in internal wave activity is the result of interaction of tides with seafloor topography of the Exmouth Plateau, when the water column is more highly stratified.

Biological communities – The Northwest Province represents the beginning of a transition between tropical and temperate biological communities. The predominantly southward flowing surface currents continue to bring tropical Indo–Pacific organisms into this bioregion, but the presence of the northward flowing Leeuwin Undercurrent also transports temperate species from more southern areas (Brewer *et al*. 2007). North West Cape is a boundary point for a transition in demersal shelf and slope fish communities from tropical dominated communities to the north and temperate communities to the south (Last *et al*. 2005). The benthic shelf and slope communities of this bioregion comprise both tropical and temperate species with a north-south gradient. The high endemism in demersal fish species associated with the slope (as has been described for the Northwest Transition and Timor Province) is also evident in this bioregion. The continental slope between North West Cape and the Montebello Trough has been identified as one of the most diverse slope habitats of Australia with over 508 fish species and the highest number of endemic species (76) of any Australian slope habitat. However, the reasons for this high level of endemism are not understood.

Whale shark. Photo: Gavin Leese, Queensland Department of Primary Industries and Fisheries.

The Exmouth Plateau is also likely to be an important area for biodiversity as it provides an extended area offshore for communities adapted to depths of around 1000 m. The circulation of deep water currents in the bioregion probably brings deep water species in closer proximity to species that occur on the plateau and may result in important associations of biological communities (Brewer *et al*. 2007). For example, channels and valleys from the plateau to the deeper slope and adjoining abyss may act as conduits for the delivery of materials and sediments and may sustain suites of communities at the base of the plateau. The deeper waters of the inner edge of Exmouth Plateau, around the Montebello Trough, are believed to be an important feeding site for sperm whales, indicating an area of high biological productivity. However, little specific information is available on the biological communities of the Exmouth Plateau and associated slope.

Despite the present poor knowledge of the benthic communities on the Exmouth Plateau, information on sediments in the bioregion indicates that benthic communities are likely to include filter feeders and epifauna. Soft-bottom environments are likely to support patchy distributions of mobile epibenthos, such as sea cucumbers, ophiuroids, echinoderms, polychaetes and sea-pens. The biological communities within canyons in the bioregion are also poorly understood. The canyons in this bioregion probably channel currents onto the plateau, driving upwelling in the canyon heads. These are associated with aggregations of baitfish, which in turn attract larger pelagic species such as billfish and tuna.

Pelagic species occurring above the plateau, slope and canyons are likely to include nekton and small pelagic fish, attracted to seasonal upwellings, as well as larger predators such as billfish, sharks and dolphins. A number of migratory species have been recorded in this bioregion including whale sharks, cetaceans, marine turtles (e.g. loggerheads, leatherback and olive ridley turtles are known to traverse the bioregion) and whale sharks. All are known to feed on and around the adjacent Ningaloo Reef, which is situated on the shelf and slope of the Cape Range Peninsula. Ningaloo Marine Park (Commonwealth and State waters) occurs in both this bioregion and the adjacent Central Western Transition, Central Western Shelf Transition and Northwest Shelf Province bioregions, but is discussed in detail in the Central Western Shelf Transition bioregion (Section 2.1.6) and in Chapter 3.

Ecosystem processes – It is believed that overall biological productivity above the Exmouth Plateau and slope is generally low, again because of the overriding influence of the oligotrophic tropical waters. However, the Exmouth Plateau acts as a physical obstacle, forcing deeper, cooler and more nutrient-rich waters onto the plateau. Internal wave activity during summer may further stimulate biological productivity when nutrient-rich waters are raised into the photic zone. Satellite imagery has identified areas of increased biological productivity along the northern and southern boundaries of the plateau, as well as in the east along the shelf edge through the Montebello Trough (Brewer *et al*. 2007). The extent to which internal waves play a part in these increases in productivity (if at all) is unknown.

The trophic dynamics of deeper waters in the Northwest Province, and in particular on the Exmouth Plateau, can be separated into pelagic and benthic food webs. Detritus falling from the pelagic environment to the seafloor plays a key role in nutrient cycling from pelagic to benthic environments (Brewer *et al*. 2007). Small pelagic fish are thought to be the main consumers of phytoplankton and zooplankton in the pelagic system and are, in turn, preyed on by larger tertiary consumers such as billfish, sharks and dolphins. Bacteria on the seafloor are likely to utilise available nutrients in sediments and detritus and are fed upon by primary consumers such as nematodes and copepods. Detritivores such as molluscs and crustaceans may also directly feed upon detritus. Both the primary consumers and detritivores are probably preyed upon by larger secondary consumers such as crustaceans and demersal fish.

The heads of canyons extending between the Cuvier Abyssal Plain (lying in the adjacent Central Western Transition bioregion) and the slope of the Northwest Province, and in particular the Cape Range Canyon, are sites of localised seasonal biological productivity that are associated with bursts in phytoplankton, zooplankton and tropical krill production. These sporadic bursts of productivity are believed to have a significant influence on the adjacent Ningaloo Reef and help to explain the high biodiversity of this area. The narrowness of the shelf means that the nutrients channelled to the surface via canyons in the slope are immediately available to reef consumers. A general lack of terrestrial nutrient inputs means that this deep water source is a major source of nutrients for Ningaloo Reef, and is therefore very important in maintaining the marine ecosystem.

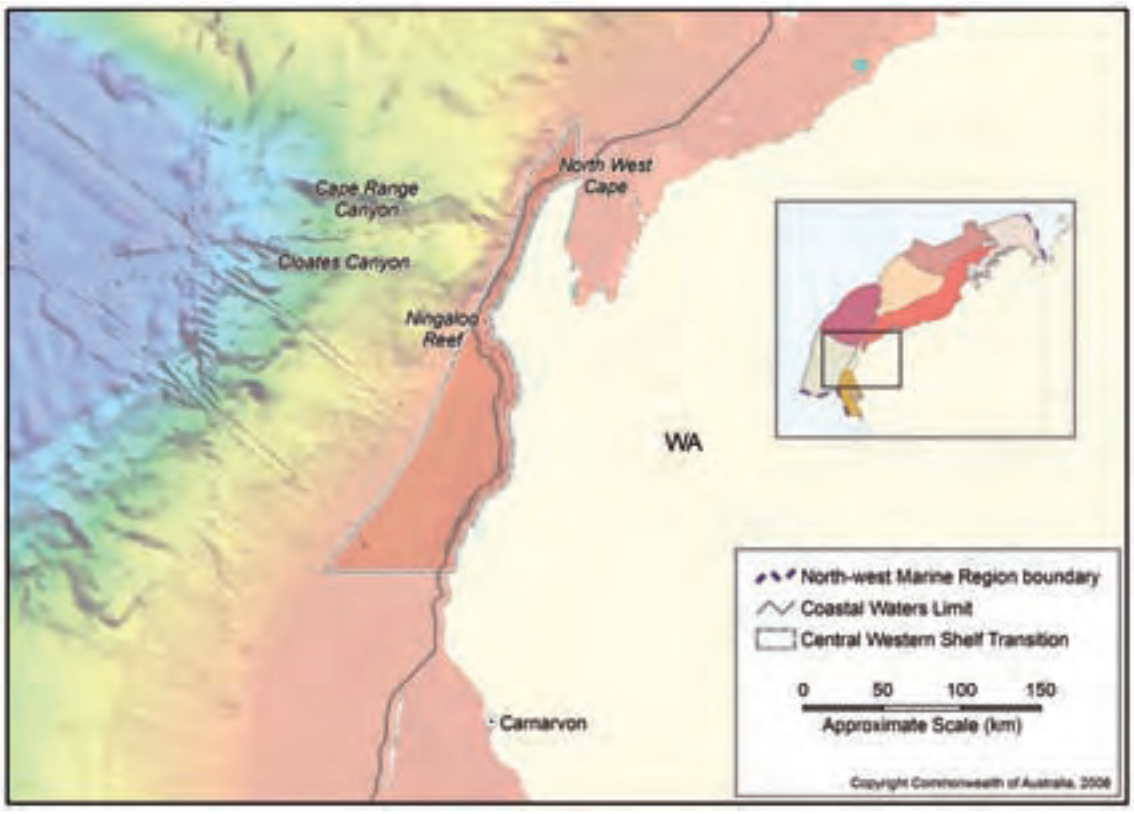
Table 2.5 Features and areas of ecological importance in the Northwest Province

Feature or area	Rationale
Exmouth Plateau	The Exmouth Plateau is an area of enhanced localised biological productivity. This productivity is seasonal and occurs in sporadic bursts. It is driven by the interaction of regional oceanography and topographic features. The plateau is a topographic obstacle that forces the upwelling of deeper, more oxygen and nutrient-rich waters up into the photic zone where primary productivity can occur. The Exmouth Plateau also receives detritus and other matter from the pelagic environment, which supports an important suite of demersal species. Enhanced productivity on the Exmouth Plateau is likely to support a number of marine species and be the site of distinct marine ecosystems.
Canyons on the slope, including the Cape Range Canyon	The canyons on the slope of this bioregion act as conduits for sediment transport and the channelling of deeper waters up onto the slope and towards the adjacent shelf. Biological productivity at the head of the Cape Range Canyon in particular is thought to support aggregations of whale sharks, sweetlip emperors and other species, and is thought to be a significant contributor to the biodiversity of the adjacent Ningaloo Reef. The soft-bottom habitat of the canyons is also likely to support important assemblages of epibenthic species.
Demersal fish communities associated with the slope	The upper and middle parts of the continental slope in this bioregion have important demersal fish communities, which display a high degree of endemism compared with other areas of slope in the Australian EEZ. In particular, the continental slope between North West Cape and the Montebello Trough supports, over 508 fish species of which 76 are endemic. The high numbers of species found here is believed to be associated with areas of enhanced biological productivity as a result of the interaction between seasonal currents and seafloor topography.

Red Squirrelfish (*Sargocentron rubrum*), sponges and sea fans on low outcropping and undercut reef in 100 m water depth off Ningaloo. Photo: CSIRO.

2.1.6 Central Western Shelf Transition

Figure 2.16 ***The Central Western Shelf Transition***



Covering an area of 9698 km², of which 7340 km² or 75.7 per cent is in Commonwealth waters, the Central Western Shelf Transition is located on the continental shelf between Carnarvon and the tip of North West Cape. Commonwealth waters in the bioregion constitute less than one per cent of the total area of the North-west Marine Region. The bioregion varies in width from 25 km in the south, to less than 1 km along the western edge of North West Cape. This bioregion includes both State and Commonwealth waters between depths of 0–80 m. Ningaloo Reef is a significant component of this bioregion, but also extends into the Northwest Province, the Central Western Transition Province and a small portion of the Northwest Shelf Province. For the purposes of the Bioregional Profile, the geomorphology and biological communities of Ningaloo Reef are discussed in this section.

Geomorphology – The Central Western Shelf Transition is located entirely on the continental shelf and is comprised mainly of sandy sediments. The close proximity of the coast to the shelf break is a significant feature of this bioregion and is an important factor in determining its biodiversity.

Ningaloo Reef is the most significant geomorphic feature in the bioregion. It extends south of North West Cape along the Cape Range Peninsula, and stretches for over 260 km. It is the only example in the world of an extensive fringing coral reef on the west coast of a continent. It is marked by a well-developed spur and groove system of fingers of coral formations penetrating into the ocean with coral sand channels in between. The spurs provide calmer regions for coral growth, whereas the grooves experience strong scouring surges and tidal run-off and have little coral growth. A lagoon on the inshore side separates the reef from the mainland. The lagoon averages 2–4 m in depth and ranges in width from 200 m to over 6 km. Seaward of the reef crest the reef drops gently to depths of 8–10 m. The waters reach 100 m depth 5–6 km beyond the reef edge.

Oceanography – The interaction of the Leeuwin Current, Leeuwin Undercurrent and the Ningaloo Current are the dominant oceanographic features of the Central Western Shelf Transition. The Leeuwin Current and Leeuwin Undercurrent are centred on the shelf break to the west of this bioregion, but it is likely that local eddies associated with interactions of these currents, as well as internal tides around the shelf break, result in the transport of these waters into the bioregion.

The narrowness of the shelf in this bioregion also ensures that there is close connectivity between deeper waters of the shelf break and the coastal waters of the bioregion. Between September and mid-April, inner-shelf waters are dominated by the northward-flowing Ningaloo Current, which flows inshore of the 50 m depth contour (Hanson *et al*. 2005). Further inshore, a wave, wind and tidally driven flow dominates, as strong localised currents around Ningaloo Reef are generated by the funnelling of the ebb tide through the spur and groove system of the reef. The interaction between these physical drivers results in the bioregion being an area of enhanced, although still sporadic, biological productivity. The Central Western Shelf Transition receives little freshwater run-off.

Biological communities – The Central Western Shelf Transition, along with the Central Western Transition and the southern areas of the Northwest Province, is located within a significant biogeographic transition between tropical and temperate species. The predominantly southward flowing surface currents bring tropical Indo–Pacific species into this bioregion, but the influence of the northward flowing Leeuwin Undercurrent also transports temperate species from more southern areas into the bioregion (Brewer *et al*. 2007). This is reflected in the benthic ecological communities of the bioregion, which include both tropical and temperate species transitioning along a north-south gradient.

A large proportion of this bioregion is covered by the Ningaloo Marine Park, which is one of the most significant hotspots of biodiversity within the North-west Marine Region (see Chapter 3 for more information on Ningaloo Marine Park (Commonwealth Waters)). The park encompasses both State and Commonwealth waters. Commonwealth waters of the park are deeper than 30 m, with those north of Point Cloates extending as deep as 70–100 m, and those further south 40–80 m. The Ningaloo Marine Park incorporates a diversity of habitats including: areas of open ocean in Commonwealth waters that support pelagic species such as tuna, billfish and whales; the seabed of the continental slope and shelf that supports demersal and benthic plants and animals including fish, molluscs, algae, sponges, soft corals and burrowing bivalves; as well as coral reefs and intertidal areas such as rocky shores and mangroves in State waters.

Some sponge species and filter-feeding communities found in deeper waters around the reef appear to be significantly different to those of the Dampier Archipelago and Abrolhos Islands, indicating that the Commonwealth waters of the park have some particular areas of potentially high and unique sponge biodiversity (Rees *et al*. 2004). Overall, the biological communities of the reef differ from the hard coral reefs located elsewhere in the North-west Marine Region because of the proximity of the reef to shallow waters along the coast, and are thought to provide unique habitat for a number of species.

Ningaloo Reef is an area of high biodiversity, with over 200 species of coral, more than 460 species of reef fish, as well as molluscs, crustaceans and other reef plants and animals (LeProvost, Dames and Moore 2000). Marine turtles, dugongs and dolphins frequently visit the lagoon and aggregations of large planktivores such as whale sharks and manta rays are found on the outer reef. Humpback whales are seasonal visitors to the reef, migrating along the outer reef edge. The olive seasnake is commonly observed on the outer reef and large predators such as the oceanic white-tip shark, tiger shark, blue shark and grey reef shark occur in deeper Commonwealth waters outside the reef.

Ningaloo Reef is recognised worldwide for its annual aggregations of whale sharks. It is estimated that 300–500 whale sharks visit Ningaloo every year (Meekan *et al*. 2006). Aggregations occur between March and June, coinciding with mass coral spawning events and seasonal localised increases in productivity. Studies have identified a complex relationship between whale shark numbers and inter-annual changes in the strength of the Leeuwin Current and coastal water temperatures (Wilson et al. 2001).

Ecosystem processes – The narrowness and shallowness of areas of the shelf and the interaction of slope and shelf edge processes results in the Central Western Shelf Transition being a relatively biologically productive environment compared to much of the Region. Because of the shallowness of the shelf, the chlorophyll maxima sit on the bottom of the seafloor to water depths of around 70 m. The benthic environment is therefore directly connected to the pelagic system through mixing and vertical migration of plankton, resulting in a diverse benthic environment of sponges, soft corals and associated demersal fish. Seagrass and algal beds in shallower areas of the bioregion also enhance benthic productivity.

Interactions between the Ningaloo Current and the Leeuwin Current result in upwellings of cold water in the adjacent Northwest Province and Central Western

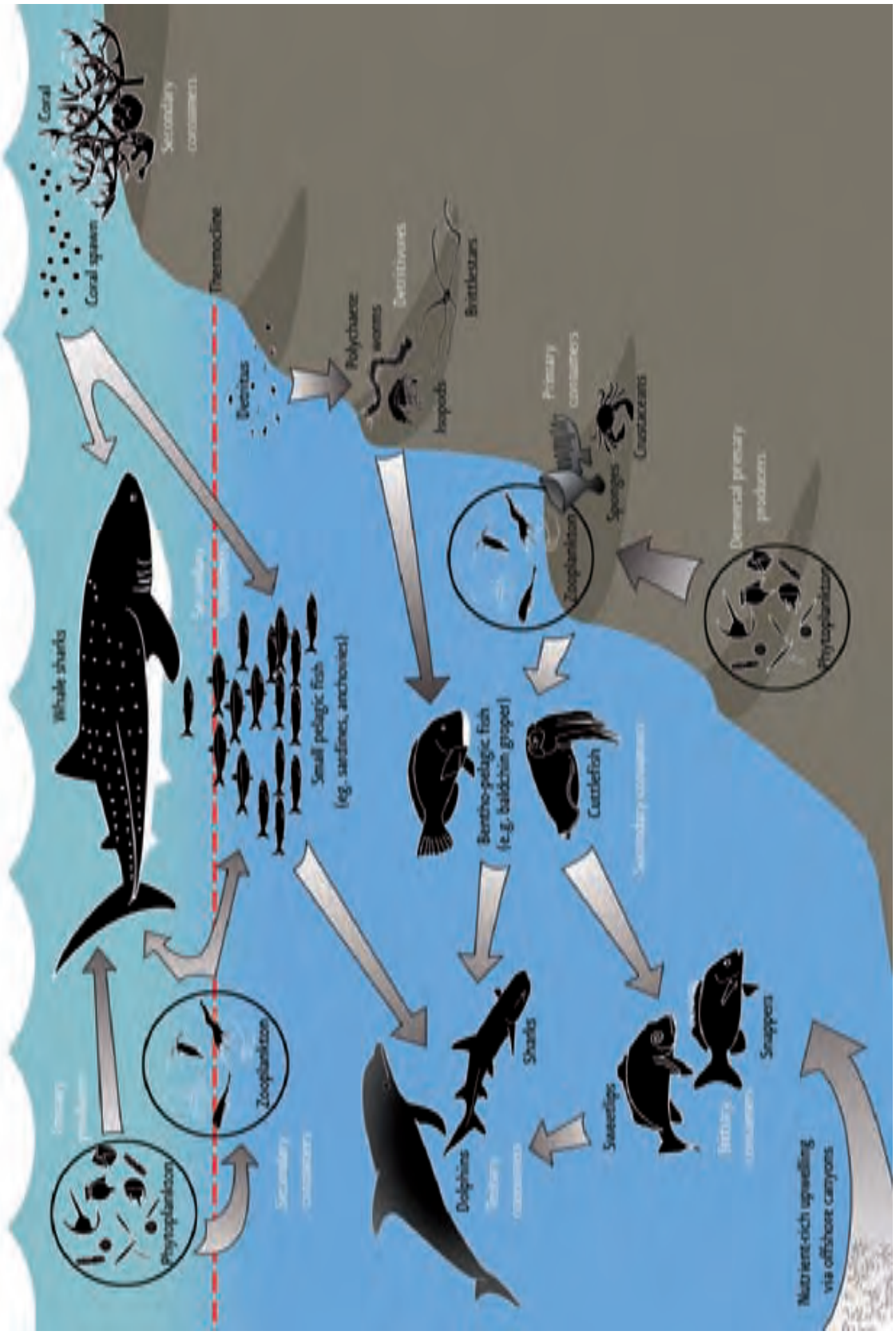


Figure 2.17 *Trophic structures of the Central Western Shelf Transition*

Transition from water depths of around 100 m. These upwellings are channelled onto Ningaloo Reef through canyons in the slope, such as the Cape Range Canyon (located in the Northwest Province) and Cloates Canyon (located in the Central Western Transition). The lack of coastal run-off, and the narrow nature of the shelf at North West Cape means that the Ningaloo Reef is almost entirely dependent on this offshore source of nutrients (Brewer *et al*. 2007). Circulation of currents throughout the reef is further enhanced through the spur and groove system, as these formations enhance the transport of nutrients around the reef.

Currents in the bioregion have a significant influence on coral larvae transport. It is thought that the Ningaloo Current is instrumental in the dispersal of coral larvae from Ningaloo Reef following annual autumn mass reef spawning events. The circulatory but northward flow of the current is believed to be responsible for retaining the 'stock' of coral spawn within the Ningaloo Reef system (Taylor & Pearce 1999) and little is thought to travel south. This retention of planktonic biomass within the Ningaloo Reef system is likely to be responsible for the extremely active food chains during coral spawning events, and the occurrence of seasonal aggregations of whale sharks (Taylor & Pearce 1999) (Figure 2.17). Other reef organisms, such as polychaete worms, spawn at the same time as coral and both events inject large amounts of protein into the waters of the bioregion, boosting the zooplankton food chain and further supporting aggregations of whale sharks and manta rays (Taylor & Pearce 1999). The maintenance of this nutrient stock is thought to be important for the survival of the reef itself.

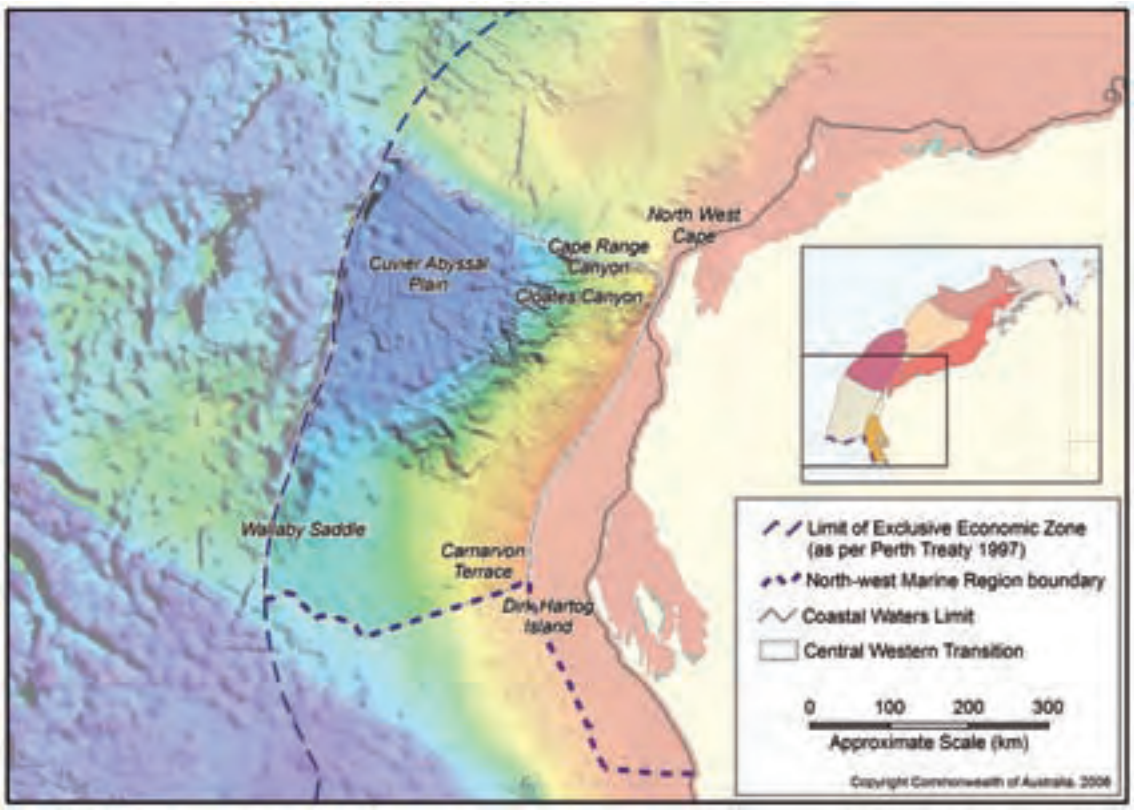
While the majority of the reef occurs in State waters of Ningaloo Marine Park, the Commonwealth waters of the park provide essential biological and ecological links that sustain the unique and diverse species of the reef, particularly by supplying nutrients to the reef communities from further offshore. Commonwealth waters are also important areas for the congregation and migration of species into and out of the nearshore zone.

Table 2.6 Features and areas of ecological importance in the Central Western Shelf Transition

Feature or area	Rationale
Ningaloo Marine Park–North West Cape	Ningaloo Reef is an important geomorphic feature, with enhanced biological productivity, high species biodiversity and feeding aggregations of marine life. It is unique globally as the only fringing coral reef located on the western side of a continental landmass. As it is located adjacent to an arid hinterland and receives very little if any terrestrial run-off, it is almost entirely reliant upon processes in the marine environment for nutrient inputs. Some of its important features include: • Site of predictable upwelling as a result of interactions between the Ningaloo Current and the Leeuwin Current as well as upwelling processes on the adjacent shelf break. • High species diversity and abundance of marine species including demersal fish, coral reef fish, crustaceans and dugongs as well as many other marine creatures of both tropical and temperate origin. • It is the only marine park and only place in the world that is a known aggregation site for whale sharks, which feed on seasonal concentrations of krill and zooplankton along the reef. • It lies in the annual migration path for humpback whales and is regularly visited by numerous migratory seabird species listed on China-Australia and Japan-Australia Migratory Bird Agreements (CAMBA and JAMBA).

2.1.7 Central Western Transition

Figure 2.18 The Central Western Transition



The Central Western Transition occurs entirely in Commonwealth waters off the shelf between Dirk Hartog Island and North West Cape. It has an area of 162 891 km² and represents 15 per cent of the North-west Marine Region. Its eastern boundary coincides with the shelf break and in the north comes within a few kilometres of the coast on the Cape Range Peninsula. About 40 per cent of the bioregion occurs in water depths greater than 4000 m and the deepest areas of the bioregion occur within the Cuvier Abyssal Plain at around 5330 m.

Geomorphology – The Central Western Transition is characterised by large areas of continental slope, with sediments dominated by muds and sands that decrease in grain size with increasing depth. The slope is incised by numerous topographic features such as terraces (i.e. the Carnarvon Terrace), canyons (i.e. Cloates Canyon and Carnarvon Canyon) and rises. A large part of the bioregion consists of the Cuvier Abyssal Plain. The Wallaby Saddle is another important feature of this bioregion and it is the most extensive area of this type of topographic feature in the North-west Marine Region (Baker *et al.* 2008). The southern boundary of the bioregion is shared with the adjacent South-west Marine Region and several geomorphic features such as the Carnarvon Terrace occur across both the North-west and South-west Marine Regions.

Oceanography – As in the Northwest Province, the Leeuwin Current follows the shelf break throughout this bioregion. The current is strongest during autumn and winter (April to September) and drives a meandering stream of warm, low nutrient surface waters south along the slope. It is underlain by the Leeuwin Undercurrent, which flows northwards towards the equator. Inshore, on the eastern boundary of the bioregion and the adjacent Central Western Shelf Transition and Central Western Shelf Province, interactions occur between a weakened Leeuwin Current and the northward-flowing Ningaloo Current, during summer. This interaction facilitates vertical mixing of water layers and is believed to be associated with sporadic bursts in biological productivity.

Seasonal and sporadic upwelling is also thought to occur in association with other topographic features in the bioregion. Localised upwelling associated with the Cape Range Canyon (shared with the Northwest Province) and Cloates Canyon may result in localised increases biological productivity around canyon heads. Productivity along the shelf break may be increased by

the action of internal waves. The Wallaby Saddle is also believed to be an area of upwelling, as it is shallower than deep ocean areas to its north and south, causing an upward movement of deeper, cooler waters. This upwelling is thought to support aggregations of small pelagic fish and associated predators.

The Central Western Transition is distinguished by a transition in water temperatures from tropical in the north to more temperate in the south. Water temperature also decreases quickly with increasing depth. The deeper waters are less subject to seasonal wind stress and therefore experience less vertical mixing than shallower waters.

Meso-scale eddies associated with the Leeuwin Current and Leeuwin Undercurrent are a feature of the adjoining South-west Marine Region and may extend into the Central Western Transition. The anti-clockwise eddies of the Leeuwin Current generally form during winter at predictable locations along the shelf break (Waite *et al*. 2007). They circulate in a south-westerly direction and are thought to be sites of enhanced mixing of Leeuwin Current waters with offshore waters from the Indian Ocean. Cyclonic eddies associated with the Leeuwin Undercurrent have also been observed in the South-west Marine Region and may detach from the current and migrate offshore at various locations (Rennie *et al*. 2007). It is not clear whether these eddies occur in the Central Western Transition.

Biological communities – The Central Western Transition, along with the Central Western Shelf Transition and the southern areas of the Northwest Province, is located within a biogeographic faunal transition between tropical and temperate species. The predominantly southward flowing surface currents bring tropical Indo-Pacific species into this bioregion, while the northward flowing Leeuwin Undercurrent transports temperate species from southern areas (Brewer *et al*. 2007). The benthic slope communities of this bioregion comprise both tropical and temperate species along a north-south gradient.

The biological communities of the Central Western Transition are thought to be distinctive owing to the proximity of deep ocean areas to the continental slope and shelf, resulting in close interaction between pelagic species of the Cuvier Abyssal Plain and those of the slope and shelf. Generally, the ecological communities of this bioregion have a closer resemblance to those in the South-west Marine Region, particularly in the south.

The present level of understanding of the marine environment in this bioregion is generally poor. The harder substrate of the slope in waters of 200–2000 m deep is likely to support populations of epibenthos such as bryozoans, sponges and encrusting coralline algae. These support larger infauna and benthic animals such as crabs, cephalopods, echinoderms and other suspension-feeding epibenthic organisms. In the deeper waters of the abyss, the benthic communities are likely to be sparse and include meiofauna (e.g. nematodes). The meiofauna in the abyss are capable of utilising bacterial detritus/particulate organic matter, which falls from the pelagic zone above.

The diversity of fish and cephalopod species changes with depth, generally decreasing in species numbers with increasing depth. The demersal slope fish bioregionalisation identifies some endemism in communities in this bioregion (Last *et al*. 2005). However, it is lower than other areas of the North-west Marine Region, despite the presence of a variety of slope habitats in this bioregion. Bentho-pelagic fish, such as deep water snappers, (e.g. *Paracaesio* spp, and *Eletis* spp.), hatchetfish (*Argyropelecus* spp.). Dragonfish (*Melacosteus* spp.), viperfish (*Chauliodus* spp.), and a number of squid and eel species migrate between the benthic and pelagic systems, forming an important link between these systems.

Juvenile and adult southern bluefin tuna travel through the Central Western Transition as they seasonally migrate to and from spawning grounds. Other transient fish species include broadbill swordfish (*Xiphius gladius*), bigeye tuna (*Thunnus obesus*), yellowfin tuna (*Thunnus albacares*) and striped marlin (*Tetrapturus audax*). Local pelagic predators, such as sharks and dolphins, also range across the bioregion following schools of pelagic fish. The larger pelagic species occur in higher densities in water depths of 200–2000 m. Other migratory species in this bioregion include whales, migrating northwards outside of the 200 m contour. The Wallaby Saddle in particular is thought to be an important feeding site for sperm whales.

Ecosystem processes – The oligotrophic waters of the Leeuwin Current result in generally low biological productivity throughout the Central Western Transition. Productivity bursts within this bioregion, as elsewhere in the North-west Marine Region, are spatially and temporally variable. These are associated with mixing processes occurring around topographic features such as the shelf break, the Wallaby Saddle and in canyon heads.

Upwelling in canyon heads and on the shelf break supports enhanced local and downstream productivity, resulting in concentrations of primary and secondary consumers. Primary consumers, such as micro and macrozooplankton (e.g. amphipods, copepods, mysids, cumaceans and euphausiids), attract aggregations of manta rays and whale sharks to waters off Ningaloo Reef in this bioregion and the adjoining Central Western Shelf Transition and Northwest Province. The sporadic productivity bursts (described in Section 2.1.6) are believed to be very important for Ningaloo Reef, providing the majority of nutrients to the Reef in an otherwise oligotrophic environment that receives limited terrestrial input. Biophysical processes therefore occurring in Commonwealth waters have an important role in maintaining the ecology of the Ningaloo Reef.

Meso-scale eddies associated with the Leeuwin Current and Leeuwin Undercurrent have not been recorded in the Central Western Transition but are a feature of the adjoining South-west Marine Region. These eddies may be important for transport of nutrients and plankton communities in the North-west Marine Region as well. Generally, they assist in the offshore movement of shelf planktonic communities, but are also thought to play an important role in vertical mixing of the water column. The interaction between surface and deeper eddies may trigger bursts of primary productivity when deeper, more nutrient-rich waters are mixed with warmer waters and are transported into the photic zone, where light stimulates the production of plankton.

Between the shelf and water depths of 2000 m, trophic systems are predominantly pelagically driven, as described above. In the pelagic environment, primary productivity is consumed by vertically migrating zooplankton (such as crustaceans, larval molluscs and larval fish) and other primary consumers, such as jellyfish and salps. These are preyed upon by schooling fish and cephalopods. Tertiary consumers include transient billfish and tuna and other pelagic predators such as sharks that either migrate seasonally or range through the system following schools of pelagic fish. Large migratory species found in this bioregion include toothed whales and dolphins, which prey on cephalopods, fish and crustaceans.

Demersal fish communities on much of the slope may be primarily reliant upon detrital rain for nutrients, although links between the benthic and pelagic trophic systems may be provided by caridean shrimps, small fish and other species migrating between the two systems.

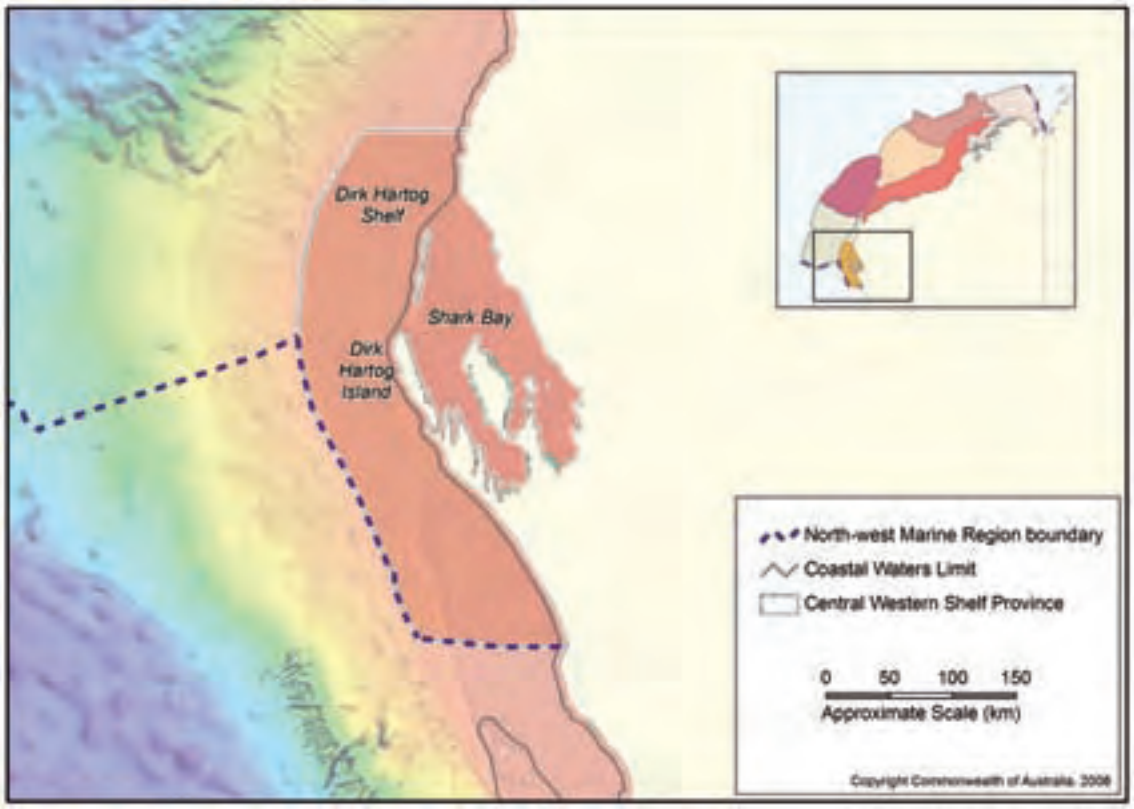
The deeper waters of the bioregion, particularly over the Cuvier Abyssal Plain, probably have distinct pelagic and benthic trophic systems. The benthic system is based upon bacterial-detrital food webs. Detrital input from subsurface phytoplankton and particulate organic matter is thought to be consumed by scavengers, such as molluscs and large isopods as well as detritus feeders and filter-feeders.

Table 2.7 Features and areas of ecological importance in the Central Western Transition

Feature or area	Rationale
Wallaby Saddle	The Wallaby Saddle is an important seafloor feature, as it is associated with enhanced biological productivity, in an area of generally low productivity. The saddle is shallower than adjoining abyss areas to the north and south and is the site of upwellings of deeper, more nutrient-rich waters. Aggregations of sperm whales are thought to occur on the Wallaby Saddle and it is believed that they feed on aggregations of small pelagic fish. These aggregations are a reflection of the relatively high biological productivity of the area. The saddle itself is also an important geomorphic feature as it represents almost the entire area of this feature type in the North-west Marine Region.
Cape Range Canyon and Cloates Canyon	The canyons on the continental slope around the Exmouth Plateau and Ningaloo Reef are important ecological features as they are the site of predictable upwellings. The canyons channel cooler, more nutrient-rich waters up on to Ningaloo Reef, and are believed to be essential in maintaining the biological productivity and ecology of the Reef. The upwelling zones are sites of marine species aggregations, and fish such as sweetlip emperor are known to associate with the top of canyons. The soft-bottom habitat of the canyons is also likely to support an important assemblage of epibenthic species.

2.1.8 Central Western Shelf Province

Figure 2.19 The Central Western Shelf Province



The Central Western Shelf Province encompasses both State and Commonwealth waters and occurs on the shelf between Kalbarri and Coral Bay, covering an area of 50 516 km² (32 996 km² or 65.5 per cent of which is in Commonwealth waters). Commonwealth waters of the bioregion constitute three per cent of the North-west Marine Region and the bioregion itself varies in depth from 0–100m. The southern and south-western boundaries of the bioregion abut the South-west Marine Region with which it shares physical drivers and species.

Geomorphology – This bioregion is located on the Dirk Hartog Shelf and is generally very flat. It varies in width from less than 20 km in the north to around 125 km in the vicinity of Shark Bay. A small area of reef and tidal sandwaves or sandbanks occur at the entrance to Shark Bay and within its vicinity. Other topographic features of the bioregion include a deep hole and associated area of banks and shoals offshore of Kalbarri. The banks and shoals in this bioregion are of note because they occur at latitudes significantly south of banks and shoals elsewhere in the North-west Marine Region (Baker *et al*. 2008).

As with other coastal bioregions, sand is the dominant component of the sediments of the Central Western Shelf Province, with small amounts of gravel and muds (Baker *et al*. 2008). The substrate within Shark Bay itself is predominantly sandy, with a small area of temperate reef at the opening of the bay.

Oceanography – Most of the bioregion lies between water depths of 50–100 m and there is little freshwater run-off or any other coastal influence on the shelf. The main currents include the southward flowing Leeuwin Current centred on the shelf break, the shelf based Ningaloo Current, which originates around Shark Bay and flows northwards, and the northern extension of the wind-driven Capes Current, which flows north during summer on the inner shelf in the southern parts of the bioregion.

Within the coastal waters of Shark Bay, adjacent to the Region, tidally driven circulation around the inner bay is restricted by a complex series of sills and channels as well as the bay's division into two gulfs. There is also little freshwater input into the bay. As a result of these factors and high evaporation rates, waters within Shark Bay are hypersaline. The flow of the Leeuwin Current along the slope intrudes into Shark Bay during winter, specifically through the Naturaliste Channel, restricting the outflow of waters from the bay. During summer,

some seepage of hypersaline water out of Shark Bay and into adjacent Commonwealth waters has been observed. These waters flow southward along the shelf, strengthened by regional winds. The resulting current is known as the Shark Bay Outflow.

Because of the shallowness of the Central Western Shelf Province, the Leeuwin Current and Shark Bay Outflow are likely to dominate the water column, but some cooler waters from the northward flowing Leeuwin Undercurrent may seep across the shelf into this bioregion and the north flowing Capes Current influences the southern portion of the bioregion during summer (Woo *et al*. 2006).

As discussed in relation to the Central Western Shelf Transition, the occurrence of meso-scale eddies associated with the Leeuwin Current and Leeuwin Undercurrent in the North-west Marine Region requires further investigation. They are a feature of the shelf break and areas further offshore and are known to occur in the offshore waters south of Shark Bay in the adjacent South-west Marine Region. It is unclear whether their influence extends into the Central Western Shelf Province.

Biological communities – The biological communities of this bioregion share many similarities with the adjoining South-west Marine Region. The Central Western Shelf Province is a transitional zone between the predominantly tropical flora and fauna of the north and temperate flora and fauna further south. For example, brown algae (*Ecklonia* spp.) is the dominant flora of the temperate reef flats of this bioregion replacing *Sargassum* spp., which is more dominant further north (DEWHA 2008). Similarly, the fish communities predominantly comprise temperate species with very little distinction between coastal and shelf communities. The western rock lobster (*Panulirus cygnus*) occurs in low densities and plays an important role as a consumer in coastal ecosystems.

Biological communities of the shelf are likely to include a sparse invertebrate assemblage of sea cucumbers, urchins, crabs and polychaetes on sandier substrates. Harder substrate areas are likely to contain sessile invertebrates such as sponges, gorgonians and more diverse fish than sandy habitats. Coastal fish species include jewfish and periodic/seasonal swarms of hardyheads that are food for a wide variety of species, including larger fish and whales (DEWHA 2008).

Bentho-pelagic fish, such as sweetlip emperor, are likely to occur around the shelf edge. Cliffs along the coast of the bioregion are thought to provide submarine feeding habitat for green turtles. A number of migratory marine species, such as dolphins, whales and dugongs, are thought to occur in Commonwealth waters as they travel between feeding and breeding grounds to the north and south.

The biological communities within Shark Bay have been studied extensively and the Bay is a declared World Heritage Area. The bay includes a diversity of habitats including areas of seagrass, sandy plains and rocky shoreline, in both high and low energy zones. Shallow fringing coral reefs occur on the eastern side of many of the bay's islands. There are also extensive sponge gardens and communities of bivalves and other mollusc

Dugongs at Shark Bay. Photo: Paul Anderson, Department of Environment and Conservation, WA.

species that are associated with finer sediments and mobile shifting banks.

Shark Bay is also a globally important site for dugongs, supporting up to 10 000 individuals. Shark Bay also supports the largest breeding population of loggerhead turtles in Australia, and the third largest in the world. The bay also supports a substantial population of bottlenose dolphins, and significant numbers of whales (primarily humpbacks) and manta rays occur in northern and western Shark Bay in winter (Preen *et al*. 1997). Higher order predators, such as tiger sharks, also occur within the shallow seagrass ecosystems of Shark Bay, feeding on sea snakes, dugongs, marine turtles and smaller shark species. Shark Bay and the adjacent shelf are also important areas for shallow water snapper (*Pagrus auratus*), which comprise three distinct breeding populations in the area, one in each inner gulf of Shark Bay and a third in the adjacent oceanic waters (Moran *et al*. 2003).

Ecosystem processes – The shallow waters of this bioregion are generally low in nutrients (nitrogen and phosphorus). Beds of macro-algae and seagrass within Shark Bay and along the bioregion's coastline provide a major source of benthic production in coastal waters, and support a benthic invertebrate fauna of high diversity and abundance. The invertebrate communities of Shark Bay have not been extensively studied but include sea cucumbers, urchins, crabs and polychaetes. Shark Bay is an area of high primary pelagic productivity. The limited flushing of the waters of Shark Bay means that nutrients remain in the bay's system, enabling the waters to support varied and abundant marine populations (Burling 1998). Harder substrate areas contain sessile invertebrates such as sponges, gorgonians and a more diverse fish fauna than sandier habitats.

Further mixing of waters offshore around the shelf break may result in increased nutrients in the photic zone, which could be transported throughout the bioregion via surface currents and tides. In these areas, the pelagic trophic system is thought to include micro and macro-zooplankton (e.g. amphipods, copepods), which are preyed upon by pelagic fish and planktivores, such as manta rays and whale sharks offshore. This bioregion generally demonstrates strong connectivity between biophysical and ecological processes occurring in State and Commonwealth waters.

Table 2.8 Features and areas of ecological importance in the Central Western Shelf Province

Feature or area	Rationale
Shark Bay–Dirk Hartog Island and surrounding waters	Shark Bay and the surrounding Commonwealth waters contain a number of habitats that support an important array of species: • Shark Bay is an important resting area for migrating humpback whales, particularly for females and calves on southern migration. Humpbacks particularly use the northern half of the bay. There are also resident populations of bottlenose dolphins. • Shark Bay has also been identified as critical feeding habitat for loggerhead and green turtles. It supports the largest breeding population of loggerhead turtles in Australia, and the third largest in the world. Dirk Hartog Island has been identified as critical nesting and internesting habitat for loggerhead turtles. Marine turtles are thought to be common in adjacent Commonwealth waters. • Wedge-tailed shearwaters, bridled terns, Caspian terns, crested terns and roseate terns breed in this area, and adjacent Commonwealth waters are likely to provide food for these species. • The dugong population in Shark Bay is thought to be one of the largest in the world and is estimated at approximately 10 000 individuals.

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Legislation

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Map data

Figure 2.2 Geomorphic/seafloor features of the North-west Marine Region

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Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Projection: Geographics, Datum: GDA94

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Figure 2.3 Surface currents in the North-west Marine Region

Australian Bureau of Statistics (1991): Australia, Populated Places

CSIRO (2001): Managing Australia's Ocean Domains, Fact sheet no.46, CSIRO, Hobart

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2004): Gazetteer of Australia

Projection: Geographics, Datum: GDA94

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Figure 2.4 Subsurface currents in the North-West Marine Region

Australian Bureau of Statistics (1991): Australia, Populated Places

CSIRO (2001): Managing Australia's Ocean Domains, Fact sheet no.46, CSIRO, Hobart

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2004): Gazetteer of Australia

Projection: Geographics, Datum: GDA94

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Figure 2.6 Provincial bioregions of the North-west Marine Region (IMCRA v.4.0)

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

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Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

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Figure 2.7 The Northwest Shelf Transition

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

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Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Projection: Geographics, Datum: GDA94

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Figure 2.8 The Timor Province

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

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Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Projection: Geographics, Datum: GDA94

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Figure 2.11 The Northwest Shelf Province

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

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Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Projection: Geographics, Datum: GDA94

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Figure 2.14 The Northwest Transition

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

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Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Projection: Geographics, Datum: GDA94

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Figure 2.15 The Northwest Province

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

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Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Projection: Geographics, Datum: GDA94

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Figure 2.16 The Central Western Shelf Transition

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2004): Gazetteer of Australia

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Projection: Geographics, Datum: GDA94

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Figure 2.18 The Central Western Transition

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2004): Gazetteer of Australia

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Projection: Geographics, Datum: GDA94

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Figure 2.19 The Central Western Shelf Province

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

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Projection: Geographics, Datum: GDA94

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Masked boobies. Photo: Nadeena Beck, Department of the Environment, Water, Heritage and the Arts.

Chapter 3 Conservation Values of the North-west Marine Region

Marine Bioregional Plans will identify those components of marine biodiversity and heritage that are recognised as **conservation values** by the Australian Government. Knowing what the conservation values are for each Marine Region will help in making decisions about proposed developments and other ongoing activities.

For the purpose of marine bioregional planning, conservation values are defined as those elements of the Region that are either specifically **protected** under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or the *Historic Shipwrecks Act 1976*, or have been identified through the planning process as **key ecological features** in the Commonwealth marine environment. Key ecological features are not specifically protected under the EPBC Act, although the Commonwealth marine environment as a whole is a matter of national environmental significance under the EPBC Act. Key ecological features are being identified as conservation values within Commonwealth waters to help inform decisions affecting the marine environment in each Marine Region.

Matters specifically protected under Parts 13 and 15 of the EPBC Act are recognised conservation values. In the North-west Marine Region, these include listed threatened, migratory and marine species, cetaceans (whales, dolphins and porpoises), Commonwealth marine reserves, Ramsar sites and places listed on the Commonwealth Heritage List. Historic shipwrecks are also identified as conservation values by virtue of their protection under the *Historic Shipwrecks Act 1976*.

The marine conservation values identified in this chapter will be the subject of assessment during the development of the North-west Marine Bioregional Plan to:

- understand the threats posed by current and emerging activities;
- determine priorities for mitigating these threats; and
- provide guidance for future decisions under the EPBC Act on potential significant impacts on listed threatened and listed migratory species or the Commonwealth marine environment of the North-west Marine Region (see section 3.1 for definition).

The nature and location of conservation values will also be considered in the establishment of Marine Protected Areas (MPAs) as part of the National Representative System of MPAs (see Chapter 4). However, conservation values will not automatically be included in Commonwealth marine reserves. In accordance with the Regional Specifications (Section 4.2), only those marine conservation values for which spatial protection is both desirable and appropriate will be considered in developing the MPA network for the Region.

More information on the marine bioregional planning process in the North-west Marine Region can be found in Chapter 6.

Manta ray feeding at Scott Reef. Photo: Australian Institute of Marine Science.

3.1 Key ecological features of the marine environment

Under the EPBC Act, the 'marine environment' under Commonwealth jurisdiction is a **matter of national environmental significance** (see Section 23 of the Act). This means that any action that will have or is likely to have a significant impact on the Commonwealth marine environment must be referred to the Minister for the Environment, Heritage and the Arts for assessment and approval. National guidelines have been developed to help in determining whether actions are likely to have a significant impact and can be found at <www.environment.gov.au/epbc/guidelines-policies.html>.

The North-west Marine Bioregional Plan will identify and describe key ecological features of the North-west Marine Region's marine environment. Once the Plan is finalised, these key ecological features will be considered in making decisions about whether an action is likely to have a significant impact on the Commonwealth marine environment.

For the purpose of marine bioregional planning, key ecological features of the marine environment meet one or more of the following criteria:

- a species, group of species or a community with a regionally important ecological role (e.g. a predator, or a prey species that interacts significantly with a large biomass or number of other marine species);
- a species, group of species or a community that is nationally or regionally important for biodiversity;
- an area or habitat that is nationally or regionally important for:

  a) enhanced or high biological productivity (such as predictable upwellings),

  b) aggregations of marine life (such as feeding, resting, breeding or nursery areas), or

  c) biodiversity and/or endemism; or
- a unique seafloor feature with known or presumed ecological properties of regional significance.

Key ecological features in the North-west Marine Region have been identified by the Australian Government Department of the Environment, Water, Heritage and the Arts on the basis of advice from scientists about the ecological processes and characteristics of the Region. A scientific workshop was conducted in September 2007, bringing together marine scientists with specific experience and expertise in the Region. The workshop explored what is currently known about the ecosystems of the North-west Marine Region, and the scientific understanding of likely interactions and ecosystem processes. The outcomes of the workshop are available at <www.environment.gov.au/coasts/mbp/north-west>.

Chapter 2 identified features and areas of ecological importance in both State and Commonwealth waters within each provincial bioregion. The marine bioregional planning process focuses on matters within Commonwealth waters. Therefore, key ecological features have only been identified within Commonwealth waters of the North-west Marine Region.

Table 3.1 identifies the key ecological features of the North-west Marine Region recognised during the development of this Bioregional Profile, and summarises the rationale used to identify a specific feature as a conservation value in the Region (Chapter 2 provides further context for understanding the role of different features in the ecosystem). The collection of further and finer-scale information during the next stage of the planning process will improve our understanding of key ecological features in the Region. This information will also be used to confirm and refine the key ecological features identified during the profiling stage of the process and will underpin the analysis of threats facing the marine environment over the next 10–20 years. The North-west Marine Bioregional Plan will include a refined list of key ecological features.

Fourteen key ecological features have been identified so far within the North-west Marine Region. These include unique geomorphic (seafloor) or topographic features, as well as areas or habitats that are considered to be regionally important (Table 3.1). Figure 3.1 identifies the location of the key ecological features.

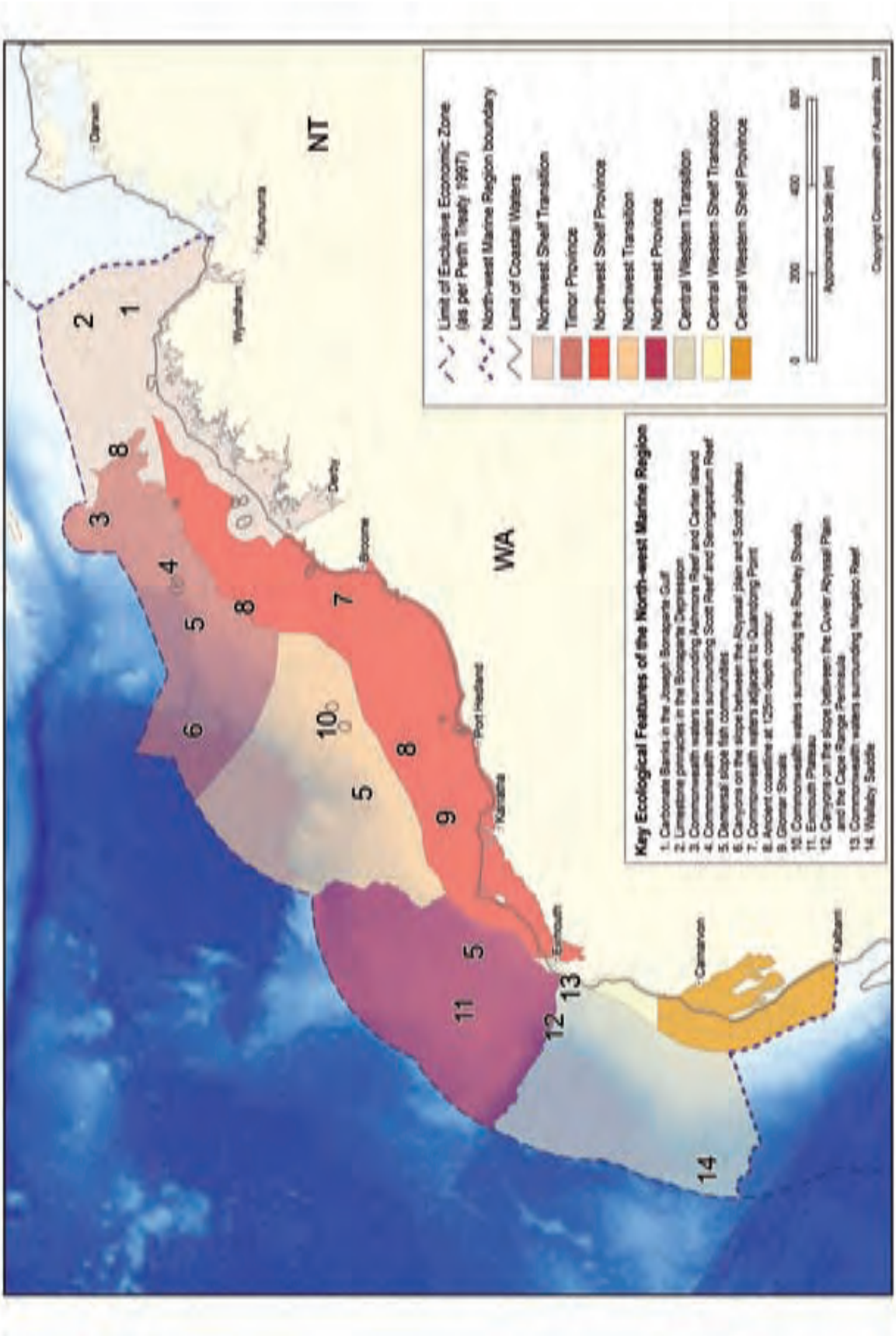


Figure 3.1 Key ecological features of the North-west Marine Region

Table 3.1 Key ecological features of the North-west Marine Region

Key ecological features	Provincial bioregions IMCRA v.4.0	Rationale
1. Carbonate banks in the Joseph Bonaparte Gulf	Northwest Shelf Transition	**Unique seafloor feature** The carbonate banks within the Joseph Bonaparte Gulf consist of a hard substrate with flat tops and steep sides that rise from water depths of 150–300 m. They rise to between 50-100 m of the surface. Each bank occupies an area generally less than 10 km² and is separated from the next bank by narrow channels. They are regionally significant as over 90 per cent of the carbonate banks in the North-west Marine Region are located within this bioregion, and overall the Region contains more than 70 per cent of the carbonate banks in the entire Australian Exclusive Economic Zone (EEZ). Scientists believe that the banks are either drowned carbonate platforms or have formed in association with seafloor hydrocarbon seeps, and the hard carbonate substrate is ideal for reef-building organisms. The carbonate banks are thought to be sites of enhanced biological productivity and support filter-feeding coral communities utilising suspended nutrients. The banks and channels are likely to support a high diversity of animals including reef fish, sponges, soft and stony corals, gorgonians, bryozoans, ascidians and other sessile filter feeders. The banks and channels are known to be important foraging areas for loggerhead turtles and the north-west Kimberley breeding population of flatback turtles. Olive ridley and green turtles are also likely to occur in the area.
2. Limestone pinnacles in the Bonaparte Depression	Northwest Shelf Transition	**Unique seafloor feature** The limestone pinnacles of the Bonaparte Depression are believed to be the remnants of calcareous shelf and coastal deposits which have eroded to their current elevations. They can be up to 50 m high and 50–100 km long and are an important seafloor feature because of their prevalence in this area. The pinnacles in the Bonaparte Depression represent 60 per cent of the limestone pinnacles in the entire North-west Marine Region, and 9 per cent of the limestone pinnacles in the entire Australian EEZ. The pinnacles are believed to be associated with enhanced local biological productivity, because the movement of water around these features is likely to facilitate the mixing of nutrients and sediments in the photic zone. Associated communities are thought to include sessile benthic invertebrates including hard and soft corals and sponges, and aggregations of demersal fish species such as snappers, emperors and groupers. The pinnacles are also thought to be important feeding sites for green, loggerhead, olive ridley and flatback turtles.
3. Commonwealth waters surrounding Ashmore Reef and Cartier Island	Timor Province	**Enhanced biological productivity; feeding and breeding aggregations; high biodiversity** Ashmore Reef and Cartier Island are Commonwealth marine reserves and have been relatively well-studied. They are regarded as biodiversity hotspots as they support a diverse array of pelagic and benthic marine species. The waters surrounding Ashmore and Cartier are areas of enhanced localised biological productivity in relatively unproductive waters. Localised upwelling and turbulent mixing around the reef systems provide nutrients to the system. The reefs provide varied habitat that attracts a diverse range of primary and secondary consumers, including a particularly diverse fish fauna. Toothed whales and dolphins are also found around these reefs. Large areas of seagrass in waters surrounding Ashmore Reef are important for a genetically distinct dugong population. Both Ashmore and Cartier reefs support an unusually high diversity and density of sea snakes, for which these reefs are internationally significant. They are also important staging points for migratory wetland birds and the site of some of the most important seabird colonies in the North-west Marine Region.

Key ecological features	Provincial bioregions IMCRA v.4.0	Rationale
4. Commonwealth waters surrounding Scott and Seringapatam reefs	Timor Province	**Enhanced biological productivity; feeding and breeding aggregations; high biodiversity** Scott and Seringapatam reefs are coral-dominated reefs which have been relatively well-studied and are regarded as biodiversity hotspots that support diverse pelagic and benthic marine species. The waters surrounding the reefs are areas of enhanced localised biological productivity in relatively unproductive waters due in part to the action of internal waves generated by internal tides. The reefs are regionally significant for their affinities with both the fauna of the Indo-Pacific region and Indonesia. The reefs support many species of fish, molluscs and echinoderms, some of which are not found elsewhere in Western Australia. The reefs and surrounding waters support a high diversity of fish species including small pelagic and tropical reef species, groupers, emperors, dolphinfish, marlin and sailfish. Sperm, blue and small toothed cetaceans are thought to visit the area. Scott Reef supports a small but genetically distinct breeding population of green turtles and both reefs are important for sea snakes and seabirds. Despite their proximity to each other, Scott and Seringapatam reefs have distinctly different sponge fauna.
5. Demersal slope fish communities	Timor Province, Northwest Transition, Northwest Province	**Communities with high species biodiversity and endemism** Demersal slope fish assemblages in the Timor Province, the Northwest Transition and the Northwest Province are characterised by high endemism and species diversity. The level of endemism of demersal fish species in these bioregions is high compared to anywhere else along the Australian continental slope. The Northwest Province, specifically the continental slope between North West Cape and the Montebello Trough, has more than 500 fish species, 76 of which are endemic, making it the most diverse slope bioregion in Australia. The slope of the Timor Province and the Northwest Transition also contains more than 500 species of demersal fish, of which 64 are considered to be endemic, and is the second richest area for demersal fish species across the entire Australian continental slope. The demersal fish species occupy two distinct demersal community types (biomes) associated with the upper slope (water depths of 225–500 m) and the mid-slope (water depths of 750–1000 m).
6. Canyons on the slope between the Argo Abyssal Plain and Scott Plateau	Timor Province	**Enhanced biological productivity; feeding aggregations; unique seafloor feature** The canyons on the slope between the Argo Abyssal Plain and Scott Plateau and the north of Scott Reef are believed to be up to 50 million years old and are associated with small periodic upwellings that locally enhance biological productivity. Deep ocean currents upwelling in the canyon create a nutrient rich, cold water habitat attracting fish aggregations that in turn attract large predatory fish, sharks and toothed whales and dolphins. Whaling records from the 19th century indicate that aggregations of sperm whales occurred on the Scott Plateau. There is also anecdotal evidence that the Scott Plateau may be a breeding ground for sperm whales and beaked whales.
7. Commonwealth waters adjacent to Quondong Point	Northwest Shelf Province	**Enhanced biological productivity; feeding aggregations** Waters surrounding Quondong Point are an area of enhanced localised biological productivity attracting large feeding aggregations of birds and baitfish. Aggregations of humpback whales, other cetaceans, marine turtles and dugongs are also regularly reported here and the area may provide important habitat for sawfish, although this is yet to be confirmed. The physical and biological processes that result in enhanced biological productivity in this area are not well understood but may be associated with a unique combination of bathymetry and oceanography.

Key ecological features	Provincial bioregions IMCRA v.4.0	Rationale
8. Ancient coastline at 125 m depth contour	Northwest Shelf Province, Northwest Shelf Transition	**Unique seafloor feature** The shelf of the North-west Marine Region contains several terraces and steps which reflect the gradual increase in sea level across the shelf that occurred during the Holocene. The most prominent of these occurs episodically as an escarpment through the Northwest Shelf Province and Northwest Shelf Transition, at a depth of approximately 125 m. It has been suggested that humpback whales, whale sharks and other migratory pelagic species may use this escarpment as a guide as they move through the Region. The topographic variation of the ancient coastline may also facilitate small localised upwellings as a result of internal tide activity or regional mixing associated with seasonal changes in currents and winds. These areas of enhanced biological productivity could attract baitfish which may provide food for migrating species.
9. Glomar Shoals	Northwest Shelf Province	**Unique seafloor feature; high biodiversity** The Glomar Shoals are a unique seafloor feature of highly fractured molluscan debris, coralline rubble and coarse carbonate sand that occurs approximately 30–40 km offshore of Dampier in Commonwealth waters, between depths of 26–70 m. Anecdotal evidence indicates that this area has localised increased biological productivity which attracts fish such as Rankin cod, brownstripe snapper, red emperor, crimson snapper and frypan bream, all of which are caught in large numbers by commercial fisheries in this area.
10. Commonwealth waters surrounding the Rowley Shoals	Northwest Transition	**Enhanced biological productivity; feeding and breeding aggregations; high biodiversity** The Rowley Shoals are a collection of three atoll reefs: Clerke, Imperieuse and Mermaid, which are thought to be sites of enhanced biological productivity due to the action of the breaking of internal waves generated by internal tides. Breaking internal waves cause mixing and the resuspension of nutrients up into the photic zone, which triggers enhanced primary productivity. The productive waters are circulated throughout the reef system and are readily available to primary consumers. Mermaid Reef is the only reef of the Rowley Shoals which occurs entirely in Commonwealth waters, and is a Commonwealth marine reserve. Clerke and Imperieuse reefs occur in State waters, and form the Rowley Shoals Marine Park. The reefs have been relatively well studied and are noted for their high species diversity. Biodiversity surveys of the reefs have identified 184 species of corals, 264 species of molluscs, 82 species of echinoderms and 389 species of finfish. Unique sponge faunal assemblages are associated with each of the reefs. Because of the predominantly southward flow of currents past the Rowley Shoals and beyond, the Rowley Shoals are also thought to provide a source of invertebrate and fish recruits for reefs further south. Steep changes in slope around the reefs attract a range of migratory pelagic species such as dolphins, tuna, billfish and sharks. Surveys around Mermaid Reef have confirmed that there is a high diversity of sharks around the Rowley Shoals, including grey reef and silvertip whaler sharks. Sharks are found in considerable numbers on the Rowley Shoals, compared with their low abundance on Scott and Ashmore reefs, which have been adversely affected by overfishing in the MoU Box.
11. Exmouth Plateau	Northwest Province	**Unique seafloor feature** The Exmouth Plateau covers an area of approximately 50 000 km^2 and consists of a generally rough and undulating surface at water depths of approximately 500 m to more than 5000 m. The plateau is thought to be dotted with numerous pinnacles. It is an important geomorphic feature that modifies the flow of deep waters, and has been identified as a site where internal waves are generated by internal tides. The plateau also receives settling detritus and other matter from the pelagic environment.

Key ecological features	Provincial bioregions IMCRA v.4.0	Rationale
12. Canyons on the slope between the Cuvier Abyssal Plain and the Cape Range Peninsula	Northwest Province, Central Western Transition	**Enhanced productivity; aggregations of marine life; unique seafloor feature** The canyons on the slope between the Cuvier Abyssal Plain and the Cape Range Peninsula include the Cape Range Canyon and the Cloates Canyon. They are believed to be associated with upwelling as they channel deep water from the Argo Abyssal Plain up onto the slope, where it mixes with the overlying water layers at the canyon heads. The upwelling zones at the canyon heads are sites of species aggregations such as sweetlip emperor fish. The soft bottom habitats within the canyons themselves are likely to support important assemblages of epibenthic species. Biological productivity at the head of Cape Range Canyon in particular is known to support species aggregations, including whale sharks. The canyons are thought to be significant contributors to the biodiversity of the adjacent Ningaloo Reef, as they channel deep water nutrients up to the reef, stimulating primary productivity.
13. Commonwealth waters surrounding Ningaloo Reef	Northwest Province, Central Western Transition, Central Western Shelf Transition, Northwest Shelf Province	**Unique seafloor feature; high biodiversity; aggregations of marine life** Ningaloo Reef is globally significant as the only extensive coral reef in the world that fringes the west coast of a continent. Ningaloo Reef extends for over 260 km along the Cape Range Peninsula. The Commonwealth waters around Ningaloo Reef are a Commonwealth marine reserve. As the reef is located next to an arid hinterland and receives very little terrestrial run-off, it is almost entirely dependent on processes in the marine environment for nutrient input and maintenance of its ecology. The waters of the reef are a site of enhanced biological productivity, due to upwelling associated with the adjacent canyons on the slope and interactions between the Ningaloo Current and the Leeuwin Current. The reef is known to support an extremely abundant array of marine species including over 200 species of coral and more than 460 species of reef fish, as well as molluscs, crustaceans and other reef plants and animals. Marine turtles, dugongs and dolphins frequently visit the reef lagoon. The Commonwealth waters around Ningaloo include areas of potentially high and unique sponge biodiversity. Upwellings on the seaward side support aggregations such as whale sharks and manta rays (these waters are the main known aggregation area for whale sharks in Australian waters). Humpback whales are seasonal visitors to the outer reef edge and seasnakes, sharks, large predatory fish and seabirds also utilise the reef and surrounding waters.
14. Wallaby Saddle	Central Western Transition	**Unique seafloor feature; aggregations of marine life** The Wallaby Saddle occurs on the slope within this bioregion, towards the edge of Australia's EEZ. It represents almost the entire area of this type of geomorphic feature in the North-west Marine Region. It is shallower than adjoining abyssal areas to the north and south and is believed to be associated with upwelling as deeper more nutrient-rich waters are pushed up onto the saddle. Aggregations of sperm whales are known to occur on the Wallaby Saddle and it is believed that they feed on aggregations of baitfish that are attracted to the productive waters.

3.2 Nationally protected species

Species listed under the EPBC Act are commonly referred to as 'protected species' because it is an offence to kill, injure, take, trade, keep or move a listed species without authorisation. Under the EPBC Act, species can be listed as threatened, migratory, or marine. Cetaceans are also protected under the Act through the establishment of the Australian Whale Sanctuary. Further information on the EPBC Act is provided in Appendix B. Nationally protected species include:

- **Threatened species** – those species that have been identified as being in danger of becoming extinct;
- **Listed migratory species** – those species that are listed under:
    - *the Convention on the Conservation of Migratory Species of Wild Animals* (CMS or Bonn Convention),
    - *the Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment 1974* (JAMBA),
    - *the Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986* (CAMBA),
    - *the Agreement between the Government of Australia and the Government of the Republic of Korea on the Protection of Migratory Birds 2007* (ROKAMBA),
    - *the Partnership for the Conservation of Migratory Waterbirds and the Sustainable Use of their Habitats in the East Asian Australasian Flyway* (Flyway Partnership), or
    - any other relevant international agreement, or instrument made under other international agreements approved by the Minister for the Environment, Heritage and the Arts.

  Further information on the CMS, JAMBA, CAMBA and ROKAMBA is provided in Appendix A;
- **Cetaceans** – all species of cetacean (comprising whales, dolphins and porpoises) are protected in Australian Commonwealth waters through the establishment of the Australian Whale Sanctuary under the EPBC Act; and
- **Listed marine species** – species occurring naturally in a Commonwealth marine area that the Australian Government recognises as requiring protection to ensure their long-term conservation. Listed marine species occurring in the North-west comprise:
    - sea snakes (family Hydrophiidae);
    - dugongs (genus Dugong);
    - marine turtles (families Cheloniidae and Dermochelyidae);
    - seahorses, sea-dragons, pipefish and ghost pipefish (families Syngnathidae and Solenostomidae); and
    - birds (seabirds, shorebirds, waterbirds and other coastal or migratory species that occur naturally in Commonwealth marine areas).

Species can be listed under more than one category; for instance marine turtles are listed as threatened species, migratory species and as marine species.

Under the EPBC Act, species listed as 'threatened' or 'migratory' are matters of national environmental significance. (Species listed as 'extinct' or 'conservation dependent' are not matters of national environmental significance under the EPBC Act). Proposals for activities likely to have a significant impact on matters of national environmental significance must be referred to the Australian Government Minister for the Environment, Heritage and the Arts for approval. The requirement to refer proposals for actions likely to have a significant impact on matters of national environmental significance applies to activities proposed not only in areas managed by the Commonwealth but also in areas managed by the States and Territories.

Significant Impact Guidelines for Matters of National Environmental Significance have been produced to provide advice to proponents on when referrals should be submitted for approval. These guidelines provide specific advice about the kinds of actions likely to have a significant impact on threatened and migratory species. The guidelines also provide specific advice about the kinds of actions likely to have a significant impact on the Commonwealth marine environment. Under these guidelines, any actions in the Commonwealth marine environment that will have, or are likely to have, "a substantial adverse effect on a population of a marine species or cetacean including its life cycle (e.g. breeding, feeding, migratory behaviour, life expectancy) and spatial distribution" are identified as actions that should be referred for approval. These guidelines are available

at <www.environment.gov.au/epbc/guidelines-policies.html>.

Species listed under the EPBC Act are also protected from adverse interactions with commercial fishing operations. Under the EPBC Act, all fisheries managed under Commonwealth legislation, and State managed fisheries that have an export component, must be assessed to ensure that, over time, those fisheries are managed in an ecologically sustainable way. These fishery assessments are conducted using the *Guidelines for the Ecologically Sustainable Management of Fisheries*. These guidelines specify that fisheries must be conducted in a manner that does not threaten by-catch species and that "avoids mortality of, or injuries to, endangered, threatened or protected species". Further information about fisheries assessments carried out under the EPBC Act is available at <www.environment.gov.au/coasts/fisheries>.

The EPBC Act includes other forms of protection for listed species to ensure that human activities do not threaten their survival in the wild (see Appendix B for further information and relevant links).

3.2.1 Protected species in the North-west Marine Region

The North-west Marine Region is an important area for many species that are protected under the EPBC Act. Many of the species listed under the EPBC Act are also protected under State legislation.

In the North-west Marine Region there are 151 species protected under the EPBC Act that are *known to occur*: 17 species listed as threatened, 73 as migratory, 21 cetaceans and 126 listed as marine (Table 3.2). In addition, there are another 75 species that *may occur* or *occur infrequently* in the Region. Species that *may occur* or *occur infrequently* in the North-west Marine Region are defined as those:

- that are accidental visitors to the Region; or
- that on the best available information about their range, are considered likely to occur in the Region.

Appendix C lists all species protected under the EPBC Act that are *known to occur* and all that *may occur* or *occur infrequently* in the North-west Marine Region.

Table 3.2 Number of protected species known to occur in the Region by broad taxonomic group (as at March 2008)

	Listed Threatened Species		Listed Migratory Species	Cetaceans (whales, dolphins and porpoises)	Listed Marine Species
	Endangered	Vulnerable			
Sharks	-	4	2	-	-
Bony Fish	-	-	-	-	17
Sea Snakes	-	-	-	-	20
Marine Turtles	2	4	6	-	6
Birds	1	3	54	-	82
Dugongs	-	-	1	-	1
Cetaceans	1	2	10	21	-
Totals	4	13	73	21	126

At the time of finalisation of this Bioregional Profile, there are no species listed as 'critically endangered' in the Region. There are also no species known to have become extinct in the Region.

Protected species group report cards have been prepared for each of the broad taxonomic groups listed under the EPBC Act that are known to occur in the Region (Appendix D). The report cards identify threatened and migratory listed species, describe their ecology, identify important areas for threatened and migratory species within the Region, explain what processes and activities pose a threat to their continued survival and identify how these threats are being mitigated. The report cards also point to relevant references and research for further reading. The report cards are available at <www.environment.gov.au/coasts/mbp/north-west>, and will be updated as new information becomes available. Protected species group report cards are available for sharks, bony fish, sea snakes, marine turtles, birds, dugongs, and cetaceans (whales, dolphins and porpoises) occurring in the North-west Marine Region.

Species listed as 'threatened' or 'migratory' under the EPBC Act are considered matters of national environmental significance. Important areas for threatened and migratory species have been identified in the North-west Marine Region and in State waters adjacent to the Region. Table 3.3 identifies breeding areas, nursery and calving areas, feeding areas and resting areas for threatened or migratory sharks, marine turtles, birds, dugongs and cetaceans. These areas were identified on the basis of available information, expert advice and the following criteria:

- **sharks**: nursery grounds and feeding areas;
- **marine turtles**: aggregation areas, nesting and foraging areas;
- **birds**: colonies, feeding areas, and staging areas for migratory shorebirds;
- **dugongs**: feeding and breeding areas; and
- **cetaceans** (whales, dolphins and porpoises): aggregation areas, feeding areas, calving areas and migration resting areas.

Additional important areas for species protected under the EPBC Act may be identified during the next stage of the planning process, as further and finer scale information about the Region is collected. This information will underpin the analysis of the threats protected species may face over the next 10–20 years, and will be included in the North-west Marine Bioregional Plan.

Table 3.3 Important breeding, feeding and resting areas for species listed as threatened or migratory under the EPBC Act

Where available, further information and references for important areas for threatened and migratory species are provided in Appendix D.

Important Areas	
Shark Bay – Dirk Hartog Island	**Resting area – humpback whales** An important resting area for migrating humpback whales, particularly for females and calves on their southern migration. Also home to resident populations of bottlenose dolphins. **Breeding and feeding area – marine turtles** Supports the largest breeding population of loggerhead turtles in Australia and the third largest in the world. Dirk Hartog Island has been identified as critical nesting and internesting habitat for loggerhead turtles. Shark Bay has been identified as a critical feeding habitat for loggerhead and green turtles. **Breeding area – seabirds** Wedge-tailed shearwaters, bridled terns, Caspian terns, and roseate terns breed in this area. **Breeding and feeding area – dugongs** The Shark Bay population of dugongs is thought to be one of the largest in the world and is estimated to include approximately 10 000 individuals.
Ningaloo Reef – North West Cape	**Feeding area – whale shark** This is the main known aggregation area in Australian waters for whale sharks, where they feed on concentrations of krill and zooplankton. **Breeding area – marine turtles** North West Cape is a major green turtle nesting area and an important nesting area for loggerhead turtles.

Important Areas	Rationale
Exmouth Gulf (including Muiron Islands)	**Resting area – humpback whales** An important resting area for migrating humpbacks, particularly for females and calves on their southern migration. **Breeding area – marine turtles** The Muiron Islands off North West Cape have been identified as critical nesting and internesting habitat for loggerhead turtles and also support a major green turtle rookery. **Breeding and feeding area – dugongs** A population of approximately 1000 individuals has been recorded in the Gulf, although numbers are thought to have decreased after the destruction of seagrass beds during Cyclone Vance in 1999.
Serrurier Island	**Breeding area – marine turtles** A major nesting area for green turtles and may also be a foraging area for this species. **Breeding area – birds** Caspian terns, little terns, wedge-tailed shearwaters and ospreys breed on Serrurier Island and nearby Airlie Island.
Thevenard Island	**Breeding area – marine turtles** Supports a significant flatback turtle rookery and small numbers of green turtles. **Feeding area – marine turtles** Feeding area for green turtles.
Montebello – Lowendal – Barrow islands and surrounding waters	**Resting area – humpback whales** Resting area for migrating humpback whales. Also has resident populations of common bottlenose dolphins and Indo-Pacific humpback dolphins. **Breeding area – marine turtles** Green, hawksbill and flatback turtles regularly nest in this area. Occasional nesting by loggerhead turtles has also been recorded on Barrow Island. Barrow Island and surrounding waters within a 20 km radius have been listed as critical nesting and internesting habitat for green turtles and also support an important flatback turtle rookery. The Montebello Islands and surrounding waters have been identified as critical nesting and internesting habitat for both flatback and hawksbill turtles. Varanus Island (part of the Lowendal Islands) and surrounding waters have been identified as critical nesting and internesting habitat for hawksbill turtles and supports an important flatback turtle rookery. Summer mating aggregations of green turtles occur to the west of Barrow Island and within the Montebello Island group. **Feeding area – marine turtles** Possible green turtle foraging grounds occur over the Barrow Shoals off the south-east coast of Barrow Island. Hawksbill turtle feeding grounds occur in the Mary Anne and Great Sandy Island groups to the south of the Barrow Shoals. There is also some evidence that juvenile flatback turtles use the Barrow Island region as developmental habitat. **Breeding area – birds** These islands support significant colonies of wedge-tailed shearwaters and bridled terns. The Montebello Islands support the biggest breeding population of roseate terns in Western Australia. Ospreys, white-bellied sea-eagles, eastern reef egrets, Caspian terns, and lesser crested terns also breed in this area. **Feeding area – seabirds** Observations suggest an area to the west of the Montebello Islands may be a minor zone of upwelling in the Region, supporting large feeding aggregations of terns. There is also some evidence that the area is an important feeding ground for Hutton's shearwaters and soft-plumaged petrels. **Feeding area/staging post – migratory shorebirds** Barrow Island is ranked equal tenth among 147 sites in Australia that are important for migratory shorebirds. Barrow, Lowendal and Montebello islands are internationally significant sites for six species of migratory shorebirds, supporting more than one per cent of the East Asian-Australasian Flyway population of these species.
Mangrove Islands	**Aggregation area – marine turtles** Aggregations of male green turtles occur on the Mangrove Islands prior to the nesting season. However, the purpose of these aggregations is unknown.

Important Areas	Rationale
Onslow to Dampier Archipelago	**Breeding area – birds** Islands between Onslow and the Dampier Archipelago are important nesting sites for wedge-tailed shearwaters, roseate terns, crested terns, Caspian terns, bridled terns, ospreys, eastern reef egrets, beach stone-curlews and white-bellied sea-eagles.
Dampier Archipelago	**Breeding area – marine turtles** Rosemary Island and all surrounding waters within a 20 km radius have been identified as critical nesting and internesting habitat for flatback turtles. The island also supports the most significant hawksbill turtle rookery in Western Australia and one of the largest in the Indian Ocean. Dampier Archipelago also supports major green and flatback turtle nesting sites. **Breeding area – birds** Important nesting areas for wedge-tailed shearwaters, bridled terns, fairy terns, roseate terns, Caspian terns, eastern reef egrets, beach stone-curlews, ospreys and white-bellied sea-eagles.
Port Hedland	**Breeding area – marine turtles** Important flatback turtle rookeries occur at Port Hedland and Cape Thouin. Critical nesting and internesting habitat for flatback turtles has also been identified at Mundabullangana Beach.
Bedout Island	**Breeding area – seabirds** Bedout Island supports one of the largest colonies of brown boobies in Western Australia. Masked boobies, lesser frigatebirds, roseate terns and common noddies also breed in the area.
Eighty Mile Beach – Roebuck Bay	**Breeding area – marine turtles** Major rookery for flatback turtles. **Feeding area/staging post – migratory shorebirds** Eighty Mile Beach and Roebuck Bay are two of the most important areas in Australia for migratory shorebirds. The area regularly supports up to 500 000 birds at any one time, with more than 850 000 birds using the area annually. The area is an internationally significant site for 20 species, regularly supporting more than one per cent of the East Asian-Australasian Flyway population. **Breeding and feeding area – cetaceans** Roebuck Bay is thought to be an important area for Australian snubfin dolphins and other inshore dolphin species.
Mermaid Reef – Rowley Shoals	**Breeding area – seabirds** Red-tailed tropicbirds, white-tailed tropicbirds and little terns breed in this area. **Feeding area/staging post – migratory shorebirds** Sand cays of the Rowley Shoals may be important resting and feeding sites for migratory shorebirds.
Quondong Point	**Feeding area – marine turtles** Feeding area for flatback, loggerhead, hawksbill and green turtles. **Aggregation area – cetaceans** High densities of migrating humpbacks as well as false killer whales, pygmy blue whales and dolphins.
Lacepede Islands	**Breeding area – marine turtles** The Lacepede Islands and surrounding waters within a 20 km radius have been identified as critical nesting and internesting habitat for green turtles, supporting the largest green turtle rookeries in Western Australia. **Breeding area – seabirds** The Lacepede Islands support some of the largest brown booby colonies in Western Australia. Lesser frigatebirds, bridled terns, roseate terns and common noddies also breed in the area.

Important Areas	Rationale
Kimberley coast	**Calving area – humpback whales** The main calving area for the West Australian population of humpback whales is centred around Camden sound but extends to south of Broome and north of the Maret Islands. High densities of migrating humpbacks are observed in Pender Bay. **Breeding and feeding area – cetaceans** Shallow coastal waters and estuaries along the Kimberley coast, particularly Pender Bay, Beagle Bay and tidal creeks around Yampi Sound and between Kuri Bay and Cambridge Gulf are important areas for Australian snub-fin dolphins and Indo-Pacific humpback dolphins.
Adele Island	**Breeding area – seabirds** This area supports large colonies of brown boobies and lesser frigatebirds as well as smaller populations of red-footed boobies, masked boobies and lesser crested terns.
Bonaparte Archipelago	**Breeding area – marine turtles** The Maret Islands and other islands of the Bonaparte Archipelago including the Montalivet islands, Albert Island and the Lamarck Islands support significant green and flatback turtles rookeries.
Scott Reef	**Breeding area – marine turtles** Supports a small but genetically distinct breeding population of green turtles. **Feeding area/staging post –birds** Scott Reef is an important staging post for migratory shorebirds and a foraging area for seabirds including roseate terns, lesser frigatebirds and brown boobies.
Browse Island	**Breeding area – marine turtles** Major rookery for green turtles. **Aggregation area – cetaceans** Offshore waters surrounding Browse Island support a larger number of cetacean species than any other area on the Western Australian coast, including large pods of oceanic dolphins, pygmy killer whales, false killer whales, melon-headed whales, minke whales and pilot whales. May also be a feeding area for blue whales.
Ashmore Reef – Cartier Island	**Breeding area – marine turtles** Critical nesting and internesting habitat for green turtles, supporting one of three genetically distinct breeding populations in the North-west Marine Region. Low levels of nesting activity of loggerhead turtles have also been recorded here. **Feeding area – marine turtles** Supports large and significant feeding populations of green, hawksbill and loggerhead turtles. It is estimated that approximately 11 000 marine turtles feed in the area throughout the year. **Breeding and feeding area – dugongs** Ashmore Reef is thought to support a small (less than 50 animals) but genetically distinct population. **Breeding area – seabirds** These islands support some of the most important seabird colonies on the North West Shelf including colonies of bridled terns, common noddies, brown boobies, eastern reef egrets, frigatebirds, tropicbirds, red-footed boobies, roseate terns, and lesser crested terns. **Feeding area/staging post – migratory shorebirds** Ashmore Reef and Cartier Island are important staging areas for many migratory shorebirds.
Montgomery Reef	**Feeding area – marine turtles** Records of green turtles, and possibly other species.
Cape Dommett	**Breeding area – marine turtles** Major rookery for flatback turtles.
Joseph Bonaparte Gulf	**Feeding area – marine turtles** Carbonate banks in the Joseph Bonaparte Gulf are foraging areas for flatback and loggerhead turtles. Green, olive ridley and flatback turtles are thought to forage around pinnacles in the Bonaparte Depression.

3.3 Protected places

The Australian Government has responsibility for the conservation of Australia's natural, indigenous and historic heritage, including the management of protected places on the World, National and Commonwealth Heritage Lists and the Register of the National Estate. Protected places likely to occur in the marine environment include Marine Protected Areas and historic shipwrecks.

Marine Protected Areas – Within the North-west Marine Region, there are four existing Commonwealth marine reserves which contribute to the National Representative System of MPAs – Ningaloo Marine Park (Commonwealth Waters), Mermaid Reef Marine National Nature Reserve, Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve (see Figure 3.2). In addition, there are a number of existing and proposed MPAs in State waters adjacent to the Region. These include (among others) the Rowley Shoals Marine Park, Ningaloo Marine Park (State Waters), Barrow Island Marine Management Area and the proposed Dampier Archipelago Marine Park, as well as over 300 island conservation reserves and a number of proposed coastal reserves along the Pilbara and Eighty Mile Beach coasts. More information on MPAs in State waters can be found at <www.naturebase.net>.

Also within the Region, Mermaid Reef, Ashmore Reef, Seringapatam Reef and the Commonwealth waters of the Ningaloo Marine Area and Scott Reef are listed on the Commonwealth Heritage List. In Western Australian State waters adjacent to the Region, Shark Bay and the Dampier Archipelago, including the Burrup Peninsula, are listed on the National Heritage List.

National Heritage – An area encompassing Ningaloo Reef, Cape Range and Exmouth Gulf was nominated to the National Heritage List in October 2005. In March 2008, the Australian Heritage Council found that parts of the Ningaloo Reef-Cape Range-Exmouth Gulf nominated area, including Ningaloo Marine Park (State and Commonwealth Waters) and the Muiron Islands Marine Management Area, might have outstanding heritage value to the nation. Following public consultation, the Council will consider recommending the place for inclusion in the National Heritage List. Further information on the Commonwealth and National Heritage lists can be found at <www.environment.gov.au/heritage>.

Figure 3.2 Existing Marine Protected Areas in the North-west Marine Region

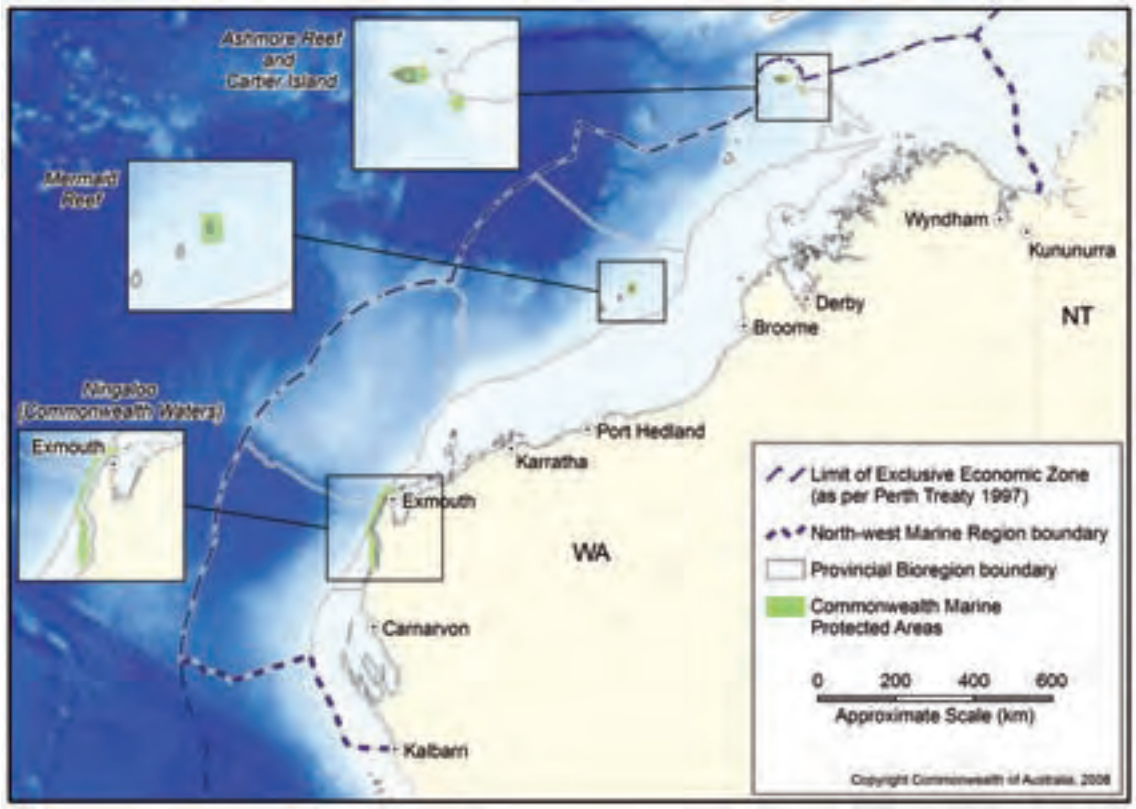
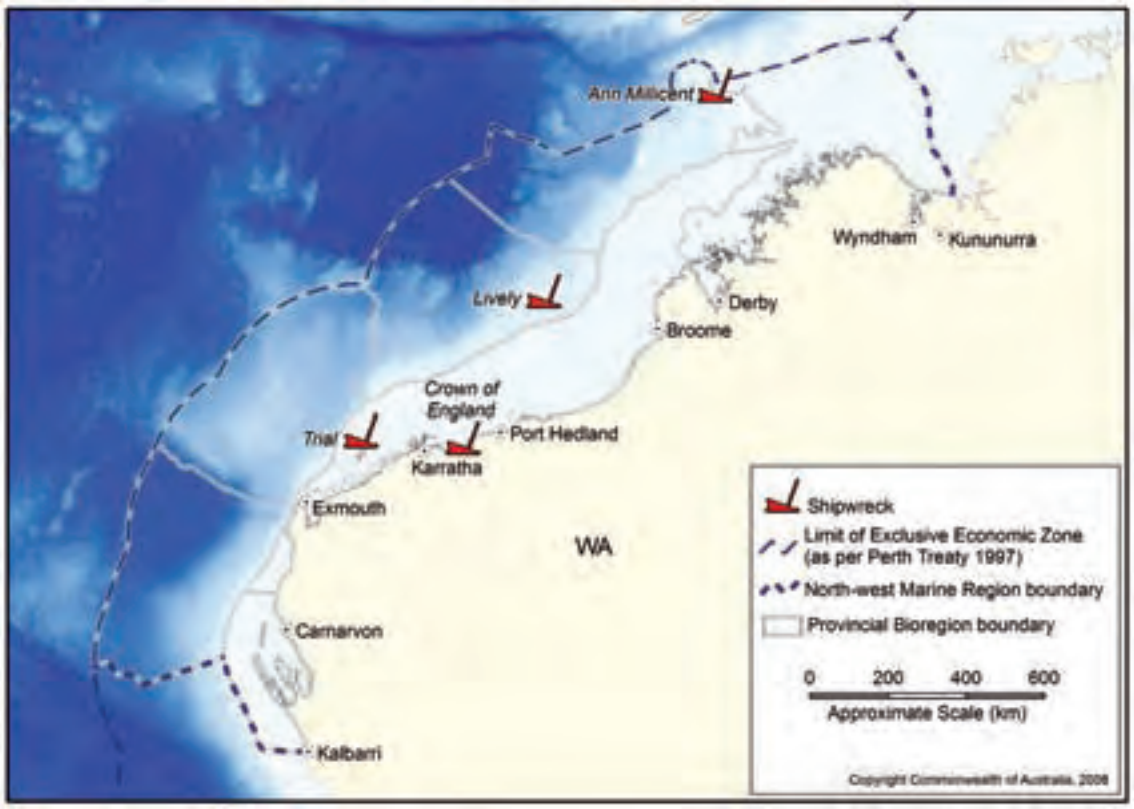


Figure 3.3 ***Historic shipwrecks of the North-west Marine Region***



World Heritage – The Australian Government is committed to also nominating Ningaloo Reef-Cape Range for inclusion on the World Heritage List. The Department of the Environment, Water, Heritage and the Arts is currently preparing the nomination in close consultation with the Western Australian Government. The nominated area is likely to include the entire Ningaloo Marine Park (State and Commonwealth Waters). Further information on the World Heritage List can be found at <whc.unesco.org/en/list>.

The Shark Bay World Heritage Area lies within State waters adjacent to the Region. This area is recognised for its outstanding natural heritage values including its diverse seagrass assemblages, its large dugong population, and its importance as a resting area for migrating humpback whales, a nesting area for marine turtles, and a nursery habitat for many species of fish and crustaceans. Further information on the Shark Bay World Heritage Area can be found at <www.sharkbay.org>.

Wetlands of International Importance – Ashmore Reef is included on the list of Wetlands of International Importance under the *Convention on Wetlands of International Importance 1971* (Ramsar Convention) for its variety of marine habitats, its biodiversity, including populations of threatened or endangered species and ecological communities, its important seabird rookeries, and its role as a staging-post for migratory shorebirds. Three sites in State waters adjacent to the North-west Marine Region are also listed as Ramsar sites: Eighty Mile Beach, Roebuck Bay and the Ord River Floodplain. Eighty Mile Beach and Roebuck Bay support globally significant populations of migratory shorebirds, while the Ord River Floodplain is the most biologically diverse, contiguous floodplain and mangrove system in Western Australia. More information on these sites can be found at <www.ramsar.org> or on the Western Australian Department of Environment and Conservation website <www.dec.wa.gov.au/management-and-protection/wetlands/wa-s-ramsar-sites.html>.

Historic Shipwrecks – There are four known historic shipwrecks in the Region (see Figure 3.3). All historic shipwrecks older than 75 years, including any that are as yet undiscovered, are protected under the *Historic Shipwrecks Act 1976*. More information on the *Historic Shipwrecks Act 1976* can be found in Appendix B.

3.3.1 Commonwealth marine reserves in the North-west Marine Region

Ningaloo Marine Park (Commonwealth Waters)

Ningaloo Marine Park (Commonwealth Waters) stretches approximately 300 km along the west coast of the Cape Range Peninsula near Exmouth, and covers 2436 km². The Commonwealth marine reserve is adjacent to the Ningaloo Marine Park (State Waters), which covers 2640 km². Ningaloo Marine Park (Commonwealth Waters) was proclaimed in May 1987 under the *National Parks and Wildlife Act 1975*, which was replaced by the EPBC Act. The park has since been extended twice (in July 1992 and again in April 2004), to include two areas that were formerly the subject of petroleum exploration permits. The State park was also extended in 2004 to include the whole of the Ningaloo Reef within the Marine Park. Ningaloo Marine Park (Commonwealth Waters) is managed cooperatively by the Department of the Environment, Water, Heritage and the Arts, the Western Australian Department of Environment and Conservation and the Western Australian Department of Fisheries.

Ningaloo Reef is one of the longest fringing barrier reefs in the world and has been included on the IUCN List of Coral Reefs of International Significance. As a whole, the combined State and Commonwealth Ningaloo Marine Parks provide a unique representation of an entire marine ecosystem, from the intertidal environments of the coastline to the coral reef and lagoon and the deep oceanic environments of the edge of the continental shelf. The parks lie along a transition zone between tropical northern and temperate southern flora and fauna, with a number of tropical species reaching their southern limit in the parks.

Ningaloo Reef contains a high diversity of corals (more than 200 species), reef fish (more than 460 species), molluscs, crustaceans and other reef plants and animals. Many deepwater pelagic species such as marlin, sailfish and swordfish are also found much closer to shore here than in other parts of Australia and the world, because of the narrow continental shelf and the influence of the Leeuwin Curent. More information on the ecology of Ningaloo Reef and surrounding waters can be found in Chapter 2.

The reef also provides important habitat for several threatened or migratory species. Ningaloo is one of the few places in the world where whale sharks congregate regularly in significant numbers. It is also part of the annual migration route for humpback whales and supports a high density of threatened marine turtles. The area is part of the migratory route of many trans-equatorial shorebirds or waders, and provides valuable feeding grounds for many migratory seabirds. It is also an important feeding area for manta rays in autumn and winter.

Under the EPBC Act, Commonwealth marine reserves are assigned to an IUCN protected area category reflecting the management objectives for each reserve (see <www.environment.gov.au/parks/iucn.html> for more information on the IUCN's reserve categories). The Ningaloo Marine Park (Commonwealth Waters) is managed as an IUCN Category II – National Park: Protected Area Managed Mainly for Ecosystem Conservation and Recreation. As such, commercial fishing, petroleum and mining activities are not permitted. A range of other activities such as recreational fishing and commercial tourism activities are allowed under permit from the Director of National Parks.

The EPBC Act also prohibits actions affecting native species inside the park unless authorised under the *Ningaloo Marine Park (Commonwealth Waters) Management Plan 2002* (EA 2002). Further information on the Ningaloo Marine Park is available at <www.environment.gov.au/coasts/mpa/ningaloo>.

Mermaid Reef Marine National Nature Reserve

Mermaid Reef is the most northerly reef of the Rowley Shoals, which lie 300 km west of Broome. The reserve was established in March 1991 by proclamation under the *National Parks and Wildlife Conservation Act 1975*, which was replaced by the EPBC Act. The Mermaid Reef Marine National Nature Reserve covers a total area of 5.4 km², including the seabed and subsurface to a depth of 1000 m.

The two other reefs in the Rowley Shoals, Clerke Reef and Imperieuse Reef, include permanent sand cays above the high water mark and fall under State jurisdiction. These two reefs constitute the Rowley Shoals Marine Park, which was declared as a Class A Marine Reserve by the West Australian Government in 1990. The Department of the Environment, Water, Heritage and the Arts manages Mermaid Reef National Nature Reserve through a cooperative management arrangement with the Western Australian Department of Environment and

Conservation and the Western Australian Department of Fisheries.

The Rowley Shoals, including Mermaid Reef, have national and international significance due to their relatively pristine character, geomorphological interest and diverse fauna, including many species of molluscs, echinoderms and finfish which have not been recorded elsewhere in Western Australia, and which reflect the shoals' strong links with Indonesian fauna. It is thought that the shoals are an important stepping stone in maintaining gene flow among the northwest Australian coastal reefs. The reefs have been listed on the IUCN List of Coral Reefs of International Significance and are considered to be the best examples of shelf-edge oceanic reefs in Australian waters. The remote location of the reefs means that they do not have a history of disturbance by coral predators, such as the crown-of-thorns starfish.

The Mermaid Reef Marine National Nature Reserve is classified as an IUCN Category Ia – Strict Nature Reserve. As such, the reef is managed primarily for scientific research, limited commercial tourism and educational purposes, and is closed to all forms of fishing and collecting. The Mermaid Reef Management Plan (EA 2000) expired on 16 May 2007, and a draft management plan will be released for public comment in 2008. Until the new plan takes effect, the reserve is being managed in a manner consistent with its IUCN Category 1a classification, under approvals issued by the Director of National Parks. Further information on the Mermaid Reef National Nature Reserve is available at <www.environment.gov.au/coasts/mpa/mermaid>.

Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve

Ashmore Reef and Cartier Island lie off the coast of northern Western Australia approximately 600 km north of Broome. The Ashmore Reef National Nature Reserve was established in August 1983 under the *National Parks and Wildlife Act 1975*, which was replaced by the EPBC Act. The Ashmore Reef National Nature Reserve covers an area of approximately 583 km^2, and was designated as a Wetland of International Importance under the Ramsar Convention on 21 October 2002.

Cartier Island Marine Reserve, approximately 45 km to the south-east of Ashmore Reef, was established in June 2000 (also under the *National Parks and Wildlife Act 1975)* and covers approximately 167 km^2.

These reserves protect unique and vulnerable marine ecosystems with high biological diversity which, like the Rowley Shoals, are thought to be important biological stepping-stones between centres of biodiversity in the Indo-Pacific and reef ecosystems on the North West Shelf – possibly playing an important role in the maintenance of biodiversity in reef systems farther south.

The Ashmore Reef and Cartier Island reserves protect critical habitat for an unusually high diversity and abundance of sea snakes, and provide feeding and breeding areas for three species of marine turtle. Ashmore Reef is an important staging post for many migratory shorebirds and supports substantial seabird breeding colonies. The reef also supports a small population of dugongs that is thought to be genetically distinct from other Australian populations.

Both reserves include the seabed and substrate to a depth of 1000 m. The two reserves lie within an area subject to a Memorandum of Understanding (MoU) between Indonesia and Australia which provides for continued Indonesian traditional fishing activities in an area known as the MoU Box. The MoU Box also includes Scott Reef and Seringapatam Reef. More information on the MoU can be found in Appendix A.

As a result of its proximity to Indonesia and the MoU arrangements allowing traditional Indonesian fishing in the MoU Box, Ashmore Reef is frequently visited by traditional Indonesian fishermen. Although no commercial fishing is allowed in Ashmore, traditional fishermen do visit the area to shelter, obtain fresh water from the well on West Island and visit grave sites. The Department of the Environment, Water, Heritage and the Arts and the Australian Customs Service work together to inform users about the rules of the reserves. The *Ashmore Guardian* has been stationed at Ashmore Reef since April 2008 and provides a near permanent presence to ensure the reefs' protection.

Cartier Island Marine Reserve and the majority of Ashmore Reef National Nature Reserve are classified as IUCN Category Ia – Strict Nature Reserve, and are closed to the public. At Ashmore, West Island Lagoon and part of West Island is zoned as IUCN Category II – National Park. Visits to the reserves are limited to this area, although historically there have been few visitors to the reserves. Commercial fishing and oil and gas exploration are not allowed in the reserves, and commercial tourism and scientific research must be conducted under a permit. Cartier Island and the surrounding area within

a 10 km radius is a declared Defence Practice Area, although it is not currently in active use.

Due to the risk of unexploded ordinance, visitor access to Cartier Island is prohibited and the area is closed to shipping. These reserves are managed under the *Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve Management Plan* (EA 2002), which expires in June 2009. As with other Commonwealth marine reserves, it is prohibited under the EPBC Act to kill, injure, take, trade, keep or move a member of a native species in these reserves except in accordance with the management plan. Further information on the Ashmore Reef National Nature Reserve and the Cartier Island Marine Reserve is available at <www.environment.gov.au/coasts/mpa/ashmore>.

3.3.2 Historic shipwrecks

Most historic shipwrecks are found in State waters. However, there are four historic shipwrecks which are known or believed to lie within the Commonwealth waters of the North-west Marine Region. These are:

- the ***Trial***, which is the earliest known shipwreck in Australian waters. It is an English East Indian ship wrecked on Trial Rocks north of the Montebello Islands in 1622, on its way to the port of Batavia in Indonesia from Plymouth in England;
- the ***Lively***, an English whaler vessel believed wrecked on the western edge of Mermaid Reef in 1818;
- the ***Ann Millicent***, an iron hulled barque wrecked on the southern reef edge of Cartier Island in 1888; and
- the ***Crown of England***, foundered during a cyclone at Depuch Island in 1912.

It should be noted that information about the location of shipwrecks is often approximate and that other historic shipwrecks may yet be discovered within the Region.

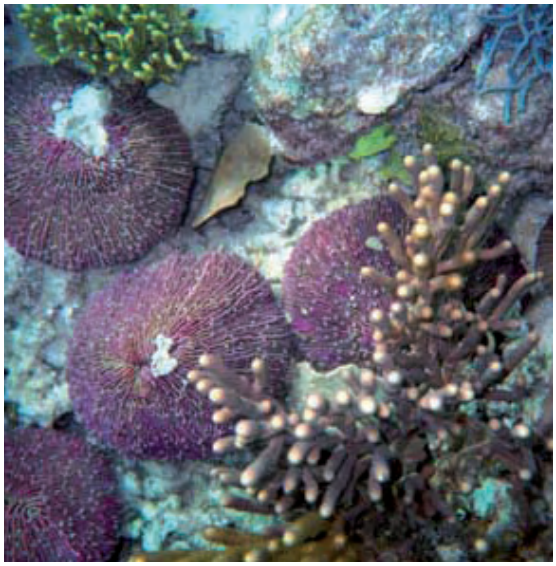
Historic shipwrecks are recognised and protected under the *Historic Shipwrecks Act 1976*, which protects historic wrecks and associated relics found in waters from the low water mark to the edge of the continental shelf. Under the Historic Shipwrecks Act, all wrecks more than 75 years old are protected, together with their associated relics. The Minister for the Environment, Heritage and the Arts can also make a declaration to protect any historically significant wrecks or articles and relics that are less than 75 years old. More information on the Historic Shipwrecks Act can be found in Appendix B.

The Act aims to ensure that historic shipwrecks are protected for their heritage values and maintained for recreational and educational purposes. It also regulates activities that may result in the damage, interference, removal or destruction of an historic shipwreck or associated relic. Under the Historic Shipwrecks Act:

- anyone who finds the remains of a ship or articles associated with a ship is required to give notification of the location as soon as practicable to the Minister for the Environment, Heritage and the Arts; and
- historic relics must not be removed, or the physical fabric of a wreck disturbed, unless a permit has been obtained.

The Act also provides for protected zones to be declared around wrecks that may be at particular risk of being interfered with. Permits are required to enter protected zones, which can cover an area up to a radius of 800 m. There are currently no declared protected zones under the Historic Shipwrecks Act in the North-west Marine Region. The only protected zone in Western Australia is in State waters adjacent to the Region around the wreck of the *Zuytdorp*, a Dutch East India Company ship wrecked on the Western Australian coast north of Kalbarri.

Further information about historic shipwrecks and the Historic Shipwrecks Act can be found at <www.environment.gov.au/heritage/shipwrecks>.



Coral at Ashmore Reef. Photo: Kriton Glenn, Department of the Environment, Water, Heritage and the Arts.

3.4 Consideration of pressures on regional conservation values

There is a range of pressures currently impacting or likely to impact upon conservation values in the Region. While Appendix D describes some of the threats relevant to species listed under the EPBC Act, threats to all conservation values will be considered in detail in the next stage of the bioregional planning process, the development of the Draft Marine Bioregional Plan.

Australia's marine biodiversity is under increasing pressure from many uses of the marine environment including fisheries, shipping, petroleum and mineral extraction, tourism and recreation. Pressures from changing land use, including agricultural and urban run-off and coastal development, also exist. Climate change is an increasingly significant concern (see Box 3.1). Increasing population globally, regionally and locally will also result in increasing threats to biodiversity and pressures on resources.

Australia's oceans have been the subject of significant recent research activity but large gaps in our knowledge remain. Based on available knowledge, Australia's marine biodiversity is probably in better condition than that of many other countries. However, despite the combined efforts of Australia's governments, industries, stakeholders and the community, there are significant concerns with decline in some key species and localised impacts on habitats and populations.

Despite limitations in knowledge about marine biodiversity and habitats, their current condition and the pressures affecting them, sufficient evidence exists to conclude that a cumulative decline in marine biodiversity is occurring. The effects of a number of threatening processes are causing declines in habitats, changes in ecosystems and loss of species. The key pressures on marine biodiversity include: climate change, resource use, land-based impacts, introduced marine pest species, and marine pollution.

An overview of the types of pressures impacting on marine biodiversity can be found in the 'Coasts and Oceans' chapter of the *2006 State of the Environment Report* at <www.environment.gov.au/soe/2006/publications/report/coasts.html>.

The information collected during the profiling stage will inform an assessment of the pressures on the regional conservation values described in this chapter as well as options for addressing them. Chapter 6 contains more information about how and when in the process stakeholders' input will be sought to inform the development of the plan.

Box 3.1 Climate change impacts on marine life

The 2006 CSIRO report Impacts of Climate Change on Australian Marine Life <www.greenhouse.gov.au/impacts/publications/marinelife.html> provides an overview of the potential impacts of climate change on marine biodiversity and ecosystems.

Climate change is expected to have considerable impacts on marine life and marine ecosystems. There will inevitably be flow-on implications for human societies and economies, particularly those in regional Australia highly dependent on the marine environment and its resources.

Evidence from Australian waters is sparse, mainly due to a lack of historical long-term data collection. Importantly, little modelling has been conducted to predict future changes in Australian marine ecosystems and this remains a critical gap.

Three general findings emerged from this study:

- Firstly, although particular factors such as temperature stand out as prominent drivers of observed changes in Australia's marine flora and fauna, it is the combined effects of multiple climate and oceanographic factors that will shape Australia's marine life in the future;
- Secondly, Australia's marine life is currently affected strongly by non-climate related stressors such as fisheries, coastal runoff and pollution, and the ecological effects of these stressors will serve to reduce ecosystem resilience to climate change. An integrated and adaptive management approach is required to deal with these combined effects; and
- Finally, both monitoring time series data and modelling of climate change impacts in Australia's marine ecosystems are extremely limited at present, and represent crucial components of a strategic national assessment of climate change impacts that can inform development of policy and management strategies.

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Partnership for the Conservation of Migratory Waterbirds and the Sustainable Use of their Habitats in the East Asian Australasian Flyway (Flyway Partnership).

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Department of Environment and Heritage, 2006, *EPBC Act Policy Statement 1.1 Significant Impact Guidelines – Matters of National Environmental Significance*, DEH, Canberra, <www.environment.gov.au/epbc/publications/nes-guidelines.html> accessed 10/05/2007.

Department of the Environment and Water Resources (DEW), 2007, *Guidelines for the Ecologically Sustainable Management of Fisheries – Edition 2*, Commonwealth of Australia, Canberra, <www.environment.gov.au/coasts/fisheries/publications/guidelines.html>, accessed 06/05/2008.

Map data

Figure 3.1 Key Ecological Features of the North-west Marine Region

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Projection: Geographics, Datum: GDA94

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Figure 3.2 Existing Marine Protected Areas in the North-west Marine Region

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

Department of the Environment, Water, Heritage and the Arts (2007): Commonwealth Marine Protected Areas Managed by DEWHA

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Projection: Geographics, Datum: GDA94

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Figure 3.3 Historic Shipwrecks of the North-west Marine Region

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2003): Historic Shipwrecks Register Points

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

Department of the Environment, Water, Heritage and the Arts (2007): Commonwealth Marine Protected Areas Managed by DEWHA

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Projection: Geographics, Datum: GDA94

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Barrel sponge (*Xestospongia testudinaria*) in 70 m of water off Mermaid Reef, Rowley Shoals. Photo: CSIRO.

Chapter 4 Establishing New Marine Protected Areas in the North-west Marine Region

Australia is committed to the development of a National Representative System of Marine Protected Areas (MPAs). The primary goal of the National Representative System of MPAs is to establish and manage a comprehensive, adequate and representative network 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. In summary, the approach to developing MPAs will ensure that:

- each distinct provincial bioregion in Australian waters will be represented in the MPA network;
- the design of the MPA network should be sufficient to achieve the conservation of all major ecosystem functions and features; and
- the network should properly represent the identified habitats and biota (the range of plants and animals and the places where they live) characteristic of each provincial bioregion.

The MPA network, established through the marine bioregional planning process, will include both multiple use zones equivalent to IUCN Category VI, and highly protected zones equivalent to IUCN Categories I and II (see Box 4.1). The MPA network will be developed in the absence of detailed biological information for many areas, so a precautionary, staged and adaptive approach will be taken, consistent with the principles of ecologically sustainable development. This approach will allow for continued gathering of information about specific ecological, economic and social values in the area, as well as the threats to those values. The Government will identify important information gaps and strategies for addressing them over time.

The National Representative System of MPAs will be developed using the national *Guidelines for Establishing the National Representative System of Marine Protected Areas* <www.environment.gov.au/coasts/mpa/publications/nrsmpa-guidelines.html> agreed between the Australian Government, the States and the Northern Territory in 1998.

Diver at Scott Reef. Photo: Australian Institute of Marine Science.

Banded seasnake, Scott Reef. Photo: Australian Institute of Marine Science.

Since 1998, there have been many decisions that have helped formulate the Australian Government's approach to establishing an MPA network. These include the development of a clearer understanding of how the *Guidelines for Establishing the National Representative System of Marine Protected Areas* (ANZECC 1998) will be applied by the Australian Government, drawing on the best available scientific information. The Department of the Environment, Water, Heritage and the Arts, in consultation with other Australian Government agencies, has set out this approach in the *Goals and Principles for the Establishment of the National Representative System of Marine Protected Areas in Commonwealth Waters*. The goals and principles are derived from the *Guidelines for Establishing the National Representative System of Marine Protected Areas* and the Australian Government's implementation experience to date to ensure proper consideration of ecological and socio-economic requirements. These goals and principles are set out in Section 4.1 of this chapter.

The Australian Government considers that measures other than MPAs also play a critical role in biodiversity conservation and that the existence and effectiveness of those measures should be taken into account in assessing the adequacy of any MPA network.

In addition to MPAs, the Government supports the use of spatial measures in fisheries management. While the two spatial management mechanisms are designed and used for different purposes, they can have mutually beneficial outcomes. Fisheries-specific measures, including both temporal and permanent area closures, are developed according to the particular goals and circumstances of each fishery. MPAs are developed in Commonwealth waters for the purpose of general biodiversity conservation or to address threats to particular species or habitats – not to manage fisheries. Nevertheless, MPAs may lead to improved fisheries performance and fisheries closures may contribute to biodiversity conservation. The Government seeks to ensure that the design of MPAs takes into account the potential for beneficial impacts on fishery resources and that MPAs are selected and zoned to enhance or conserve fish stocks where possible.

MPAs have long-term benefits for the environment and the economy. However, even where impacts can be minimised, they may adversely affect some businesses in the short to medium-term. The Government recognises that a new MPA network may transfer some marine resources from current production to biodiversity conservation. Therefore, before any new MPAs are declared, the socio-economic costs and benefits will be assessed and the Government will decide on the provision of any adjustment assistance to affected businesses.

4.1 Goals and principles

The Australian Government is committed to the development of a National Representative System of MPAs by 2012. The development of Marine Bioregional Plans for each of Australia's five large scale Marine Regions provides an opportunity to make substantial progress towards this goal. Areas suitable for inclusion in the National Representative System of MPAs will be identified during the planning process.

The network will be representative of the 41 provincial-scale bioregions recognised in Commonwealth waters, as identified by the *Integrated Marine and Coastal Regionalisation of Australia Version 4.0* (IMCRA v.4.0) <www.environment.gov.au/coasts/mbp/publications/imcra/imcra-4.html>. The focus is to ensure that MPAs are developed for those provincial bioregions that are currently not represented, or are under-represented, in MPAs. (Note the Bioregional Profile uses the terms *provincial bioregion* and *bioregion* interchangeably to refer to the provincial bioregions defined by IMCRA v.4.0).

Because the management of MPAs may require conditions to be put on the nature and extent of activities that can occur within them, the identification of areas suitable for inclusion in the National Representative System of MPAs needs to be based upon clear goals and principles. These goals and principles recognise both the scientific information available and the interests of ocean users whose activities may be affected by new MPAs.

The approach seeks to draw on available scientific information, while recognising that the information base is poor for some areas. Large areas of each Marine Region are far offshore, comprised of very deep water, and have not been subject to detailed study or data collection. In these circumstances, existing and peer-reviewed information will be supplemented with information drawn from known relationships between biodiversity and the physical environment – that is, where detailed species and habitat data are lacking, surrogates for biological diversity (such as water depth, substrate type and geomorphology) will be used. This is because we know that marine habitats with different physical characteristics (water depth, substrate type, geomorphology etc.) generally support different assemblages of biodiversity.

Key inputs into the MPA identification process will include:

- existing scientific information underlying IMCRA v.4.0 (e.g. bathymetry, geomorphic features, distribution of endemic biota);
- additional regional information on habitats, species distribution and ecology gathered during the marine bioregional planning process;
- data on the location and distribution of human activities in the Marine Region;
- views of ocean users and stakeholders in each Marine Region;
- consideration of the contribution that existing spatial management measures can make to the National Representative System of MPAs; and
- consideration of potential management effectiveness (e.g. feasibility of compliance).

Bridled terns and black noddies on Lacepede Island. Photo: Mark Ziembicki.

4.1.1 Goals

Four goals to maximise conservation outcomes will guide the identification of areas suitable for inclusion in the National Representative System of MPAs. These goals apply nationally, and they will be used to guide identification of representative MPAs in all the Marine Regions (except the South-east, where the process has been completed). Additionally, a number of supporting principles will assist in determining the location, selection (when more than one option to meet the goals is available), design and zoning of suitable areas.

Goal 1 – Each **provincial bioregion** occurring in the Region should be represented at least once in the MPA network. Priority will be given to provincial bioregions not represented in the existing National Representative System.

Goal 2 – The MPA 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 MPA network should seek to include examples of **benthic/demersal biological features** (e.g. habitats, communities, sub-regional ecosystems, particularly those with high biodiversity value, species richness and endemism) known to occur in the Region at a broad sub-provincial (greater than hundreds of kilometres) scale.

Goal 4 – The MPA network should include all **types of seafloor** features. There are 21 seafloor types across the entire Exclusive Economic Zone (EEZ). Some provincial bioregions will be characterised by the presence of a certain subset of features, such as continental slope or seamounts.

4.1.2 Guiding principles

Location of MPAs

1. MPAs will be located taking into account the occurrence and location of existing spatial management arrangements (e.g. existing protected areas and sectoral measures) that contribute to the goals.

2. The goals should be met with the least number of separate MPAs required to maximise conservation outcomes (i.e. a smaller number of larger MPAs rather than many small MPAs).

Selection

3. The capacity of an MPA to mitigate identified threats to conservation values.

4. The occurrence of spatially defined habitats for and/or aggregations of threatened and/or migratory species.

5. The occurrence of ecologically important pelagic features which have a consistent and definable spatial distribution.

6. The occurrence of known small-scale (tens of kilometres) ecosystems associated with the benthic/demersal environment.

7. Relevant available information about small-scale distribution of sediment types and sizes and other geo-oceanographic variables.

8. Occurrence of listed heritage sites (where inclusion in the MPA network would improve administration of protection regimes).

9. Socio-economic costs should be minimised.

Design

Once the broad location of MPAs has been determined, the following design principles should be applied to further refine the size and shape of individual MPAs:

10. Individual areas should, as far as practicable, include continuous depth transects, (e.g. from the continental shelf to the abyss).

11. Whole seafloor (geomorphic) features should be included.

12. Features should be replicated wherever possible within the system of MPAs (i.e. included more than once).

13. Size and shape of MPA boundaries should be orientated to account for inclusion of connectivity corridors and biological dispersal patterns within and across MPAs.

14. Boundary lines should be simple, as much as possible following straight latitudinal/longitudinal lines.

15. Boundary lines should be easily identifiable, where possible coinciding with existing regulatory boundaries.

16. The size and shape of each area should be set to minimise socio-economic costs.

For each area identified as a candidate MPA, specific conservation objectives will be set, which will reflect the four goals. For example, they may relate to the integrity of bioregional characteristics (Goal 1) or to specific large-scale biological features (Goal 3) that the area aims to represent. They may also relate to other relevant principles, such as the integrity of habitat important for threatened or migratory species (Principle 4). To accommodate climate change as far as practicable, design principles and zoning that promote resilience and adaptation will be incorporated. In particular, accommodating latitudinal or longitudinal movement in ecosystem or species distributions and changes in oceanographic features and currents, anticipated in response to climate change.

Zoning

Because zoning of MPAs (i.e. the allocation of appropriate management regimes to different zones) has the potential to affect the socio-economic costs associated with the establishment of any protected area, the Australian Government recognises the importance of addressing zoning considerations as early as possible in the process. The following **zoning principles** will be applied in developing the MPA network in each Marine Region:

17. Zoning will be based on the EPBC Act/World Conservation Union (IUCN) categories of protection (see Box 4.1).

18. The regional MPA network will aim to include some highly protected areas (IUCN Categories I and II) in each bioregion.

19. Zoning will be based on the consideration of the risk that specific activities pose to the conservation objectives of each MPA.

20. Zoning of MPAs will seek to ensure that the conservation objectives of the area are protected, taking into account a precautionary approach to threat amelioration, as well as the relative costs and benefits (economic, social and environmental) of different zoning arrangements.

Box 4.1 IUCN Categories assigned under the EPBC Act for Marine Protected Areas

Under the EPBC Act, marine reserves must be assigned to an IUCN category. These IUCN categories are:

- Strict nature reserve (IUCN Ia): Managed primarily for scientific research or environmental monitoring;
- Wilderness area (IUCN Ib): Protected and managed to preserve its unmodified condition;
- National Park (IUCN II): Protected and managed to preserve its natural condition;
- Natural Monument (IUCN III): Protected and managed to preserve its natural or cultural features;
- Habitat/species management area (IUCN IV): Managed primarily, including (if necessary) through active intervention, to ensure the maintenance of habitats or to meet the requirements of specific species;
- Protected landscape/seascape (IUCN V): Managed to safeguard the integrity of the traditional interactions between people and nature; and
- Managed resource protected area (IUCN VI): Managed to ensure long-term protection and maintenance of biological diversity with a sustainable flow of natural products and services to meet community needs.

See <www.environment.gov.au/parks/iucn.html> for more information.

4.2 Regional specifications for identifying representative Marine Protected Areas in the North-west Marine Region

In meeting its objectives in establishing a National Representative System of MPAs, the Australian Government is committed to minimising the socio-economic costs involved for both industry and government. All Commonwealth waters support important industries. The North-west Marine Region is of particular importance for the future of Australia's petroleum industry. A key consideration in implementing the goals and principles will therefore be minimising adverse impacts on petroleum exploration and development.

4.2.1 Meeting the national goals in the North-west

To achieve the four national goals for the establishment of the National Representative System of MPAs in the Region (as outlined in Section 4.1.1), the following set of regional specifications have been developed, drawing on available biophysical information. Much of this information is available in more detail in this Bioregional Profile or in the associated web-based products.

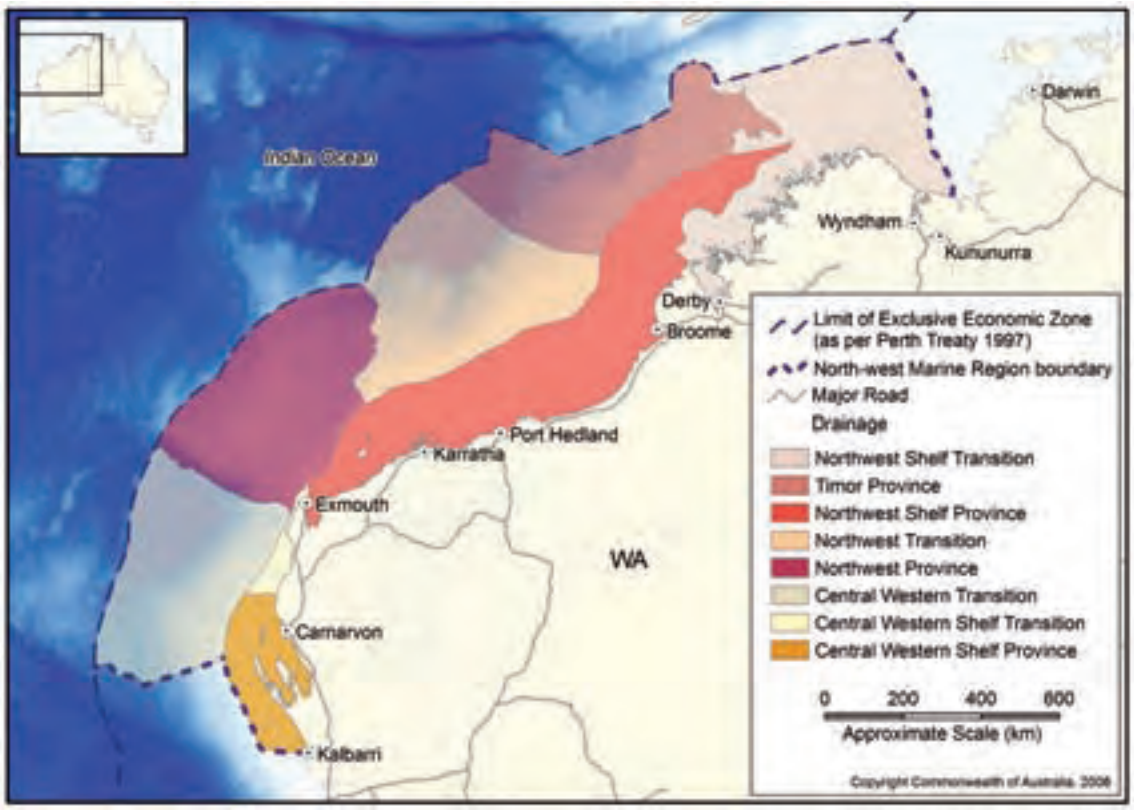
Specifying Goal 1 – provincial bioregions

The network of representative MPAs in the North-west Marine Region will represent each of the eight bioregions as defined by IMCRA v.4.0 (Figure 4.1). Each provincial bioregion has been identified because it reflects broad-scale patterns of biodiversity and evolution. In identifying new areas for inclusion in the National Representative System of MPAs, priority will be given to areas representative of provincial bioregions with no, or very low levels of representation.

Of these eight provincial bioregions, four are wholly contained within Commonwealth waters in the North-west Marine Region (the Central Western Transition, Northwest Province, Northwest Transition and Timor Province). Three provincial bioregions, the Central Western Shelf Province, Central Western Shelf Transition and Northwest Shelf Province include State waters. The Northwest Shelf Transition straddles both the North and North-west Marine Regions and includes Commonwealth, State and Northern Territory waters (see Table 4.2).

Four MPAs currently exist in the North-west Marine Region: Ashmore Reef National Nature Reserve, Cartier Island Marine Reserve, Mermaid Reef National Nature Reserve and Ningaloo Marine Park. More information on these reserves is available in Chapter 3.

Figure 4.1 Provincial bioregions of the North-west Marine Region (IMCRA v.4.0)



All these reserves are highly protected IUCN reserve categories I and II. The Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve both occur in Timor Province, and Mermaid Reef National Nature Reserve is found in the Northwest Transition. These MPAs are representative of reef ecosystems within these bioregions. However, they are not representative of the provincial bioregions as a whole.

Ningaloo Marine Park (Commonwealth Waters) occurs mostly in the Central Western Shelf Transition, but also covers very small areas (less than one per cent) of three other provincial bioregions: the Central Western Transition, Northwest Province and Northwest Shelf Province. The Ningaloo Marine Park (State and Commonwealth waters) represents reef, continental shelf and slope features and, because of the small number of geomorphic features of this provincial bioregion, could be regarded as representative of the Central Western Shelf Transition.

There are no MPAs in Commonwealth waters in either the Central Western Shelf Province or the Northwest Shelf Transition. In identifying new areas in the Region suitable for inclusion in the National Representative System of MPAs, priority will therefore be given to areas representative of the provincial bioregions not currently represented in MPAs, as detailed in Table 4.1.

The Northwest Shelf Transition provincial bioregion straddles the North-west and North Marine Regions. Identification of MPAs in this bioregion will be determined in conjunction with the North marine bioregional planning process. The North Marine Bioregional Plan is scheduled for completion before the North-west Marine Bioregional Plan.

Specifying Goal 2 - depth ranges

Depth is one of the main factors determining distribution of benthic and demersal biological communities. Depth reflects certain basic physical variables – such as light penetration, temperature and pressure – that determine what types of animals and plants are found in particular locations. The range of depths that occur in the North-west Marine Region should be represented in the network of representative MPAs. Water depths in the North-west Marine Region range from 0–5895 m (Figure 4.2). However, most of the Region is relatively shallow, with over 40 per cent of its total area in waters less than 200 m deep and over 50 per cent in depths of less than 500 m. This reflects the large areas of continental shelf and slope that occur in the Region.

In comparison with other Marine Regions (except the North Marine Region), the North-west contains a small proportion of deep water. Waters greater than 4000 m deep comprise less than 15 per cent of the Region's waters (Potter *et al*. 2006). The depth range and area of each bioregion in the Region is shown in Table 4.2.

Four of the North-west's provincial bioregions occur only on the continental shelf (Central Western Shelf Province, Central Western Transition, Northwest Shelf Province and Northwest Shelf Transition). These provincial bioregions therefore do not display a marked variation in depth. In some inshore areas in the north of the Region, and particularly in the Joseph Bonaparte Gulf (Northwest Shelf Transition), changes in biota and habitat are associated with gradients in light penetration through the water column. In turbid or nutrient-rich waters,

Table 4.1 Representation of bioregions in current Marine Protected Areas in the Region

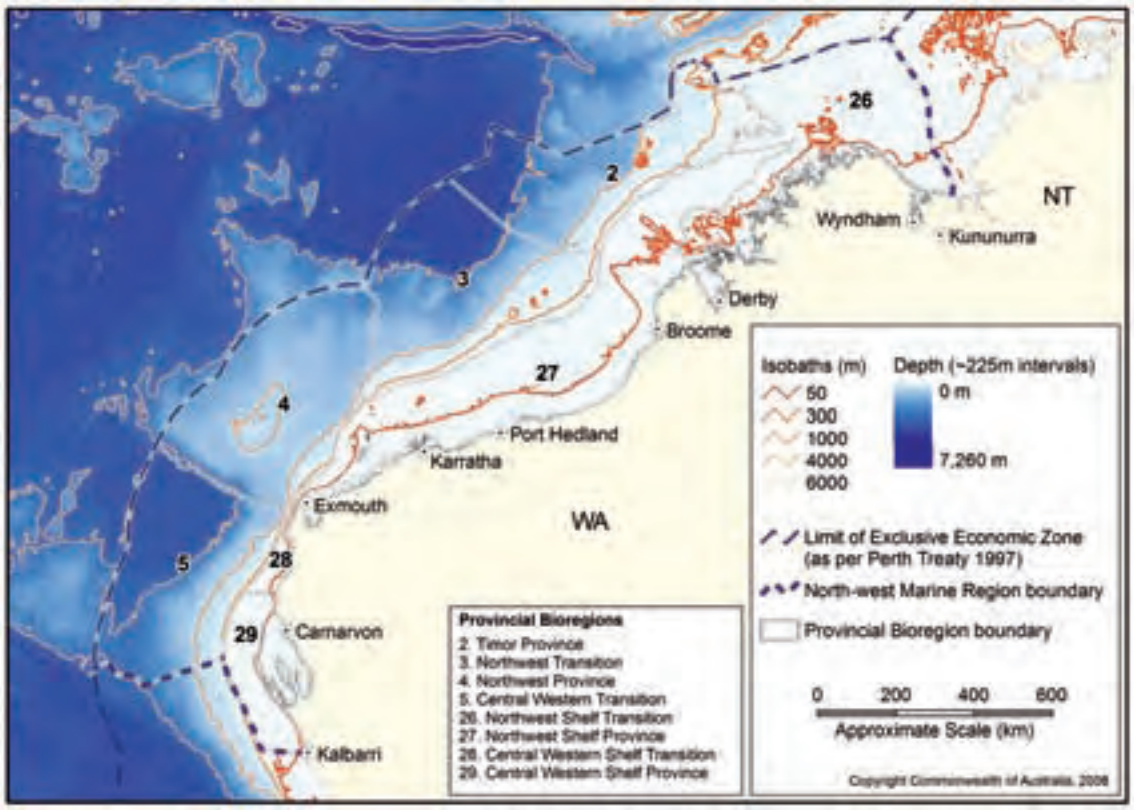
Bioregions well represented by current Marine Protected Areas
• Central Western Shelf Transition (Ningaloo Marine Park, more than 15 per cent of bioregion)
Bioregions not currently represented by any current Marine Protected Areas
• Central Western Shelf Province • Northwest Shelf Transition
Bioregions partially represented by current Marine Protected Areas
• Timor Province (Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve, less than one per cent of bioregion) • Northwest Transition (Mermaid Reef National Nature Reserve, less than one per cent of bioregion) • Central Western Transition (Ningaloo Marine Park, less than one per cent of bioregion) • Northwest Province (Ningaloo Marine Park, less than one per cent of bioregion) • Northwest Shelf Province (Ningaloo Marine Park, less than one per cent of bioregion)

Table 4.2 Depth and area of each bioregion in the North-west Marine Region

Bioregion	Total area - km² (area within the Region in brackets)	Percentage contained within the Region*	Depth range – m (average depth in brackets)
Central Western Shelf Province	50 516 (32 996)	65.3	0–112 (38)
Central Western Shelf Transition	9698 (7340)	75.7	0–106 (51)
Central Western Transition	162 891 (162 891)	100.0	0–5325 (3036)
Northwest Province	178 651 (178 651)	100.0	20–5133 (1597)
Northwest Shelf Province	238 759 (209 743)	87.8	0–140 (49)
Northwest Shelf Transition	305 463 (136 663)	44.7	0–526 (70)
Northwest Transition	184 424 (183 548)	99.5	0–5895 (2144)
Timor Province	156 669 (155 899)	99.5	0–5819 (2022)
Overall	1 287 070 (1 067 730)	83.0	0–5895

*This proportion only includes areas in Commonwealth waters, and excludes areas in State waters.

Figure 4.2 Depth ranges in the North-west Marine Region



suspended and dissolved inorganic and organic matter and living phytoplankton absorb, scatter or reflect light in the upper layers of the water column, shading the lower layers. Coastal run-off during the Northwest Monsoon and mixing of bottom sediments by tide, wind and waves can therefore play an important role in determining the structure and composition of some in-shore benthic and demersal communities. Large proportions of these provincial bioregions are under petroleum leases or are prospective for petroleum.

Specifying Goal 3 - large-scale biological features

The MPA network in the North-west Marine Region will seek to include examples of known large-scale benthic/demersal biological features (i.e. those associated with the seafloor). However, due to a range of factors, including its remoteness, the marine environment of the North-west is one of the least studied in Australia, and our understanding of the ecological communities and habitats within much of the Region is poor. With the exception of offshore islands and reefs (e.g. the Rowley Shoals, Scott Reef and Ashmore Reef), the North West Shelf and the Ningaloo Reef–Shark Bay area, little is known about the large-scale biological features of the Region. The marine bioregional planning process will provide opportunities to identify gaps in our knowledge and improve our understanding of large-scale biological features that may influence identification of areas suitable for inclusion in the MPA network.

Specifying Goal 4 - seafloor features

Different biological communities are often associated with different types of seafloor geomorphology. Ensuring that the characteristic features of each provincial bioregion are represented is important in achieving a comprehensive and representative sample of biodiversity within the MPA network. 'Seafloor features' here refer specifically to the geomorphic features as defined by IMCRA v.4.0.

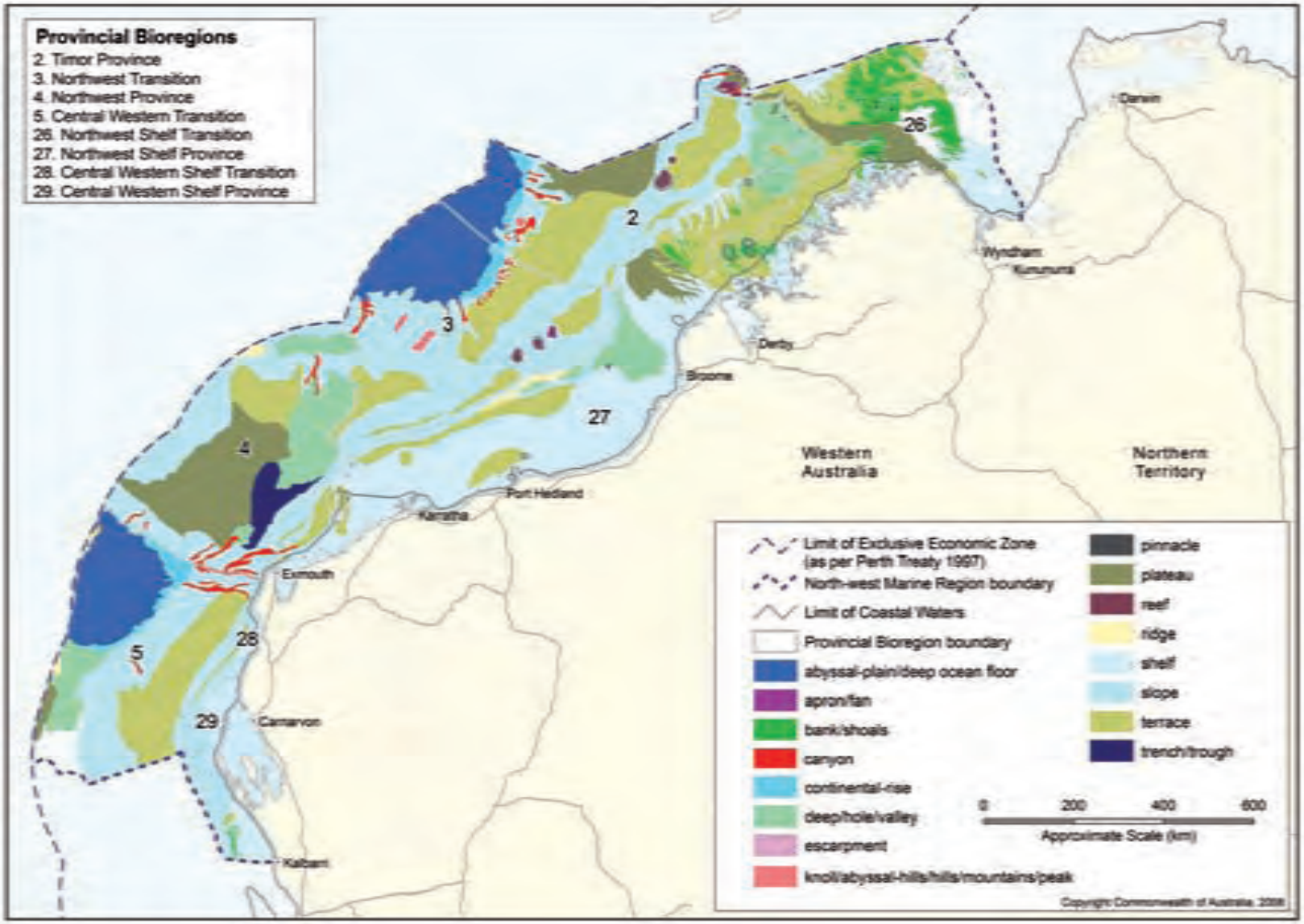
The MPA network in the North-west Marine Region will include representative examples of the 19 seafloor features (topographic or geomorphic) that have been identified in the Region (see Figure 4.3).

Some types of geomorphic or topographic features have very few occurrences within individual bioregions, or indeed across the waters of Australia's EEZ. As a result, the identification of MPAs may be influenced by the location of these features within each bioregion. Over 50 per cent of the banks and shoals, deeps, holes and valleys found in Commonwealth waters (across Australia's EEZ) occur in the North-west Marine Region. Most of the banks and shoals in the Region occur in the Northwest Shelf Transition, while the majority of deeps, holes and valleys are found in Northwest Province and Northwest Shelf Province.

The Region also contains significant areas of terrace, continental slope and tidal sandwave/sand-bank. Areas of terraces and continental slope are well distributed across bioregions off the shelf, while tidal sandwaves/sand-banks are only found in the Northwest Shelf Transition. In addition, seven of the 14 key ecological features identified in Chapter 3 occur around unique seafloor features.

Crinoid at 200 m depth, off Barrow Island. Photo: CSIRO.

Figure 4.3 Geomorphic/seafloor features of the North-west Marine Region



4.2.2 Applying the national principles in the North-west

This section outlines considerations relevant to the regional application of the MPA location, selection, design and zoning principles, as listed in Section 4.1.2. In any given Marine Region there may be different options for MPAs that meet the four goals for the establishment of a representative network. Note that only those principles that require a regional specification (i.e. require input of regionally-specific data) are considered below.

Location of Marine Protected Areas

In developing options that meet the four goals, the following principles will be applied.

Principle 1 - existing spatial management measures

Consistent with the goal, the first step in determining the approximate location of suitable MPAs will be to identify the occurrence, extent and purpose of existing spatial management arrangement (existing MPAs, sectoral management measures, etc) and to assess their capacity to contribute to a representative network in the Region. Spatial management arrangements in the North-west Marine Region and adjacent coastal areas include both temporal and permanent area closures for commercial and recreational fishing, areas managed for conservation objectives and exclusion zones associated with petroleum or communications infrastructure.

Principle 2 – small number of large marine parks

While small MPAs can sometimes be justified to protect a particular species, habitat or heritage site, representative MPAs are designed to include examples of many different environments and ecological processes. While no area of ocean, however large, can be said to be truly self-sustaining, larger areas tend to be more resilient.

Selection

When different options that meet the goals exist, the following selection principles will be considered in selecting areas suitable for inclusion in the National Representative System of MPAs.

Principle 3 - threats to the Region's conservation values

Current and future activities may pose a threat to the Region's marine environment and its conservation values. A key function of Marine Bioregional Plans is the identification of potential threats so that decision-makers are aware of long-term implications of these threats for management. An analysis of the threats to the key ecological features and protected species identified in the Region will take place during the next stage of the planning process (see Chapter 3 and Appendices C and D for more detail). Those key ecological features and places of particular importance to protected species that are subject to threat will be considered for inclusion in the proposed network of MPAs, where spatial measures are thought to be the best option for protection.

Principle 4 - habitat and aggregation areas of threatened or migratory species

While there are no habitats in the North-west Marine Region listed in the *Register of Critical Habitats* under the EPBC Act, this Bioregional Profile identifies several sites of significance to threatened and migratory species that reside in, or migrate through, the Region. Further details on the habitats and sites used by protected species known to occur in the Region are included in the table of Nationally Protected Species of the Region (Appendix C) and Protected Species Report Cards (Appendix D).

Principle 5 - ecologically important pelagic features

Fourteen key ecological features have been identified in the North-west Marine Region (see Chapter 3). Of these, five encompass pelagic environments that are consistent and definable spatial areas. These include Commonwealth waters adjacent to the Rowley Shoals, Ningaloo Reef and Scott and Seringapatam reefs – areas of enhanced biological productivity and high biodiversity. In accordance with Principle 5, these features will be considered in selecting MPAs in those instances where multiple options exist that meet the four national goals. The key ecological features are mapped in Figure 3.1, and details of their values summarised in Table 3.1 (Chapter 3).

Principle 6 - small-scale (tens of kilometres) benthic/demersal ecosystems

Ecosystem structure and functioning have been considered and described in this Bioregional Profile at broad regional and bioregional scales. Where available,

data and information on small-scale ecosystems will be considered to explore options for MPAs that meet the four national goals.

Principle 7 - small-scale distribution of sediment types and sizes

Sediment type and grain size strongly influence the species and communities that are found on and near the seafloor. Below the continental shelf in the deeper parts of the Region, our understanding of the relationship between different sediment types and their associated fauna is particularly poor. However, it is reasonable to expect that by including multiple and diverse types of sediments within the MPA network, the diversity of organisms protected will be maximised.

In instances where different options to meet the four national goals exist, data derived from a sedimentology study undertaken in collaboration with Geoscience Australia will be used to assist in the selection of candidate MPAs, with the aim of including areas that cover a broad range of sediment types.

Principle 9 - socio-economic factors

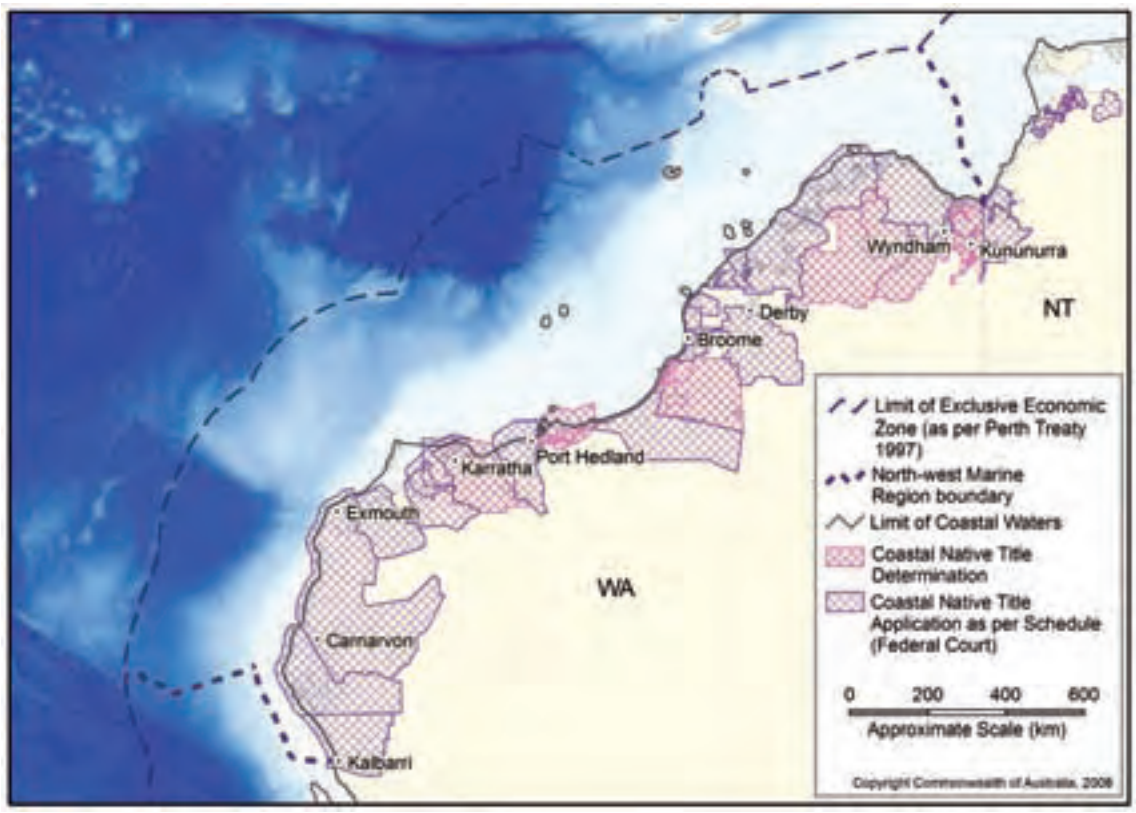
While ensuring that the representative system of MPAs provides significant outcomes for marine biodiversity conservation, the Australian Government is seeking to minimise socio-economic costs associated with displacement of activities or changes in resource access and management that might result from the establishment of MPAs. The potential impacts on current users will be considered throughout the process, particularly during the selection and design stages.

This Bioregional Profile provides summary information about the key commercial and recreational activities that occur in the Region. Reports providing further detailed information on commercial fishing and the expansion of the petroleum and minerals industries in or adjacent to the Region are available on the Department of the Environment, Water, Heritage and the Arts' website <www.environment.gov.au/coasts/mbp/north-west>. Further detailed data on the distribution, intensity and value of marine-based industries in the Region will be gathered in consultation with State Government agencies and relevant stakeholders to inform the development of conservation options during the MPA identification process.

Socio-economic aspects of establishing new MPAs will include the consideration of Native Title rights and interests. Coastal Indigenous peoples across Australia consider their sea country to encompass waters from the coastline to the horizon and sometimes beyond (see Appendix B for a description of the native title regime in Australia and Figure 4.4 for information on Native Title applications and determination in and adjacent to the North-west Marine Region). As of December 2007, 16 native title applications and six determinations had been made over sea country in or adjacent to the Region (National Native Title Tribunal 2008).

Nautilus shell, Ashmore Island. Photo: Australian Institute of Marine Science.

Figure 4.4 ***Native title applications and determinations in and adjacent to the North-west Marine Region***



4.3 Process for establishing new Commonwealth Marine Reserves in the North-west Marine Region

The identification of new MPAs in the North-west Marine Region will occur during the next stages of the marine bioregional planning process and will comprise the steps outlined below.

Step 1 – A proposed MPA network will be developed by the Department of the Environment, Water, Heritage and the Arts in accordance with the national goals and principles and regional specifications, as outlined in Section 4.2. During this time, stakeholders will be consulted by the Department. Stakeholder participation will ensure that the Department has accurate and comprehensive details of the current uses and interests in the Region. This will help ensure that the potential impacts of proposed MPAs on current users of the Region are well understood and minimised. The Department will also seek expert scientific advice to ensure the proposed network is underpinned by relevant and current data and best available knowledge.

Step 2 – The proposed MPA network will be agreed by Government for release in a Draft Plan for a three-month period of statutory public consultation. During this time, the Department will make all relevant data available and will facilitate information sessions to assist members of the public who wish to make representations to the Government in relation to the proposed MPA network or other aspects of the Draft North-west Marine Bioregional Plan.

Step 3 – After consideration of public submissions, advice from the Department, and agreement by the Government, the Final Plan will be released. It will contain a network of candidate MPAs to be declared as designated marine reserves. Marine reserves will be declared in accordance with the relevant sections of Part 15 of the EPBC Act.

Chapter 6 provides further information about how the marine bioregional planning process (including identification of MPAs) will unfold in the North-west Marine Region following the release of this Bioregional Profile.

Key references and further reading

Australian and New Zealand Environment and Conservation Council (ANZECC), Task Force on Marine Protected Areas, 1998, *Guidelines for Establishing the National Representative System of Marine Protected Areas*, Environment Australia, Canberra, <www.environment.gov.au/coasts/mpa/publications/nrsmpa-guidelines.html>, accessed 2/11/2007.

Department of the Environment and Heritage (DEH), 2006, *A Guide to the Integrated Marine and Coastal Regionalisation of Australia Version 4.0*, Commonwealth of Australia, Canberra, <www.environment.gov.au/coasts/mbp/publications/imcra/imcra-4.html>, accessed 2/11/2007.

Department of the Environment, Water, Heritage and the Arts (DEWHA), 2007, *National Representative System of Marine Protected Areas*, Commonwealth of Australia, Canberra, <www.environment.gov.au/coasts/mpa/nrsmpa>, accessed 2/11/2007.

National Native Title Tribunal, 2008, <www.nntt.gov.au>, accessed 23/03/2008.

Potter, A., Baker, C., Tran, M. & Heap A.D., 2006, *Sedimentology and Geomorphology of the North-west Marine Region of Australia*, Geoscience Australia, Canberra.

World Conservation Union, 1994, *Guidelines for Protected Area Management Categories*, IUCN, <www.iucn.org/themes/wcpa/pubs/guidelines.htm>, accessed 30/10/2007.

Legislation

Available from the Commonwealth of Australia Law website <www.comlaw.gov.au>.

Environment Protection and Biodiversity Conservation Act 1999

Native Title Act 1993

Map data

Figure 4.1 Provincial bioregions of the North-west Marine Region (IMCRA v.4.0)

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2006):

Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006):

Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data – Coast and State Borders

Geoscience Australia (2003): Australia, TOPO-2.5M Topographic Data – Drainage and Roads

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Projection: Geographics, Datum: GDA94

Produced by the Environmental Resources Information Network (ERIN)

Australian Government Department of the Environment, Water, Heritage and the Arts

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Figure 4.2 Depth ranges in the North-west Marine Region

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2006):

Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006):

Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Projection: Geographics, Datum: GDA94

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Figure 4.3 Geomorphic/seafloor features of the North-west Marine Region

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2006):

Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006):

Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2003): Australia, TOPO-2.5M Topographic Data – Drainage and Roads

Geoscience Australia (2004): Geomorphic Features of Australia's EEZ

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Projection: Geographics, Datum: GDA94

Produced by the Environmental Resources Information Network (ERIN)

Australian Government Department of the Environment, Water, Heritage and the Arts

Figure 4.4 Native title applications and determinations in and adjacent to the North-west Marine Region

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2006):

Commonwealth Marine Planning Regions

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

National Native Title Tribunal (2007): Native Title Determinations

National Native Title Tribunal (2007): Schedule of Native Title Applications

Projection: Geographics, Datum: GDA94

Produced by the Environmental Resources Information Network (ERIN)

Australian Government Department of the Environment, Water, Heritage and the Arts

Goodwyn Platform, North West Shelf Venture. Photo: Woodside.

Chapter 5 Human Activities and the North-west Marine Region

Planning for long-term ecologically sustainable use of the North-west Marine Region requires an understanding of the full range of human interactions with the marine environment. This chapter provides a broad overview of the nature and extent of the human activities that take place within and adjacent to the Region, as background information to assist in the next stage of the planning process.

This chapter is not intended to provide a detailed information-base for assessing the socio-economic costs and benefits of Marine Protected Areas (MPAs) and other conservation measures that may be proposed in developing the North-west Marine Bioregional Plan. In addition to finer-scale information, that assessment will also require consultation with stakeholders. More information on how the North-west Marine Bioregional Plan will be developed is provided in Chapter 6.

The North-west Marine Region supports a range of economic, social and cultural activities. At present, the major industries within the Region are petroleum exploration and production, commercial and recreational fishing, pearling and tourism. Other marine-based activities relevant to the Region include ports and shipping related to mining, defence training and border protection. These uses of the Region make an important economic and social contribution to settlements along the coast. These settlements range from small towns to the larger regional centres of Carnarvon, Exmouth, Onslow, Karratha, Port Hedland and Broome.

Specific and detailed consideration of the potential impacts of current and future human activities on the Region will be a focus of the next stage of the planning process. Information about interactions between specific activities and protected species that inhabit the Region is included in the protected species group report cards in Appendix D.

The information in this chapter has been drawn from a range of sources including the following works commissioned by the Australian Government:

- *Petroleum and Minerals Industries in the Northwest Marine Region*;
- *The Development, the Status and Socio-economic Linkages of Key Industries Within and Adjacent to the North West Marine Region*;
- *Sea Countries of the North West – Literature Review on Indigenous Connection to and Uses of the North West Marine Region;* and
- *A Socio-economic Overview of the Coastal Communities Adjacent to the North West Marine Region*.

Publications and other web-based resources are available at <www.environment.gov.au/coasts/mbp/north-west>.

5.1 The human dimension: an overview

The north-west of Western Australia supports a range of industries and communities reflecting a diversity of natural resources, environmental values and Aboriginal cultures.

The land adjacent to the Region has been inhabited by Aboriginal people for at least 50 000 years. Their use of the Region and adjacent coastal zone resources and ongoing connection to these areas are discussed further in Section 5.2.

Coastal and marine development since European settlement

Prior to European settlement, Aboriginal people were not alone in their use of coastal marine resources in the Region. Fishers from Makassar in South Sulawesi visited the Kimberley from the early 1700s. There is evidence that a significant trade in marine resources between the Makassans and local Aboriginal communities occurred in the Region. The Makassans collected trepang (sea cucumber), shark fin and turtle for trade with the Chinese.

The Region was one of the sites of first contact between European visitors and Aboriginal people. The Dutch navigator Dirk Hartog landed at Shark Bay in 1616, and in 1644 Abel Tasman mapped much of the coastline from Western Cape York to the Exmouth Gulf, recording many observations about the land and its people. In 1699, the English privateer William Dampier made a more thorough assessment of the coast between Dirk Hartog Island near Shark Bay and Roebuck Bay near Broome. Further exploration by the British took place in the 18th century but, like the Dutch before them, the British concluded the north-west lacked the necessary resources

and environmental conditions to make settlement a worthwhile proposition.

British colonisation of the north-west began on the Pilbara coast in the early 1860s, about 30 years after the establishment of the Swan River Colony (now Perth). Pastoralism was the first major industry in the north-west, and was followed by the establishment of small ports and service centres along the coast with towns emerging at Carnarvon, Roebourne, Point Samson, Port Hedland, Onslow, Broome, Derby and Wyndham.

The emergence of the pearling industry in the late 19th century influenced the development of towns such as Broome. By 1910, nearly 400 pearling luggers and over 3500 people were fishing for mother-of-pearl shell in waters near Broome. The advent of cheaper alternatives to mother-of-pearl led to the near collapse of the industry in the 1940s. However, the introduction of cultured pearl techniques from Japan led to the revival of the industry and today pearling is a significant contributor to the economy of the north-west.

Fishing also had an important early influence on the economic geography of the north-west. From the 1860s, most coastal communities had small fishing fleets that serviced local markets, but significant expansion of the industry occurred with the emergence of the valuable prawn trawling and demersal finfish fisheries.

The discovery of large deposits of iron ore in the Pilbara in the 1950s led to the emergence of the minerals industry in the 1960s and the transformation of the economy of the north-west and the socio-dynamics of its coastal communities. The rapid expansion of the mining industry in the Pilbara resulted in considerable development along the coast, with the construction of large ports at Dampier and Port Hedland, and associated railways and roads. New towns were established at Dampier, South Hedland, Wickham and Karratha to service the minerals industry.

The oil and gas industry emerged in the Region following the discovery of oil at Rough Range near North West Cape in 1954 and of more substantial quantities offshore on Barrow Island in 1964. In the early 1970s, major gas fields were discovered in the offshore Carnarvon Basin leading to the development of onshore Liquefied Natural Gas (LNG) processing facilities in the 1980s and additional infrastructure to support exploration and production.

The Ord River Irrigation Scheme was established in the 1960s to support the development of agriculture in the Kimberley region. The town of Kununurra was built to service the industry. Cotton was originally produced, but was phased out because of rising costs and replaced with crops such as sugar, fruits and vegetables.

The north-west today

Today, the North-west Marine Region and adjacent coastal areas support a number of industries including petroleum exploration and production, minerals extraction, ports, shipping, commercial and recreational fishing, pearling and aquaculture, marine tourism, salt production, agriculture and defence-related activities. In addition, carbon capture and storage associated with the petroleum industry may soon be an important activity.

The marine and marine-related industries operating within and adjacent to the North-west Marine Region are far from static and have experienced significant changes in their economic structure and location. Some major industries, particularly mining and petroleum exploration and development have grown rapidly over the past few decades. More mature industries, such as commercial fishing, while experiencing significant change, have tended to be more stable and in some cases have declined. All of these industries underpin economic growth, employment and social wellbeing in the towns and small communities of the north-west.

In 2006, 91 841 people lived adjacent to the Region (ABS 2006). The population count is based on place of enumeration (place of location on census night) rather than place of usual residence. Place of enumeration gives a better picture of the true population in areas with high tourist numbers or temporary residents (largely associated with mining and petroleum activities) both of which are present in the North-west.

The population is concentrated in the major coastal towns of Carnarvon, Exmouth, Karratha, Port Hedland, Broome, Derby and Kununurra although there are also a number of smaller towns that service specific industries such as mining, fishing and tourism. The north-west also has a large Indigenous population (15 195 or 17 per cent of the total population) with significant populations in Roebourne, where over 50 per cent of the town's 992 residents are of indigenous descent; Derby, 40 per cent; and Wyndham, 35 per cent; as well as the smaller Indigenous settlements of Bardi, Beagle Bay and Kulumbaru in the Kimberley region.

Between 2001 and 2006, the population in the north-west increased by 4610, or five per cent, and there was significant variation in population growth within the region. Of particular note is the 14 per cent increase in population in the Pilbara region. This growth can be attributed to the expanding petroleum and minerals sectors exemplified by an increase of nearly 25 per cent in residents in the largely industrial town of Karratha.

In contrast, the population in the Gascoyne region has declined by almost four per cent, particularly in Carnarvon (over seven per cent). This could be a reflection of the mature nature of the agricultural and fishing industries that form the basis of the Gascoyne economy. Table 5.1 shows the change in population over 2001–2006.

A feature of the north-west's population is its high mobility. Almost 21 per cent of people living in the north-west who took part in the 2006 Census were located at a different address one year earlier to the census and over 41 per cent had shifted home address since 2001. This feature is particularly prevalent in the resource-dependent centres of Karratha and Port Hedland, and largely reflects the highly cyclical nature of the resource economy where labour is contracted for short to medium periods during the development and construction phases of major projects.

In 2006, the number of people employed in the north-west was 30 822, which was a four per cent increase from 2001 (1210 more employed people). The most significant employment sectors were construction (11.7 per cent), mining (10.8 per cent), retail trade (9.3 per cent) and health care (8.9 per cent). However, the aggregated labour force statistics tend to mask the relative importance of certain industry sectors to particular regional communities. For instance, the agriculture, fisheries and forestry sector is an important provider of employment in Carnarvon and Kununurra, while in Karratha, Dampier and Port Hedland, mining, construction, and transport and storage are significantly more important.

Table 5.1 Population change in areas adjacent to the North-west Marine Region, 2001–2006

	Population		Absolute change	Per cent change
	2001	2006	2001–2006	2001–2006
Western Australia	1 851 252	1 986 249	134,997	7.2
Total population of areas adjacent to the North-west Marine Region	87 231	91 841	4610	5.3
Sub-regions				
Gascoyne (G)	13 419	12 883	-536	-3.9
Pilbara (P)	35 961	40 837	4876	13.5
Kimberley (K)	37 851	38 121	270	0.7
Regional centres				
Carnarvon (G)	7273	6729	-544	-7.4
Exmouth (G)	3137	3156	19	0.6
Karratha (P)	10 796	13 253	2457	23
Port Hedland (P)	12 776	12 908	132	1.0
Broome (K)	15 906	17 355	1449	9.0
Derby (K)	3688	3479	-209	-5.6
Kununurra (K)	5485	5617	132	3.4

Source: Clifton *et al*. 2007

Figures from the Australian Taxation Office (ATO) indicate that in 2005–2006, the mean annual taxable income in the north-west was $50 986, compared to the Western Australian average of $48 696 (ATO 2008). However, as shown in Table 5.2, this masks significant sub-regional differences. For example, competition for skilled workers in the minerals and petroleum sector has resulted in the towns of Port Hedland, Karratha and Dampier recording average incomes of $63 600, $64 537 and $72 458 respectively. While Dampier recorded the highest mean annual taxable income out of all towns adjacent to the Region, its population was relatively small with just over 2000 people. As a result mean income may be skewed towards a small number of high earning individuals rather than being representative of the entire population.

In areas with a greater reliance on the service sectors and higher Aboriginal populations there tend to be lower wages and educational levels and a higher dependency on welfare and benefits. Centres with relatively large Indigenous populations and service-based economies include Carnarvon, Derby, Kalbarri and Broome, all of which had average incomes below the State average.

Table 5.2 Mean annual taxable incomes for individuals in townships adjacent to the Region (2005–2006)

Location	2004-2005($)	2005–2006($)
Western Australia	45 660	48 696
Regional centres		
Carnarvon	40 005	42 913
Exmouth	45 234	44 145
Karratha	59 230	64 537
Port Hedland	62 309	63 600
Broome	42 313	45 325
Derby	41 426	42 416
Kununurra	49 202	52 819
Smaller towns		
Kalbarri	36 393	39 844
Denham	38 807	41 251
Onslow	46 264	50 348
Dampier	64 879	72 458
Wickham	58 870	64 082
Roebourne	42 343	43 352
Wyndham	42 471	46 716

Source: ATO (2008)

Pier at Coral Bay, Western Australia. Photo: Photolibrary.

5.2 Indigenous links to the Region

Historical connection to the Region

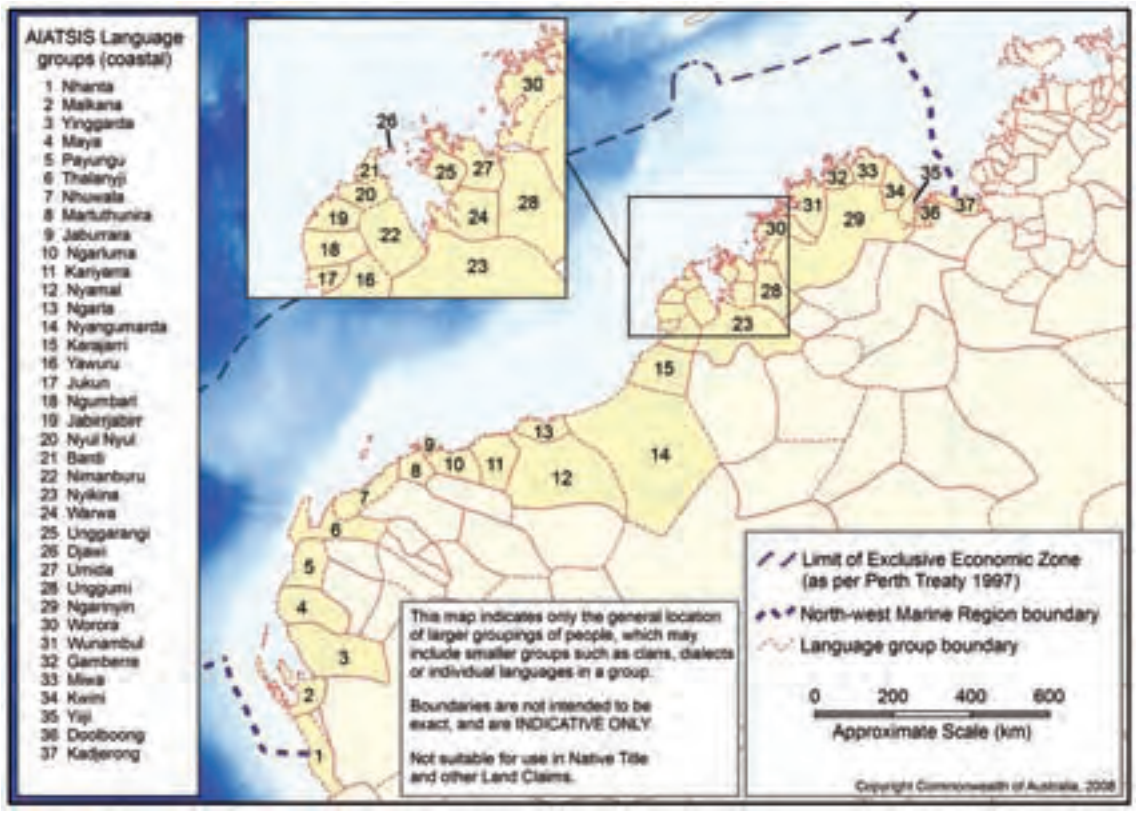
Indigenous people have a strong on-going association with the Region that extends from the beginning of human settlement in Australia some 50 000 years ago to the present. While sea level change over millennia has significantly altered many sites of significance to Indigenous people in the north-west, evidence of the close, long-standing relationship between Aboriginal peoples and the coastal and marine environments of the area is plentiful. The extensive and diverse assemblages of rock engravings (petroglyphs) at the Burrup Peninsula, which is one of the most significant collections of petroglyphs found anywhere in the world, is one of the most spectacular examples.

The saltwater peoples of the north-west continue to rely on coastal and marine environments and resources for their cultural identity, health and wellbeing, as well as their domestic and commercial economies. They are resident in most of the major population centres as well as in more remote areas adjacent to the Region. There are at least 35 different language groups in the area, as shown in Figure 5.1.

The Indigenous peoples of the north-west coast belong to discrete clan estates and language groups that occupy, or traditionally occupied, discrete areas or country. 'Country' refers to a place of origin – literally, culturally or spiritually (Australasian Legal Information Institute 2007) and 'sea country' or 'saltwater country' are terms that refer to an estate or cultural domain in which no separation between land and sea is made. Sea country may include bays, open ocean, beaches, dunes, reefs, coastal wetlands or other features, including remembered features of landscape long ago drowned by rising sea levels (see Box 5.1). Fishing, hunting and the maintenance of maritime cultures and heritage through ritual, stories and traditional knowledge continue as important uses of the nearshore region and adjacent areas.

The characteristics of each particular coastal environment as well as particular aspects of the culture of different Indigenous peoples in the north-west influence the relationship they had and continue to have with the sea. In some areas, such as Geraldton and Carnarvon, a high number of resident Aboriginal people have traditional connections to inland regions, and some of these people fish in others' sea country for

Figure 5.1 ***Distribution of Aboriginal coastal language groups in the north-west***



Box 5.1 Clans and saltwater country

Traditionally, the fundamental social unit around most of coastal Australia was the extended family or 'clan'. Intimately associated with each clan was their estate or 'country'. For coastal clans, their country always included the adjoining estuaries, beaches, coastal waters and ocean. The sea, or saltwater country, was not additional to a clan estate on land, it was inseparable from it. As on land, saltwater country contained evidence of the Dreamtime events by which all geographic features, animals, plants and people were created. It contained sacred sites, often related to these creation events, and it contained tracks, or song lines along which mythological beings travelled during the Dreamtime. The sea, like the land, was integral to the identity of each clan, and clan members had a kin relationship to the important marine animals, plants, tides and currents.

In the Region, the flooded countries of Aboriginal ancestors lie beneath Commonwealth waters and may be connected to cultural stories, sites and Dreaming tracks that may extend into Commonwealth waters. Dugongs, fish and turtles that move between coastal and Commonwealth waters in the Region are important components of Aboriginal people's culture and diet.

The relationship Aboriginal people have with the sea today is built on these traditional rights and responsibilities. The sea remains a part of their country, and is most evident in coastal communities where traditional activities such as turtle and dugong hunting, subsistence fishing and shell collecting are practiced (Smyth 2007).

purely social and economic reasons. In places that have large areas of sheltered waters, like Shark Bay, King Sound and the Dampier and Buccaneer archipelagos, saltwater people tend to make extensive sea journeys. In areas with more exposed coastlines and an absence of nearshore islands or reefs, use of the sea tends to be localised around intertidal and inshore areas. In many places, including Broome, Aboriginal people continue to rely heavily on sea resources for food and other needs (Smyth 2007).

Marine resource use by Indigenous people is generally restricted to coastal waters that are under State jurisdiction and lie adjacent to the North-west Marine Region. However, while direct use by Aboriginal people of the Region's marine environment and resources is limited, many groups continue to have a direct cultural interest in decisions affecting the management of Commonwealth waters. The cultural connections Aboriginal people maintain with the sea may be affected, for example, by activities such as commercial, recreational and illegal foreign fishing, shipping, and oil and gas exploration and development. In addition, some Indigenous people are involved in commercial activities such as fishing and marine tourism, and so have an interest in how these industries are managed in Commonwealth waters with respect to their cultural heritage and commercial interests.

Legislation

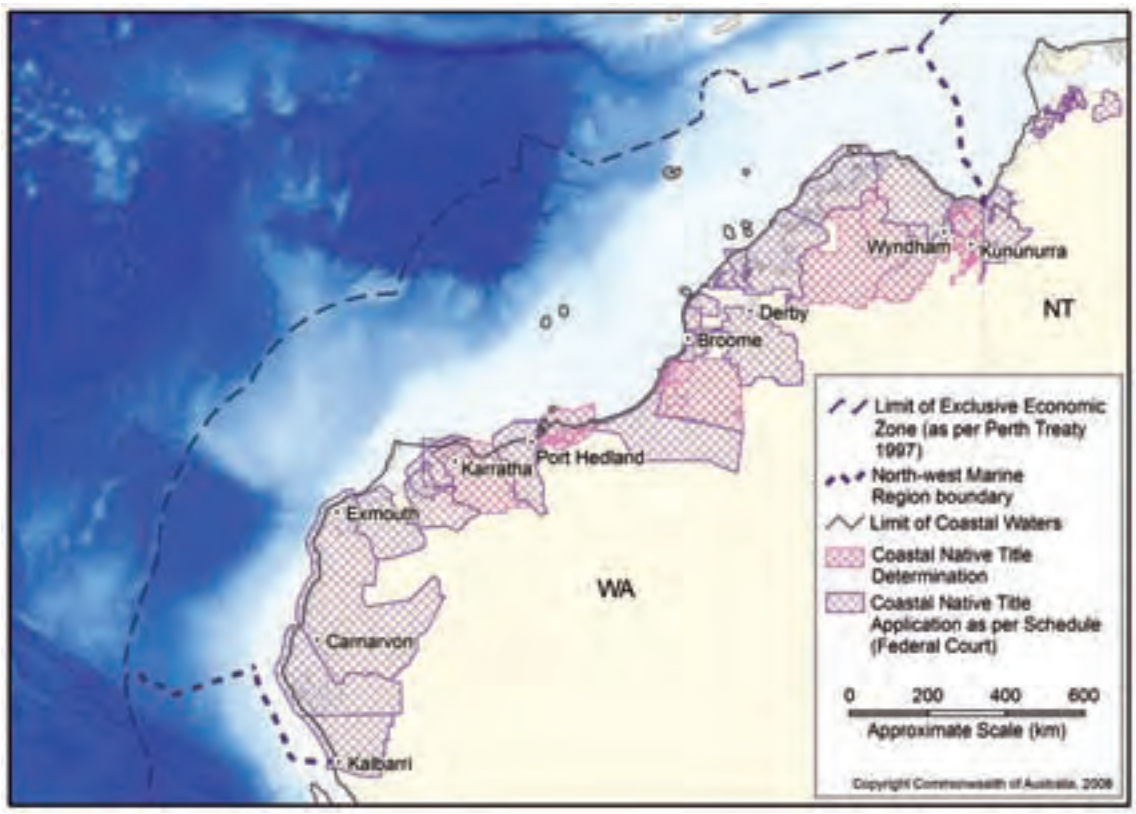
Native title is the recognition in Australian law that some Indigenous people continue to hold rights to their lands and waters that come from their traditional laws and customs (National Native Title Tribunal 2006). The *Native Title Act 1993* provides for the recognition of native title on land and in the sea. Native title rights may include traditional fishing rights.

In Western Australia, the Office of Native Title (ONT) is responsible for the implementation of the State Government's native title policy, which aims to mediate the determination of native title applications rather than going through the process of litigation. The emphasis is on reaching agreements about where native title exists, but where it is not possible to reach agreement, the State may provide alternative, non-native title land outcomes (ONT 2007), for example through the Aboriginal Lands Trust program.

The *Aboriginal Affairs Planning Authority Act 1972 (WA)* establishes the Aboriginal Lands Trust which is administered by the Western Australian Government Department of Indigenous Affairs (DIA). The primary purpose of the Aboriginal Lands Trust is to acquire and hold land and to facilitate the transfer of that land to Native Title Representative Bodies for the benefit of persons of Aboriginal descent (DIA 2007).

As of December 2007, 16 native title applications and six determinations had been made over sea country in or adjacent to the Region (National Native Title Tribunal 2008). The native title application/determination areas for the Northern Pilbara and Kimberley regions, including those that extend into Commonwealth waters, are shown in Figure 5.2.

Figure 5.2 *Native title applications and determinations in and adjacent to the North-west Marine Region*



L-R: Ju-Ju Wilson, Maureen Martin and Roy Martin, Lacrosse Island. Photo: Steve Kinnane.

Fisheries legislation in Western Australia recognises customary fishing by Aboriginal people as different to commercial and recreational fishing. Western Australia's Draft Aboriginal Fishing Strategy (2003) recognises Aboriginal Customary Fishing as a legitimate fisheries sector in terms of fisheries allocation and management, and promotes Aboriginal involvement in commercial fishing industries and their management. Some of the regulations that apply to recreational fishing also apply to customary fishing, for example, size limits, closed seasons and protected species. However, bag limits are different and some traditional fishing methods are permitted to allow for cultural events and passing-on of cultural knowledge (Aboriginal Fishing Strategy Working Group 2003).

Aboriginal involvement in resource management

Aboriginal people continue to actively manage their sea country in and adjacent to the North-west Marine Region in order to protect and manage the marine environment, its resources and cultural values. Some management arrangements involve collaboration with government agencies or other Aboriginal groups. For example, the Bardi Jawi people work with the Australian Customs Service and the Western Australian Department of Fisheries (DoF) as rangers patrolling the Kimberley coast for illegal foreign fishers (DoF 2007).

Through the North Australian Indigenous Land and Sea Management Alliance (NAILSMA), traditional owners are working to sustainably manage marine turtles and dugongs, including monitoring their populations and habitats, and identifying research and management needs (NAILSMA 2006). In the south Kimberley, Aboriginal people are involved in developing a management plan for Roebuck Bay and a coastal management plan to protect natural and cultural values along the coastline of Karajarri country south of Broome (KLC 2007).

In the Pilbara region, the Burrup Peninsula Conservation Reserve has been proposed to protect the significant cultural heritage sites in the area, including sacred sites, petroglyphs and archaeological sites containing evidence of early Aboriginal occupation and use and early contact with Europeans. The agreement between the Western Australian Government and the Ngarluma Yindjibarndi, Wong-goo-tt-oo and Yaburara Mardudhunera Traditional Owners to establish the reserve includes the transfer of freehold title for over 60 per cent of the Burrup Peninsula to the Ngarda-ngarli custodians. The reserve will be the first statutory protected area in Western Australia to be owned by Aboriginal people and will be jointly managed by the Traditional Custodians and the Western Australian Department of Environment and Conservation (DEC), through an arrangement under the *Conservation and Land Management Act 1984* (DEC 2006).

Commercial interests

While involvement of Aboriginal people in the ownership or management of marine-based commercial activities remains at low levels, at Shark Bay the Yadgalah Aboriginal Corporation is part owner of the Monkey Mia tourist operation and Aboriginal fishers hold six of the 10 licences in the commercial Shark Bay Beach Seine and Mesh Net Managed Fishery (Fletcher & Santoro 2007).

In the Kimberley region, a number of Aboriginal-owned fishing charter enterprises operate out of One Arm Point. Aboriginal people also have a historical involvement in the trochus shell industry, which began at One Arm Point in the late 1800s. Licences are now held by the One Arm Point community and two Aboriginal corporations at Lombidina and Derby.

Trochus shell. Photo: Australian Institute of Marine Science.

5.3 Marine activities

This section provides a background to the most prominent non-Aboriginal industry sectors' activities in the North-west Marine Region and adjacent coastal areas.

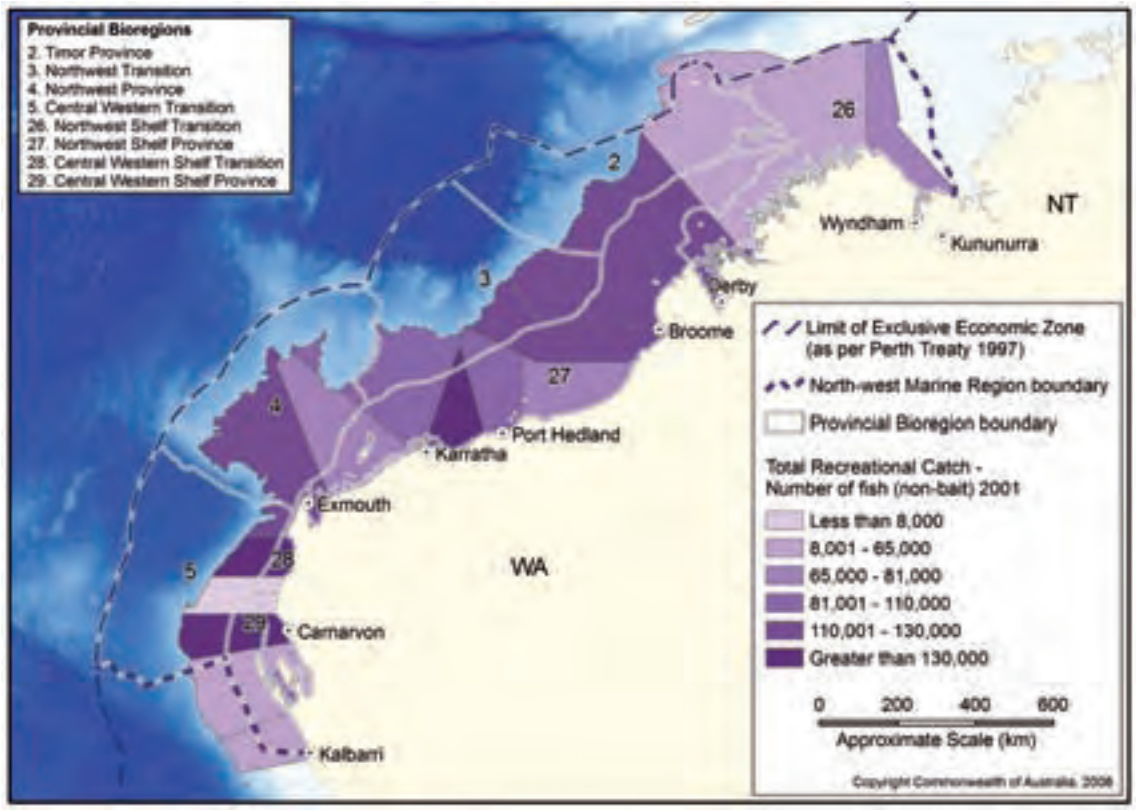
5.3.1 Recreational fishing

Recreational fishing is a popular activity in the North-west Marine Region, although most recreational fishing occurs in State waters adjacent to the Region. Commonly targeted species include members of the demersal sea perch family, emperors, coral trout, sharks, tunas, mackerels and species of gamefish.

Recreational fishing tends to be concentrated in State waters adjacent to population centres. Figure 5.3 presents information on total recreational fish catch in the north-west in 2001. It indicates that the highest recreational fishing effort is off Point Samson, (a favoured holiday location for people from the mining and petroleum towns of Dampier and Karratha), Coral Bay (reflecting high visitor numbers to Ningaloo Marine Park) and Carnarvon. Most recreational fishing effort occurs in the provincial bioregions on the continental shelf south of the Kimberley: the North-west Shelf Province, the Central Western Shelf Transition Province and the Central Western Shelf Province. Prime gamefishing locations are around offshore atolls and reefs, including the Rowley Shoals in the Northwest Transition, (although the Mermaid Reef Marine National Nature Reserve in the Rowley Shoals is closed to all forms of fishing). Recreational fishing effort is lowest in the Northwest Shelf Transition largely because of the remoteness and inaccessibility of these waters.

A 2005 survey of recreational fishers in Western Australia recorded that more than 536 000 individuals (or 31 per cent of the State population) participated in recreational fishing. The survey collected data on the basis of Western Australian Department of Fisheries (DoF) fishery regions and found that 11 percent of the State's recreational fishers fished in waters adjacent to the Gascoyne region (Shark Bay to Onslow) and seven per cent in the North region (Onslow to Kununurra) (Baharthah 2006). Recreational fishing is experiencing significant growth, particularly in the North region in winter months when tourists visit coastal areas around Onslow, the Dampier Archipelago and Broome (Fletcher and Head 2006).

Figure 5.3 Recreational fishing in the Region in 2001



Reliable information on the economic contribution made by recreational fishing to communities in the north-west is not available. However, DoF figures of participation provide an indication of the socio-economic importance of recreational fishing to townships adjacent to the Region as well as its potential impact on the marine environment.

Given the expanding population growth in the north-west region, particularly because of the growing petroleum and minerals sectors in the Pilbara, the popularity of recreational fishing is likely to continue to increase. High incomes, advances in technology and increases in vessel size are likely to result in increased recreational fishing effort in both State and Commonwealth waters.

The DoF regulates recreational fishing in offshore and State waters through its Integrated Fisheries Management Branch. Management methods include bag limits, gear restriction and zoning. Regional surveys are conducted to provide data on fishing effort at popular fishing sites as a means of managing important recreational fish stocks. Further information about Western Australian recreational fishing regulations can be found at <www.fish.wa.gov.au>.

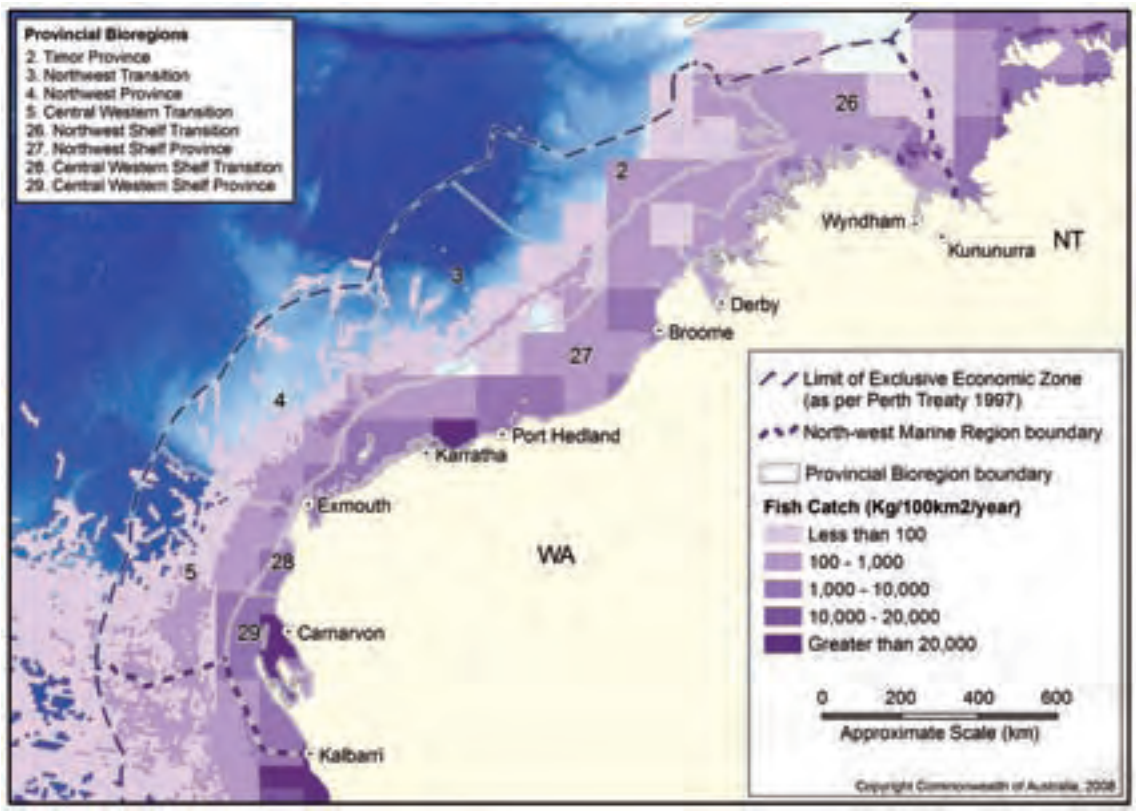
5.3.2 Commercial fishing

The waters off the north-west coast of Western Australia have been fished steadily over several decades by domestic fishers operating in both Australian Government-and Western Australian Government-managed fisheries. In the post-World War II period, the Region was also heavily fished by foreign vessels, most notably from Taiwan, Japan, China and Indonesia.

Today, there are 14 fisheries recording catch within the North-west Marine Region with another 12 primarily operating in State waters adjacent to the Region. All these fisheries are managed by either the Australian Government through the Australian Fisheries Management Authority (AFMA), or by the Western Australian Government through the DoF. The species targeted include prawns, scalefish, scampi, shark, pearl oysters, crabs and bêche-de-mer (trepang or sea cucumber).

Based on 2005–2006 data for AFMA-managed fisheries and 2006 data for DoF-managed fisheries, the total commercial catch of fisheries operating in the Region was approximately 7000 tonnes of fish, prawns and crab, and 538 882 pearl oysters. The Gross Value of Production (GVP) of this catch was an estimated $165 million, of which $122 million was from the pearl

Figure 5.4 Combined catch for all commercial fishers operating in or adjacent to the North-west Marine Region (2000–2002)



fishery. The geographic scale and relatively low value of many fisheries in the north-west, combined with data confidentiality issues (where there are less than five vessels operating in an area), mean that data tend to be available only for the fishery as a whole, including when the fishery extends beyond the Region. The catch tonnage and GVP figures given above are therefore for entire fisheries and not just the proportion caught in the Region. The exception is the North West Slope Trawl Fishery, which operates entirely within the Region. The most recent available information on the spatial distribution of the combined commercial catch of all fisheries operating in or adjacent to the North-west Marine Region is from 2000–2002 (Figure 5.4).

Fisheries managed by the Australian Government

There are four AFMA-managed fisheries in the North-west Marine Region: the Western Deepwater Trawl Fishery, the North West Slope Trawl Fishery, the Western Tuna and Billfish Fishery and the Northern Prawn Fishery (Bonaparte Statistical Area). In 2005–2006, the combined catch value of these fisheries was $7 million and the total landed catch was approximately 780 tonnes. While the Northern Prawn Fishery is the most valuable commercially managed fishery in the Region, only a small proportion of the fishery occurs in the Region, with the larger and more valuable component occurring in the adjacent North Marine Region.

In contrast to the Northern Prawn Fishery, the North West Slope Trawl Fishery and the Western Deepwater Trawl Fishery are small-scale and considered economically marginal because of high operating costs and low prices for product (Larcombe & McLoughlin 2007). Fishers active in these fisheries tend also to operate in other fisheries including the Northern Prawn Fishery. The Western Tuna and Billfish Fishery extends into the Region, but fishing activity in the Region is limited.

Table 5.3 provides a summary of the AFMA-managed fisheries operating in the Region, including the main locations of fishing effort, species caught, fishing method, catch volume and value, and number of licences/boats active within each fishery. As mentioned previously, because of the way data are collected, except where otherwise indicated, catch and GVP figures are for the entire fishery and not just the component occurring in the Region.

Fisheries managed by the Western Australian Government

There are 10 DoF-managed fisheries operating in both the North-west Marine Region and adjacent State waters. These fisheries generally have higher catch levels and value than AFMA-managed fisheries and include the Pilbara Demersal Finfish fisheries (comprised of the Pilbara Fish Trawl (Interim) Managed Fishery, the Pilbara Trap Managed Fishery, and a small line fishery component), the Northern Demersal Scalefish Fishery, the Western Australian North Coast Shark Fishery, the Pearl Oyster Fishery, the West Coast Deep Sea Crab Fishery, the Shark Bay Snapper Fishery, the West Coast Demersal Scalefish Fishery, the Mackerel Interim Fishery, the Kimberley Prawn Fishery and the Bêche-de-mer Fishery.

The most valuable fishery operating in the Region is the Pearl Oyster Fishery, which harvests wild pearl oysters as the first stage in the pearl production process. The fishery's value is measured in the price received for the end product, cultured pearls. The value of cultured pearls in 2006 was $122 million, which is 74 per cent of the total value of commercial fishery catch in the Region. However, these figures do not reflect the true contribution of the pearl fishery to the value of the Region's fisheries because the main pearl fishing areas are in State waters. More information on pearling is in Section 5.3.5.

The Pilbara Demersal Finfish fisheries and Northern Demersal Scalefish Fishery are the principal finfish fisheries in the Region and target high-value tropical finfish, particularly emperors, snappers and cods. These profitable fisheries are the most valuable finfish fisheries managed by Western Australia, with a value of $15.1 million in 2006.

In addition to the Western Australian fisheries operating in both Commonwealth and State waters, there are a wide range of DoF-managed fisheries active in State waters adjacent to the Region. These include three of the State's most valuable fisheries – the Shark Bay Prawn, Exmouth Gulf Prawn and Shark Bay Scallop fisheries, which have a combined landed catch value of $40–50 million annually.

Table 5.4 provides a summary of the DoF-managed fisheries operating in the Region. Note that because of the way data are collected, except where otherwise indicated, the catch and GVP figures are for the entire fishery and not just the component occurring in the Region.

Table 5.3 AFMA-managed fisheries active within the Region (2005–2006)

Fishery	Main area of fishery by catch and bioregion	Relationship to North-west Marine Region	Main species targeted	Main fishing method	Tonnes caught	Number of licences/ vessels	GVP ($ million)
North West Slope Trawl Fishery [1,2,3]	Concentrated on muddy bottoms along depth contour lines, just outside the 200 m isobath. Fished in the vicinity of Rowley Shoals, Scott and Ashmore reefs (Bioregions: Timor Province, Northwest Transition and Northwest Province).	Active in the Region only.	Scampi, deepwater prawn.	Demersal trawling	43.4	7 vessels (2005–2006)	0.68
Western Tuna and Billfish Fishery [4]	Minor activity in the far south of the Region from continental shelf outwards (Bioregions: Northwest Province and Central Western Transition).	Operates primarily in the South-west Marine Region but fishery extends into south of Region.	Yellowfin, bigeye, skipjack, albacore tuna, some billfish species.	Pelagic longline	480	7 vessels (2005–2006)	2.7
Western Deepwater Trawl Fishery [5]	Concentrated along the 200 m isobath off the Gascoyne coast (Bioregions: Central Western Transition, Central Western Shelf Transition and Central Western Shelf Province).	Fishing effort primarily in Region with some in adjacent South-west Marine Region.	Mixed fish species.	Otter trawl	not available	3 vessels (2005–2006) permits	0.9
Northern Prawn Fishery [6] (Bonaparte Statistical Area – includes State and Commonwealth waters)	On the continental shelf in muddy and sandy substrates in coastal to deeper waters (Bioregion: Northwest Shelf Transition).	Fishery operates primarily in North Marine Region but extends into Joseph Bonaparte Gulf.	Largely banana prawn in North-west Marine Region and some tiger prawn.	Otter trawl	231 (Bonaparte Statistical Area estimate) 5400 (whole fishery)	52 vessels (whole fishery)	2.8 (Bonaparte Statistical Area estimate) 73 (whole fishery)

Sources:

1 Newton *et al.* (2007)
2 Moore *et al.* (2007a)
3 Larcombe & McLoughlin (2007)
4 Newton *et al.* (2007)
5 Newton *et al.* (2007)
6 Raudzens (2007)

Table 5.4 DoF-managed fisheries in the Region (2006)

Fishery	Main area of fishery by catch and bioregion	Relationship to North-west Marine Region	Main species targeted	Main fishing method	Tonnes caught	Number of licenses	GVP ($ million)
Pilbara Demersal Finfish Fisheries (comprised of Pilbara Fish Trawl (Interim) Managed Fishery and the Pilbara Trap Managed Fishery)	North West Shelf (Bioregion: Northwest Shelf Province).	Fishery extends into North-west Marine Region.	Range of tropical finfish species – bluespot emperor, crimson salmon, threadfin bream, red emperor	Trawl, trap and line	2800 (Trawl, 2222; Trap, 473; and line, 105)	26 (Trawl, 11; trap, 6 and line, 9) vessels	10.5 (Trawl, 7.5; trap 2.5 and line 0.5)
Northern Demersal Scalefish Fishery	Waters from Broome to Western Australia/ Northern Territory border 30–200 m depth (Bioregions: Northwest Shelf Province and Northwest Shelf Transition).	Fishery extends into North-west Marine Region.	Goldband snapper, red emperor	Handline, dropline, traps	801	11	4.6
Pearl Oyster Fishery (wild caught) - most fishing in Western Australia waters	Inshore waters largely 10–20 m depth (Bioregion: Northwest Shelf Province).	Fishery extends into North-west Marine Region.	Silver lipped oysters	Hand collection	538 882 pearl oysters	17 licensees	122
West Coast Deep Sea Crab Fishery	Depths of 150–1200 m in Commonwealth waters around the shelf break parallel from Exmouth to Kalbarri (Bioregions: Central Western Transition, Central Western Shelf Province and Central Western Shelf Transition).	Fishery extends into North-west Marine Region.	Giant (king) crabs, crystal (snow) crabs, champagne (spiny) crabs	Pot	207	7 permits (5 full-time, 2 part-time)	2.4
Shark Bay Snapper Fishery	Continental shelf waters off Shark Bay (Bioregion: Central Western Shelf Province).	Fishery extends into North-west Marine Region.	Oceanic stock of pink snapper, goldband snapper, red emperor	Mechanised handlines	540 (318 pink snapper; 222 other species)	53 licences	3.4
Mackerel Interim Managed Fishery	Around reef, shoal and headland waters (Bioregion: Northwest Shelf Transition, Northwest Shelf Province and Central Western Shelf Province).	Fishery extends into North-west Marine Region.	Spanish, grey and other mackerel	Trolling or handline	291	18 permits	2.7

Fishery	Main area of fishery by catch and bioregion	Relationship to North-west Marine Region	Main species targeted	Main fishing method	Tonnes caught	Number of licenses	GVP ($ million)
West Coast Demersal Scalefish Fishery	Waters adjacent to Kalbarri (26°30´ S to 28° S). Inner shelf zone to 150 m contour (pink snapper). Outer shelf (150 m+) snapper and jobfish (Bioregions: Central Western Shelf Transition and Central Western Shelf Province).	Fishery extends into North-west Marine Region.	Pink snapper, emperors plus other scalefish.	Handlines and droplines	975	60 permits	7.8
Kimberley Prawn Fishery	Bioregion: Northwest Shelf Transition.	Extends into North-west Marine Region. and abuts western boundary of the Northern Prawn Fishery.	Banana prawns. Secondary species - tiger, endeavour and king prawns	Trawl	335	137 licences although only 22 boats actually operated in 2006	3.1
Bêche-de-mer (trepang) Fishery	Muddy, sandy bottomed areas from waters adjacent to Exmouth Gulf to Northern Territory border.	Fishery extends into North-west Marine Region.	Sandfish	Hand collection by diving	56	6 endorse-ments	0.45
Western Australian Tropical Shark fisheries (2004–2005 season) (includes Western Australia North Coast Shark Fishery (WANCSF) and the Joint Authority Northern Shark Fishery (JANSF))	Continental shelf waters (Bioregions: Northwest Shelf Province, Timor Province and Northwest Shelf Transition).	Fishery extends into North-west Marine Region.	Blacktip, tiger, hammer-head , lemon and sandbar sharks	Demersal longline and some gillnetting.	189	14 permits 9 in WANCSF and 5 in JANSF	0.49

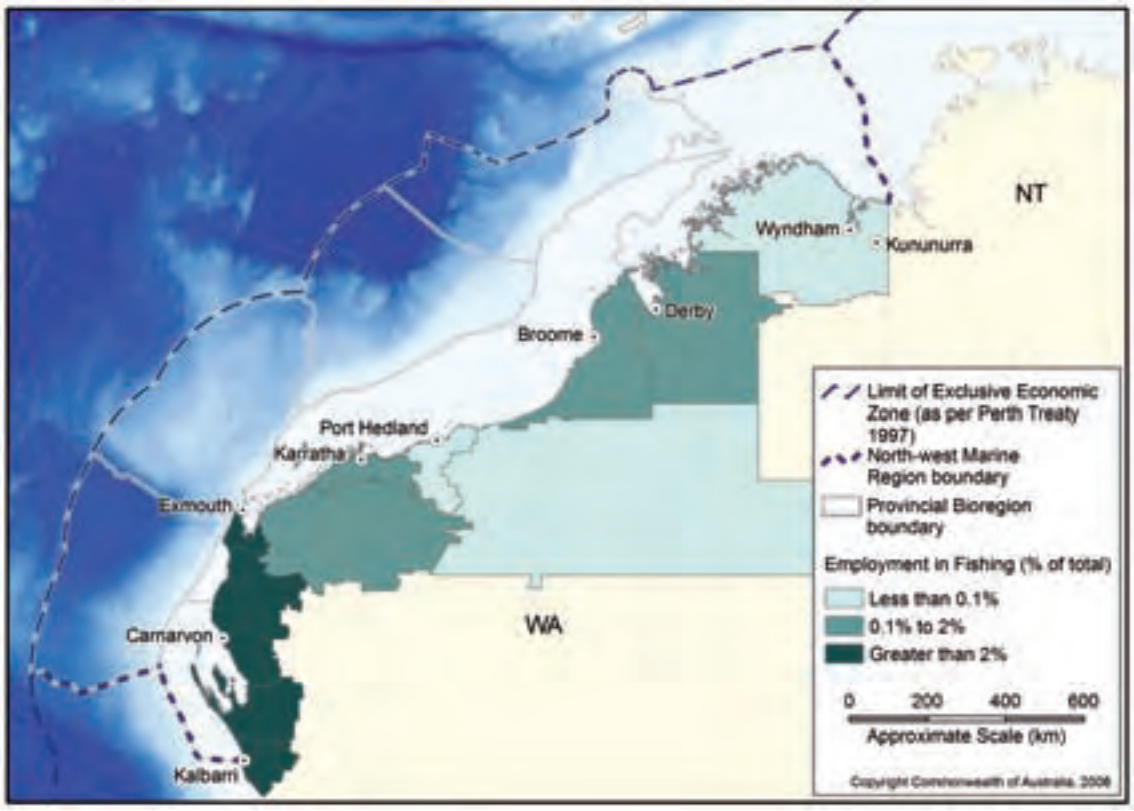
Sources: Fletcher & Santoro (2007); Heupel & McAuley (2007)

Employment

The fishing industry and related businesses are important sources of employment in the coastal communities adjacent to the Region as reflected in Figure 5.5. In 2006, the estimated number of individuals directly employed in State-managed fisheries that operate in the Region was around 330 (Fletcher & Santoro 2007). Employment in AFMA-managed fisheries in the Region is more difficult to determine because operators tend to be active in more than one fishery. For example, the North West Slope Trawl Fishery and Western Deepwater Trawl Fishery are opportunistically and seasonally fished by Northern Prawn Fishery operators (Clifton *et al*. 2007). Nonetheless, the number employed in AFMA-managed fisheries would be considerably fewer than in the DoF-managed fisheries. Because skippers and crew may work in more than one fishery, employment figures may overestimate the number of individuals directly employed in commercial fishing. However, it is more probable that they underestimate total employment in commercial fishing, because the majority of employment is either part-time or seasonal, and direct employment figures tend not to account for the contribution of family members to the fishing business. Nor do employment figures for the industry reflect the importance for communities of jobs generated downstream by fishing.

The main fish processing and wholesaling facilities adjacent to the Region are located at Denham, Carnarvon, Exmouth, Onslow and Broome. Figures from the ABS (2006) indicate that 137 individuals were directly employed in fish processing and wholesaling in towns adjacent to the Region in 2006. The Pearl Oyster Fishery directly employed 72 individuals in 2006 but the downstream pearl industry employed an estimated 500 people in north-west coastal communities (Fletcher & Santoro 2007). The future of fisheries in the Region is dependent upon a number of factors, including the long term availability of adequate stocks, costs associated with accessing fishing grounds, price received for catch and the distance from ports and markets. Also significant is the shortage of labour in the industry (particularly individuals experienced in the industry) with crew shortages adversely affecting the number of fishing days per trip. The shortage of skilled labour in the fishing industry is exacerbated in the Region by the current strong growth of the petroleum and minerals sectors in the north-west, which are typically able to offer higher wages than the fishing industry.

Figure 5.5 Percentage of total population adjacent to the Region employed in fishing and related industries



Fisheries sustainability

Most fish stocks within the Region are either classified as uncertain or adequate (Table 5.5). An important exception is the Western Australian Tropical Shark Fishery where catch levels increased significantly from 591 tonnes in 2003–2004 to 1294 tonnes in 2004–2005. This included an increase in the catch of the slow growing, long lived sandbar shark from 209 tonnes in 2003–2004 to 762 tonnes in 2004–2005. However, new management arrangements have been introduced, and the total catch of shark in this fishery reduced by 85 per cent in 2006–2007 to 189 tonnes, with sandbar shark comprising less than one tonne of the total catch (Fletcher & Santoro 2007).

Breeding stocks of oceanic pink snapper, which are targeted in the Shark Bay Snapper Fishery, are considered depleted and as a result, DoF has reduced the Total Allowable Commercial Catch of this species. Future reductions in the Total Allowable Commercial Catch may be required to rebuild stocks (Fletcher & Santoro 2007).

Both Australian and State government fisheries agencies have a range of initiatives in place to reduce the potential for adverse environmental impacts by fisheries. The sustainable management of fisheries by the Australian Government is undertaken through the *Fisheries Management Act 1991*. Supporting initiatives include the *National Policy on Fisheries Bycatch 2000*, which sets a requirement for by-catch actions in each major Commonwealth fishery to improve the protection of threatened species and minimise adverse impacts upon the marine environment. Similarly, State fisheries agencies use a range of measures to minimise adverse impacts on both target and non-target species. Measures include output controls to limit the amount of target species landed, and input controls such as gear restrictions and seasonal or area closures, to avoid wider impacts on the marine environment, protected species and/or the target species itself.

The Australian Government also assesses all export and AFMA-managed fisheries under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) against criteria designed to ensure that all fisheries are managed in an ecologically sustainable way. Fisheries in the Region are known to interact with some species listed under the EPBC Act, including cetaceans, marine reptiles, sharks and seabirds. More information on interactions between listed species and fisheries can be found in Appendix D.

Interactions between fisheries and listed species are governed by a range of regulations and codes of conduct. Assessments for specific fisheries may include progress in implementing practices to minimise impacts on the marine environment and protected species. Further information on fisheries assessments can be found at <www.environment.gov.au/coasts/fisheries>.

Table 5.5 Status of selected fish stocks in the Region

Jurisdiction	Fishery	Status of stock
Australian Government (AFMA)[1]	North West Slope Trawl Fishery	Uncertain.
	Western Deepwater Trawl Fishery	Uncertain.
	Western Tuna and Billfish Fishery	Bigeye tuna not overfished; yellowfin tuna and broadbill swordfish uncertain; overfishing of bigeye tuna is occurring in the broader Indian Ocean.
	Northern Prawn Fishery	Banana, brown tiger and grooved prawns not overfished; endeavour and king prawns uncertain.
Western Australian Government (DoF)[2]	Pilbara Demersal Finfish Fishery	Breeding stock levels adequate.
	Northern Demersal Scalefish Fishery	Breeding stock levels adequate.
	West Coast Deep Sea Crab Fishery	Breeding stock levels adequate.
	Shark Bay Snapper Fishery	Spawning biomass of oceanic pink snapper depleted.
	Pearl Oyster Fishery (wild caught)	Breeding stock levels adequate.
	Mackerel Interim Managed Fishery	Breeding stock levels adequate.
	West Coast Demersal Scalefish Fishery	Dhufish and pink snapper overfished.
	Kimberley Prawn	Breeding stock levels adequate.
	Western Australian Tropical Shark fisheries	Sandbar shark overfished, other species uncertain.

1 Larcombe & McLoughlin (eds.) 2007
2 Fletcher & Santoro (eds.) 2007

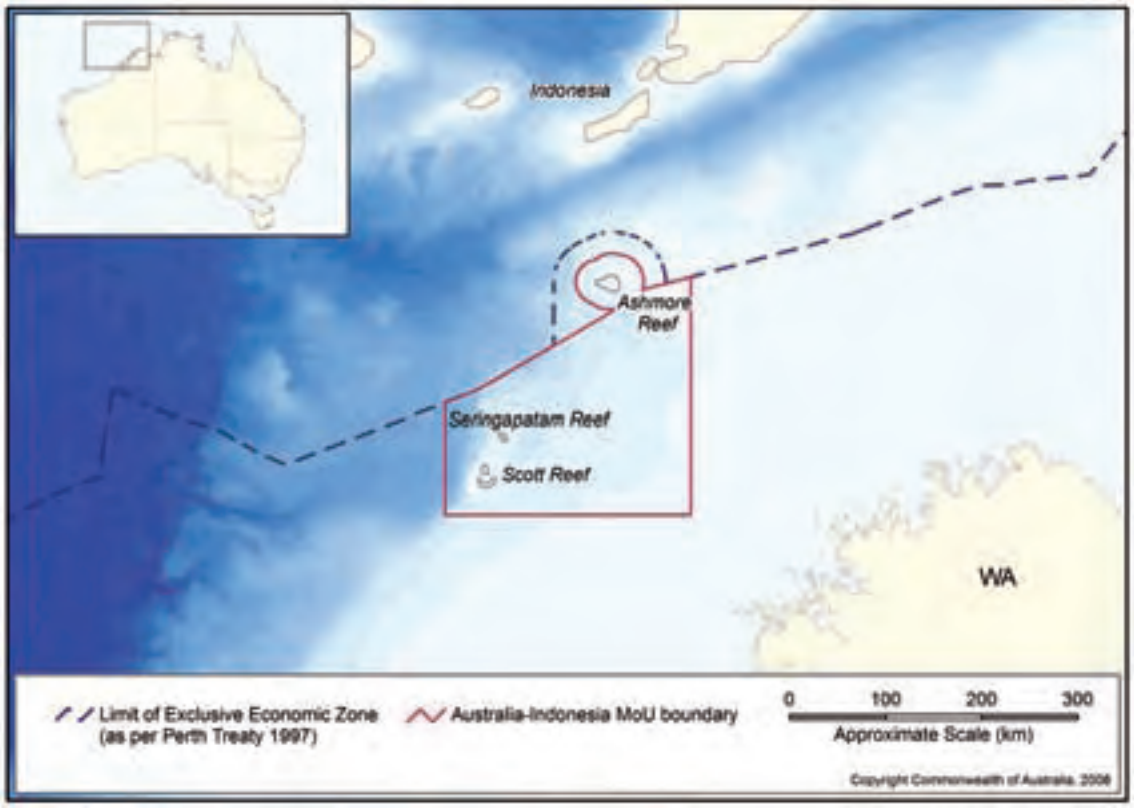
5.3.3 Traditional Indonesian fishing

Indonesian fishers have visited the northern coast of Australia and its islands and reefs for almost three centuries. In recognition of this and the importance of parts of Australia's marine jurisdiction for the livelihoods of some traditional fishers, a Memorandum of Understanding (MoU) was signed between Australia and the Republic of Indonesia in 1974 to allow traditional Indonesian fishers to fish in an area known as the 'MoU Box' (Figure 5.6). The MoU defines 'traditional fishermen' as fishers who have traditionally taken fish and sedentary organisms in Australian waters using traditional fishing methods and non-motorised sailing vessels. Under the MoU, the taking of protected wildlife including marine turtles, dugongs and clams is prohibited, as is fishing within the Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve. Fishers may access the reefs of Cartier Island, Scott Reef, Seringapatam Reef and Browse Island, and visit Ashmore Reef for access to fresh water and to visit graves (EA 2002).

Target species include trochus, trepang (bêche-de-mer or sea cucumber), abalone, green snail, sponges, molluscs and finfish including shark. In recognition that target stocks in the MoU Box have decreased significantly as a result of overfishing (including through illegal foreign fishing), Australia and Indonesia have agreed to work towards the development of a joint management plan over the next two years with the objective of conserving the MoU Box resources whilst observing the needs of traditional fishers.

More information about the MoU on traditional fishing in the Region can be found in Appendix A.

Figure 5.6 Boundary of Australian-Indonesian MoU Box



5.3.4 Illegal fishing

Illegal fishing, primarily by foreign fishers, is an important issue in the northern waters of the Region. It is a significant threat to the sustainability of fish stocks and the ecological values of the Region, as well as a quarantine and security risk.

Illegal fishers also have an impact on trochus aquaculture activities managed by the Bardi Aboriginal community at One Arm Point. In addition to catching shark, sea cucumber, trochus and finfish species in the Region, apprehended vessels have been found with protected species on board, including dugongs, marine turtles, sawfish and dolphins.

Coastwatch sightings of illegal fishing vessels within Australia's Exclusive Economic Zone (EEZ) indicated a substantial increase in illegal fishing in Australia's northern waters up to 2004–2005. In response, the Australian Government increased marine surveillance and enforcement patrols significantly and has stationed a dedicated Customs vessel at Ashmore Reef. Measures have also included improved coordination of border security agencies (through the establishment of Border Protection Command (BPC)), increased resources to undertake investigations and prosecutions and the development of cooperative arrangements with the Indonesian Government to combat the problem at its source (BPC 2007). These measures appear to have been effective with sightings of illegal vessels falling by nearly 60 per cent between 2005–2006 and 2006–2007 (Abetz & Johnston 2007). In 2007 a Regional Plan of Action was signed by Australia, Indonesia and other nations in the region to promote responsible fishing practices including combating illegal fishing in South-east Asia (Regional Fisheries Minister's Meeting 2007).

Aboriginal communities also play an important role in monitoring illegal activities in the North-west Marine Region. The Bardi Indigenous Ranger group at One Arm Point in the Kimberley works with Western Australian fisheries officers to conduct joint patrols in waters off the Kimberley coast.

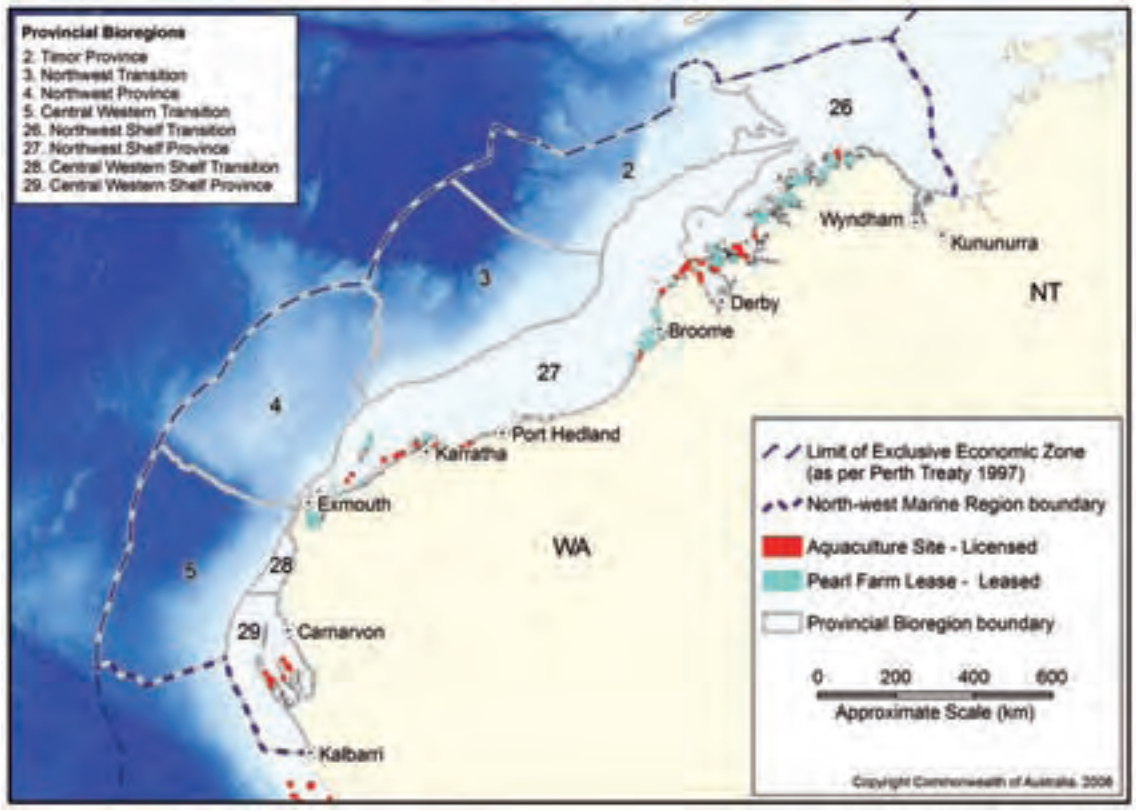
5.3.5 Pearling and aquaculture

Pearling

Western Australia is the world's largest source of quality south sea pearls, and the history of the industry in the north-west stretches back to the 19th century. The production of pearls commences with the collection by divers of silver lipped oysters from wild stocks in waters from Exmouth to Cape Leveque. Pearl oyster spat is also now produced in hatcheries (PPAA 2004).

Pearl aquaculture. Photo: Katarina Wos, Paspaley Pearling Company Pty Ltd.

Figure 5.7 Location of pearl farms and aquaculture sites



The DoF regulates the industry in accordance with the *Western Australian Pearling Act 1990*. Quotas limit the total amount of wild shell that can be harvested as well as the total amount of hatchery shell that can be seeded. To assist in the sustainable management of wild stocks, the fishery is split into management zones that limit the number of licensees operating in each area. In 2006, there were 17 licensees operating in the fishery (Fletcher & Santoro 2007).

Following seeding, oysters are placed in panels and transported to pearl farms for the grow-out phase of pearl production (Fletcher *et al*. 2006). Pearl farms are located along the north-west coast, with Broome and the Kimberley coast accommodating for around 75 per cent of the value of production (Figure 5.7). Most pearl farms are in State waters, although the farms south of Broome adjacent to Eighty Mile Beach are largely in the North-west Marine Region.

This valuable industry was worth approximately $122 million in 2005–2006, making it one of the largest and most successful aquaculture industries in Australia, and the second most valuable fishery in Western Australia after the Western Rock Lobster Managed Fishery, which operates in the South-west Marine Region. Pearling is also a significant contributor to regional employment (Fletcher & Santoro 2007).

Aquaculture

Apart from pearling activities, no offshore aquaculture currently occurs in the Region (i.e. Commonwealth waters) although it is feasible that aquaculture in Commonwealth waters could be developed in the future. The farming of other marine species is confined to State waters and onshore areas. In the Kimberley area, the tropical aquaculture facility near the Bardi Aboriginal community at One Arm Point has been producing trochus shell for a number of years (DoF 2007). Sea-cage barramundi farming occurs in Lake Argyle and a project is underway to commercialise the farming of black tiger prawn by the Kimberley Aquaculture Aboriginal Corporation (Fletcher & Santoro 2007).

5.3.6 Marine-based tourism

Charter fishing, diving, snorkelling, whale, marine turtle and dolphin watching and cruising are the main commercial tourism activities in and adjacent to the North-west Marine Region. With the exception of offshore charter fishing, most marine tourism activities occur in State waters. Nevertheless, many of the species and areas that underpin marine tourism in the north-west are either protected and/or regulated under Australian Government legislation, or have significant ecological links with the Commonwealth marine environment.

Charter fishing

Charter fishing is regulated by the DoF, except in the Ningaloo Marine Park (Commonwealth Waters), where charter fishers require a permit from the Director of National Parks. All fishing boat tour operators must be licensed and are required to submit daily trip returns on the overall number of tours, number of fishing-only tours, catch and effort estimates and tourist numbers. Charter fishing is a popular tourist activity in the Region, and most tours operate out of Broome and Exmouth.

In 2005–2006 there were 181 licensed fishing tour operators and 35 restricted fishing/eco-tour operators, although only around 50 per cent of the 181 operators used their licences during that year. Activities conducted on these tours included fishing, diving, snorkelling, wildlife observation and sightseeing. Of the 2594 tours conducted in the Gascoyne (i.e. south of Onslow), a third were fishing-only tours, with pink snapper and emperors the most targeted fish. In the Pilbara/Kimberley area, fishing-only tours accounted for two thirds of all trips, the higher proportion perhaps because of the popularity of fishing for species such as barramundi and larger gamefish offshore including Spanish mackerel, sailfish and swordfish (Fletcher & Head 2006).

Fishing tournaments

There are several offshore pelagic sport and gamefishing tournaments held each year in or adjacent to the Region. These include the Exmouth Gamex, the Dampier Classic and the Broome sailfish tournament. Species targeted include marlin, sailfish, mackerel, tuna and swordfish (Game Fishing Association of Australia 2007).

Marine mammal watching

In Western Australia in 2006–2007, there were 110 active whale watching permits, 95 dolphin watching permits and two dugong watching permits (DEC 2007). Whale watching is popular with tourists, particularly during the southward migration of humpback whales from September to late November. Adults and calves are numerous and accessible in Exmouth Gulf during this period.

Dolphin watching occurs at several locations, primarily in State waters. The best known location is Monkey Mia in Shark Bay, where a pod of dolphins regularly visits shallow waters and interacts with humans. There

Dolphins in Shark Bay World Heritage Area. Photo: Ian Anderson, Department of Environment and Conservation, WA.

Dugong at Shark Bay. Photo: Paul Anderson, Department of Environment and Conservation, WA.

are two dugong watching permit holders licensed to operate in the Shark Bay World Heritage Area, which has extensive beds of seagrass and is home to one of the world's largest populations of dugongs (DEC 2007).

The Australian Government has responsibility for ensuring that human activities around marine mammals are conducted in a manner that minimises potential threats to them. Whale and dolphin watching is regulated in Australian waters, and regulations apply to all people interacting with whales and dolphins, including commercial tourism operators and people engaged in recreational activities. The *Australian National Guidelines for Whale and Dolphin Watching 2005*, which were developed jointly by the Australian and all State and Territory governments, set out standards required for whale and dolphin watching while minimising the potential for adverse impacts on the animals. These guidelines are available at <www.environment.gov.au/coasts/publications/whale-watching-guidelines-2005.html>.

Other marine tourism or recreational activities

The North-west Marine Region and its adjoining waters support important coral reefs and a diversity of tropical marine animals and include popular diving, snorkelling and nature viewing areas. Primary dive locations include Ningaloo Marine Park (State Waters), the Rowley Shoals (including the Commonwealth marine reserve at Mermaid Reef), Scott Reef, Seringapatam Reef, Ashmore Reef and Cartier Island (Ashmore and Cartier are also Commonwealth marine reserves). The Muiron Islands, which are in State waters, are the destination for most of the dive charters operating out of Exmouth.

Broome, Exmouth and Monkey Mia are destinations for the cruise shipping industry and visitation is likely to increase into the future. At the port of Broome, cruise ship numbers have increased from 9 in 2004-2005, to 14 in 2005–2006 and 19 in 2006–2007 (BPA 2007).

Ningaloo Reef is a major tourism drawcard. Not only is Ningaloo one of the largest fringing coral reefs in the world, but it is one of only a few places worldwide where annual aggregations of whale sharks occur in nearshore waters. Diving and viewing whale sharks has become a popular tourism activity. In 2006 there were 15 licensed whale shark guides, 12 of whom operated out of Exmouth and three out of Coral Bay. In 2006, these guides took 520 tours and approximately 7590 passengers. Participation numbers are now more than double those of 10 years ago. To minimise potential adverse impacts on whale sharks and to ensure the long term sustainability of the industry, whale shark tourism operations are regulated by the Western Australian Department of Environment and Conservation (DEC) in conjunction with Tourism WA. For operators in the Ningaloo Marine Park (Commonwealth Waters), the Department of the Environment, Water, Heritage and the Arts issues permits for whale shark tour operators. Tour operators are required to operate according to a code of conduct and undergo eco-tourism training (Wilson *et al*. 2006).

The Kimberley region is fast becoming a desirable tourism destination because of its pristine marine and terrestrial environments. The operation of the Kimberley marine tourism industry is reliant on these remote wilderness values and is expected to undergo substantial growth in coming years. While most marine tourism activities are located in State waters, luxury cruises take tourists along the coastline and increasingly out to isolated coral atolls for fishing and diving (Kimberley Marine Tourism Association 2007).

5.3.7 Ports and shipping

The Region has experienced a substantial boom in the resources sector in recent years and this trend is predicted to continue as demand for oil, gas and minerals from countries such as China, Korea, Taiwan and Japan increases. Given the reliance of these industries on export markets, and the long distances involved, adequate port facilities and reliable and effective shipping services are vital. Australia's two largest ports in terms of tonnage, Dampier and Port Hedland, are located adjacent to the North-west Marine Region. The major commodities exported through the north-west ports are iron-ore, natural gas and other petroleum products, and salt. Other commodities include lead, zinc, manganese, nickel and copper.

Ports

There are 12 ports adjacent to the North-west Marine Region, including the major ports of Dampier, Port Hedland and Broome, which are operated by their respective port authorities. These authorities are autonomous bodies operating under the Western Australian Government's *Port Authorities Act 1999* and are responsible for overseeing safety, environmental management and traffic movements (DPI 2006). The main customers and managers of operations at loading facilities are largely the minerals and petroleum companies using the ports. These ports also play an important oil and gas offshore support role and export facilities for smaller mining and salt operations. Each of the major ports is discussed in detail later.

Complementing these major ports are eight non-port authority ports (Table 5.6). While the Western Australian Government has jurisdiction over these ports, it is not involved in the day-to-day administration of activities. Its primary role is to ensure the safety of port operations. Private sector firms own, manage and operate the dedicated port facilities, services and related infrastructure at the sites. Of these non-port authority ports, Onslow and Barrow Island ports are likely to expand in the future as BHP Billiton proceeds with its Pilbara Liquefied Natural Gas (LNG) activities, and Chevron begins processing LNG on Barrow Island from the giant Greater Gorgon gas fields. The location of the ports adjacent to the Region is shown in Figure 5.8.

Other commodities exported from the various ports in the Region include nickel and copper.

Potential new ports

The Western Australian Government has been considering potential sites for a new export port in the Pilbara region to meet the increasing global demand for iron ore and other commodities. Ronsard Island, which is located between Dampier and Port Hedland, was identified in 2007 as having the potential to host a 300 million tonnes per annum (Mtpa) iron ore export facility (DPI 2007). Consideration is also being given to the development of an outer harbour iron ore export facility at Port Hedland. The outer harbour would involve the dredging of a major new channel. New port facilities are also likely to be required in the vicinity of Dixon Island to service a planned industrial estate at Mount Anketell between Wickham and Karratha (Shire of Roebourne 2005).

Another port is planned for Cape Preston to support iron ore exports from the CITIC Pacific Ltd owned Cape Preston Iron Ore Project. This project will produce around 45 Mtpa of iron ore (IRC 2007).

Port Hedland

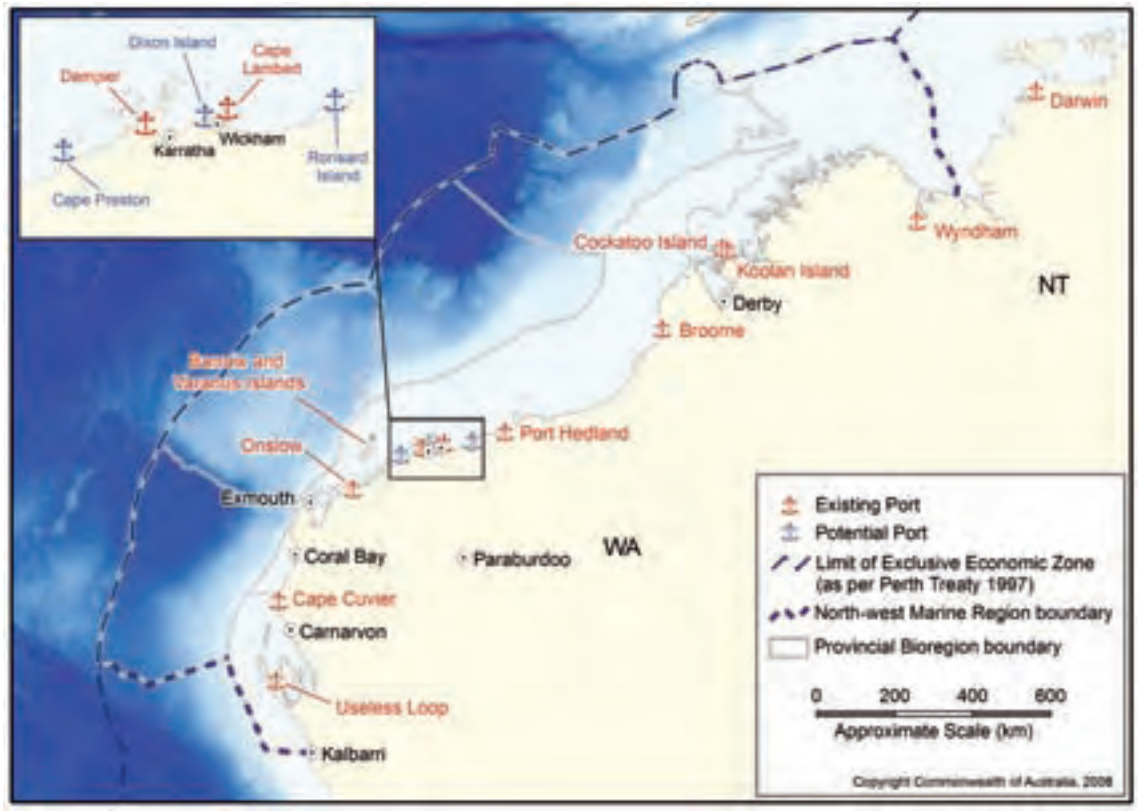
Port Hedland services the mineral-rich eastern Pilbara region, with its main bulk export commodities being iron ore and salt. It is currently the second largest Australian port based on total annual tonnage, having been eclipsed by Dampier in 2006–2007. However, the current expansion of the port is expected to re-establish its position as the largest port in Australia. In 2006–2007, throughput was 112 Mtpa, with iron ore exports accounting for approximately 95 per cent (107 Mtpa) of all trade, while salt made up 2.4 per cent (2.7 Mtpa). A number of other bulk commodities are also exported from the port including manganese, chromite and feldspar (PHPA 2007). Other key functions of the port include the provision of offshore oil and gas support and export facilities for smaller mining and salt operations.

With bulk carriers in excess of 260 000 tonnes docking at the port, ongoing maintenance dredging of the port area and the shipping channel occurs every three to four years with the approximately 700 000–1 million tonnes of dredge spoil dumped offshore under a Commonwealth permit. The current spoil site is close to capacity and a new location in Commonwealth waters (within the Northwest Shelf Province) is likely to be required in the near future (PHPA 2007).

Table 5.6 Non-port authority ports adjacent to the Region (IRC 2007)

Location	Operator	Export commodity/use
Carnarvon	Dampier Salt (Rio Tinto) (Cape Cuvier)	Salt
	Shark Bay Salt (Useless Loop)	Salt
Onslow	Onslow Salt	Salt
	Chevron Australia (Thevenard Island)	Crude oil
	Apache Energy (Airlie Island)	Crude oil
Varanus Island	Apache Energy	Domestic natural gas, crude oil
Barrow Island	Chevron Australia	Crude oil
Port Walcott	Pilbara Iron (Rio Tinto)	Iron ore
Derby	Shire of Derby/West Kimberley	Lead, zinc, tourism
Yampi Sound	Portman/Henry Walker Eltin (Cockatoo Island) Mt Gibson Iron Ore (Koolan Island)	Iron ore
Wyndham	Ord River District Cooperative	Cattle (Malaysia), sugar (Indonesia)

Figure 5.8 Current and potential future ports in the Region



The increasing demand for iron ore, which is largely driven by China's economic growth, is expected to exceed 200 Mtpa by 2010–2011. To ensure the port has capacity to meet these requirements, there are several expansions planned, including BHP Billiton's development of four new berths designed to accommodate vessels in excess of 300 000 tonnes. Fortescue Metals Group is also building two additional berths to provide capacity to export 45 Mtpa of iron ore (PHPA 2007).

Port of Dampier

The Port of Dampier is located at the base of the Burrup Peninsula, and is one of the major tonnage ports in Australia with 3404 ships visiting over 2006–2007 (DPA 2007a). The port had a throughput in 2006–2007 of 126 million tonnes (the highest in Australia) with a value in excess of $8.5 billion. The prime commodities exported were iron ore (83 per cent by tonnage), LNG (10 per cent) and salt (three per cent) (DPA 2007b). In

comparison, the Port of Sydney had a throughput of 22.5 million tonnes between March 2007–2008, although its value of trade was much higher at $50 billion (Sydney Ports 2007).

There are several industry operators at the Port of Dampier including Pilbara Iron Pty Ltd, Dampier Salt Ltd (both subsidiaries of Rio Tinto Ltd), Woodside Energy Ltd and Burrup Fertilisers (which produces liquid ammonia). Three berths are used to export iron ore and one to export salt, while liquid ammonia is exported from the Dampier Bulk Liquids Berth. Salt is exported to countries including Japan, South Korea, Taiwan and Indonesia, iron ore is exported principally to China and Japan and liquid ammonia to India, Indonesia and Japan. The iron ore and salt export berths account for 81 per cent of the port's trade throughput. Pilbara Iron is planning to construct an additional berth and service wharf to support the growth in iron ore exports, which will require dredging to increase ship size, berthing and handling capacity to 140 Mtpa.

The North West Shelf Venture, with Woodside as operator, exports LNG, liquefied petroleum gas (LPG) and condensate from the North West Shelf Venture processing facility, located adjacent to the port. In 2006–2007 12.5 million tonnes of LNG were shipped to markets in Japan, South Korea and China (DPA 2007b). With the global demand for petroleum products including LNG increasing, a fifth processing train at the North West Shelf Venture facility is being constructed which will increase LNG production to 16.3 Mtpa (Woodside 2007).

To support its offshore Pluto gas developments, Woodside is planning to construct onshore processing facilities at Burrup Industrial Estate. The plant will be located at a new site between the existing North West Shelf Venture Gas Plant and the Dampier Port. Complementing this facility will be a new loading jetty for LNG vessels.

Port of Broome

Broome is the primary deepwater port servicing the Kimberley area. In 2006–2007, the port recorded 3931 trading vessels (up from 128 vessels in 2005–2006) and doubled its total throughput to 274 905 tonnes (BPA 2007). Of the 183 019 tonnes imported, 80 per cent were petroleum products for servicing petroleum exploration and development and other industries in the north-west. The port also exports livestock and services offshore oil and gas exploration and supply vessels, pearling and fishing vessels, charter boats and large cruise ships. The port also serves as a stopover port for Royal Australian Navy and Australian Customs vessels (BPA 2007).

To meet increasing demand, particularly from the petroleum and tourism sectors, the Port of Broome recently extended its jetty to allow room for a third berth and increased the depth to handle ships up to 50 000 dead weight tonnes. This extra berth allows the port to continue operations with rig tenders, charter boats, cruise ships and trading vessels whilst tankers are discharging at the port. This has significantly increased the current capacity of the port and provides for its continued growth. Major offshore oil and gas exploration activities are underway in the Browse Basin and the development of the Basin's resources is expected to increase demand on the Port of Broome.

Cape Lambert (Port Walcott)

Cape Lambert's Port Walcott is the third major iron ore port in the north-west and is owned by Robe River Iron Associates and operated by Pilbara Iron (IRC 2007). The operations consist of an iron ore handling, processing and ship loading facility. Current annual ship loading capacity is approximately 55 Mtpa, although plans to increase capacity to 85 Mtpa are currently undergoing approval. Expansion would require dredging for additional berths and a deepening of the main shipping channel. Pilbara Iron also operates a 105 megawatt gas-fired thermal power station at Cape Lambert <www.riotintoironore.com/ENG/operations/301_pilbara.asp>.

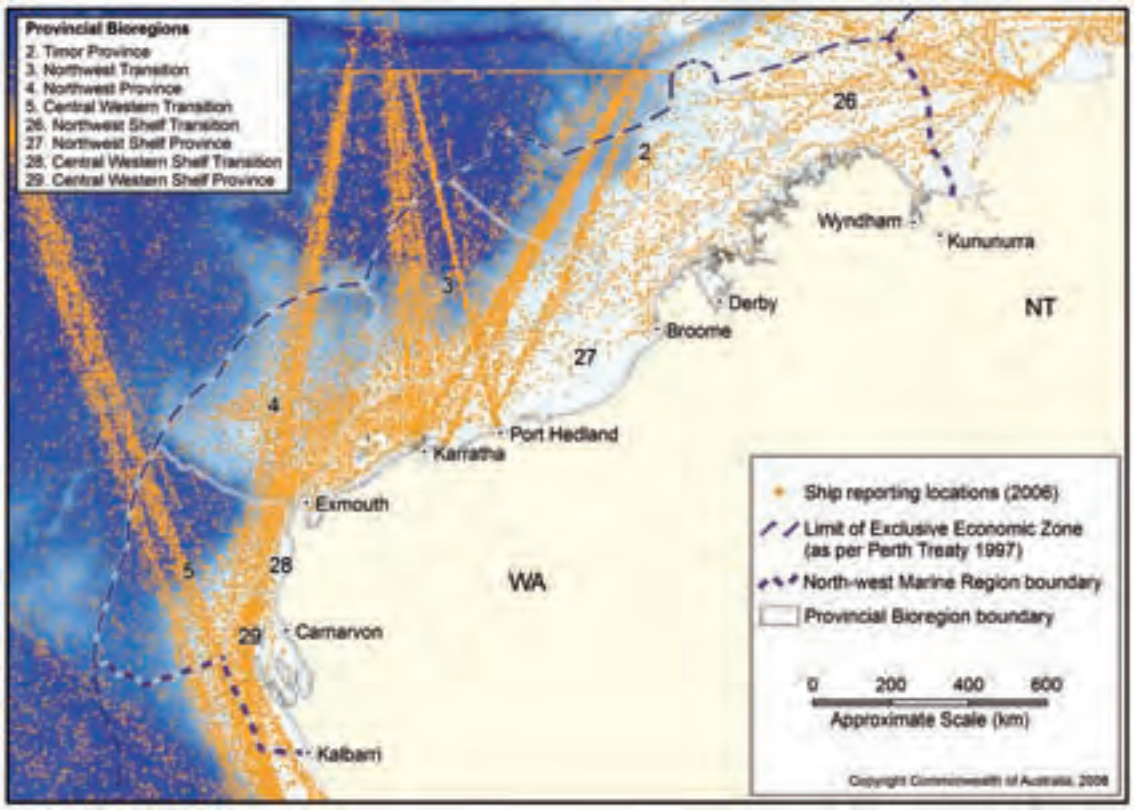
Shipping

The ports in the north-west, in particular Dampier and Port Hedland, handle large tonnages of iron ore and petroleum exports in addition to salt, manganese, feldspar chromite and copper. The massive expansion of the north-west's economy is reflected in the number of vessel visits to the Region's ports and the intensification of shipping activity. Dampier receives the highest number of vessel visits in Western Australia with 3404 recorded in 2006–2007 (Table 5.7). Port Hedland was third after Fremantle with 888 ship visits. Figure 5.9 shows the main shipping routes in the north-west in 2006, and reflects the intensity of ship movements out of Dampier and Port Hedland but also highlights the extent of traffic moving though the Region to and from the south.

Table 5.7 Number of vessel visits to Western Australian ports in 2006–2007

Port	Vessel visits
Albany	119
Broome	393
Bunbury	353
Dampier	3404
Esperance	181
Fremantle	1687
Geraldton	305
Port Hedland	888

Figure 5.9 Main shipping routes 2006



Changes in economic activity are reflected in changes in the proportions of different vessel types active in the provincial bioregions of the Region (Figures 5.10 and 5.11) (IRC 2007). Of note is the significant increase in Offshore Support Vessels in the Northwest Province, Northwest Shelf Province and Northwest Shelf Transition bioregions, which are areas of intense interest for petroleum exploration and development companies. These vessels service offshore drilling and production facilities and support construction and maintenance work for offshore petroleum activities. In 2004, around three per cent of vessels reported in the Northwest Province were Offshore Support Vessels. However, just two years later these vessels made up 40 per cent of total vessel movements in this bioregion. The proportion of iron ore bulk carriers also increased in the Northwest Province and Timor Province, reflecting the increased transit of these vessels through the Region to east Asian markets.

An increase in shipping and port expansion associated with the growth of the resources sector in the north-west has potential implications for the marine environment. Potential threats include: loss or contamination of marine habitat as a result of dredging and sea dumping, oil spills, interactions between vessels and protected species, and the introduction of marine pests through ballast water exchange and biofouling of ship hulls.

Australia manages environmental risks associated with port and shipping activities through a range of national and international legislation and agreements. Under the EPBC Act, proposed dredging operations must be referred to the Minister for the Environment, Heritage and the Arts if the activity is likely to have an impact on a matter of national environment significance. If the dredged material is to be dumped in Australian waters, the activity is subject to Commonwealth approval under the *Environment Protection (Sea Dumping) Act 1981*. Sea dumping is discussed further in section 5.3.8. More information on legislation can be found in Appendix B.

Australia meets its obligations as party to the international *Convention for the Prevention of Pollution from Ships 1973* (MARPOL) through the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*. To manage marine pest incursions, Australia has mandatory ballast water management requirements with which all international vessels must comply if intending to discharge ballast water anywhere inside the Australian territorial sea. These requirements are administered by the Australian Quarantine Inspection Service. More information on these arrangements is in Appendix A.

Northern Endeavour floating production storage and offload vessel. Photo: Woodside.

Figure 5.10 Distribution of vessel type by bioregion – 2004

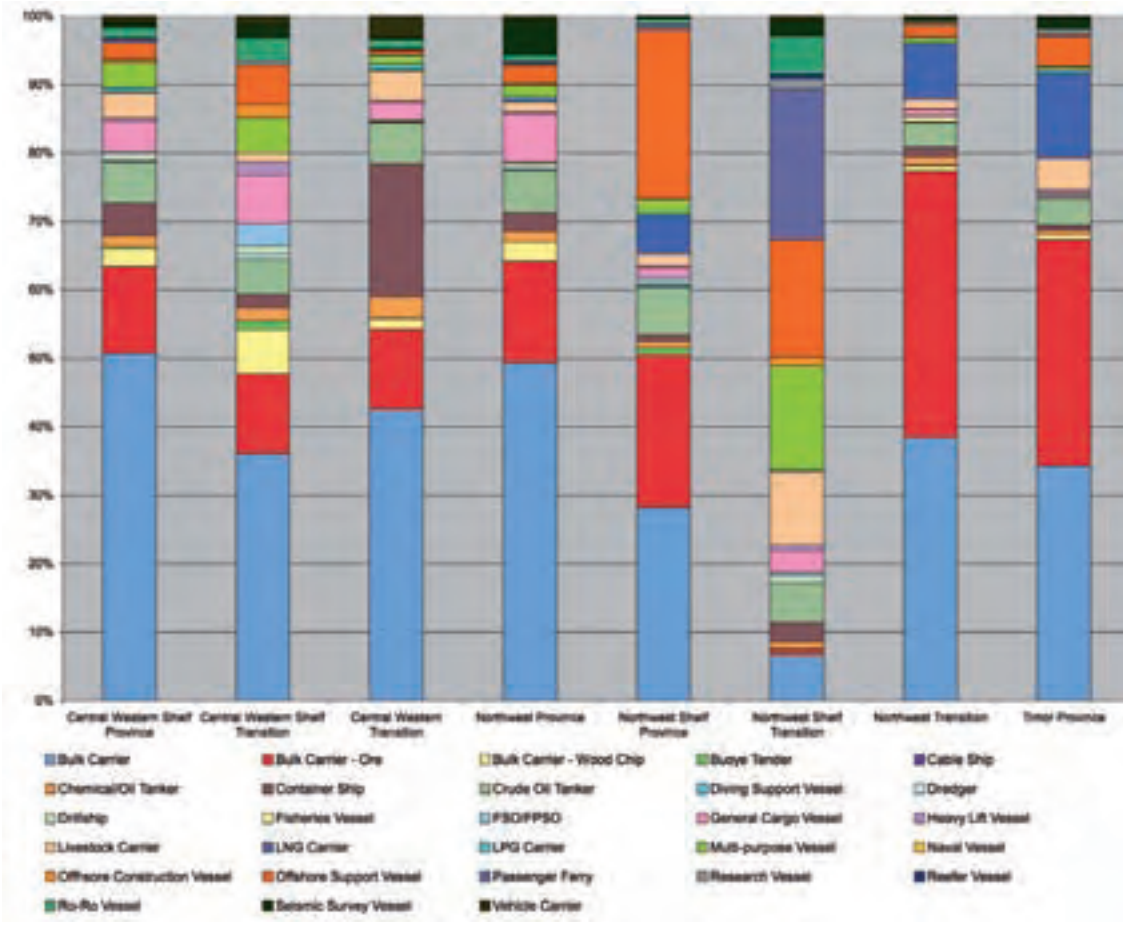
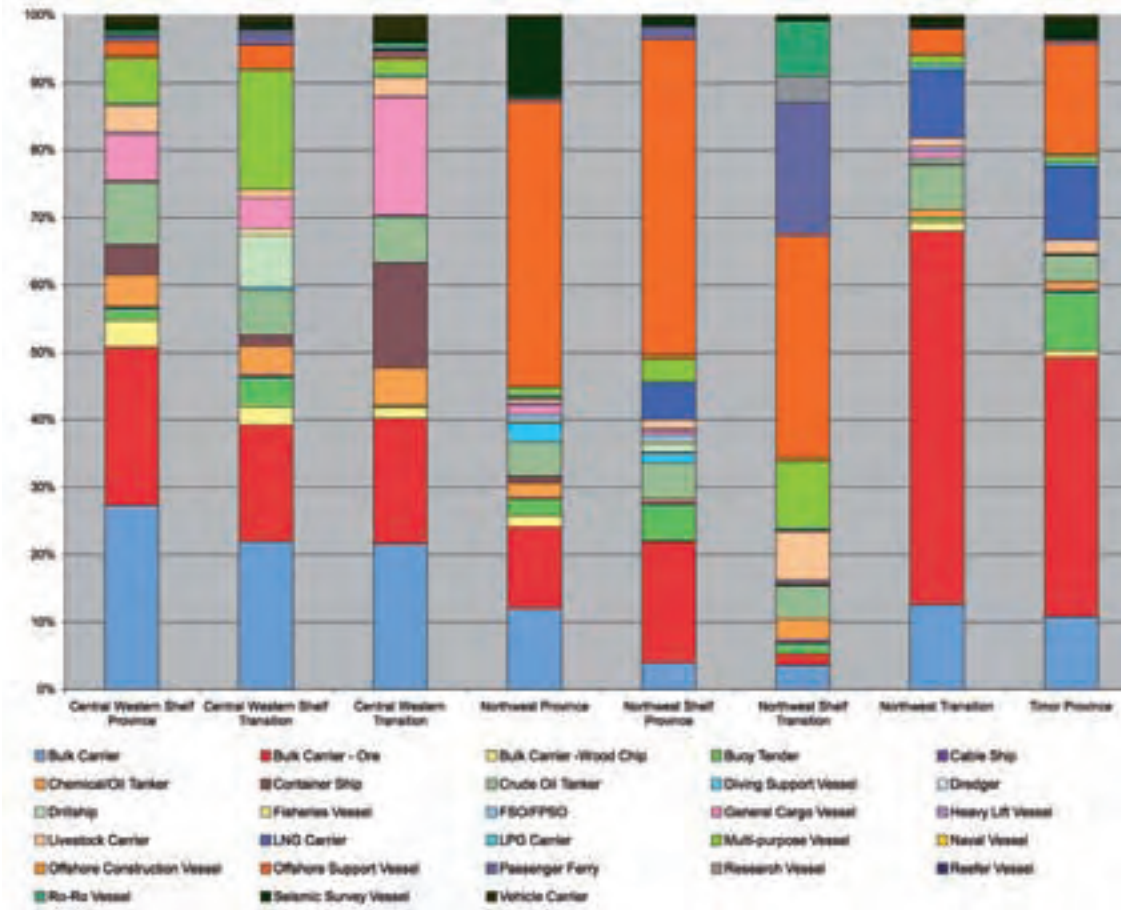


Figure 5.11 Distribution of vessel type by bioregion – 2006



5.3.8 Sea dumping

Prior to 1981, waste including vessels, ammunition and chemicals were dumped in the Region. Since 1981 the dumping of waste at sea has been regulated under the *Environment Protection (Sea Dumping) Act 1981*. This act was enacted to fulfil Australia's international responsibilities under the London Convention of 1972 and is administered by the Department of the Environment, Water, Heritage and the Arts. It applies from the low water mark out to the limits of Australia's EEZ. In 1996 the Act was amended to enact the 1996 Protocol to the London Convention. Today little dumping occurs. Permits from the Department are required for all dumping operations in Commonwealth waters. If a sea-dumping activity is likely to have a significant impact on a matter of national environmental significance it will also trigger the EPBC Act.

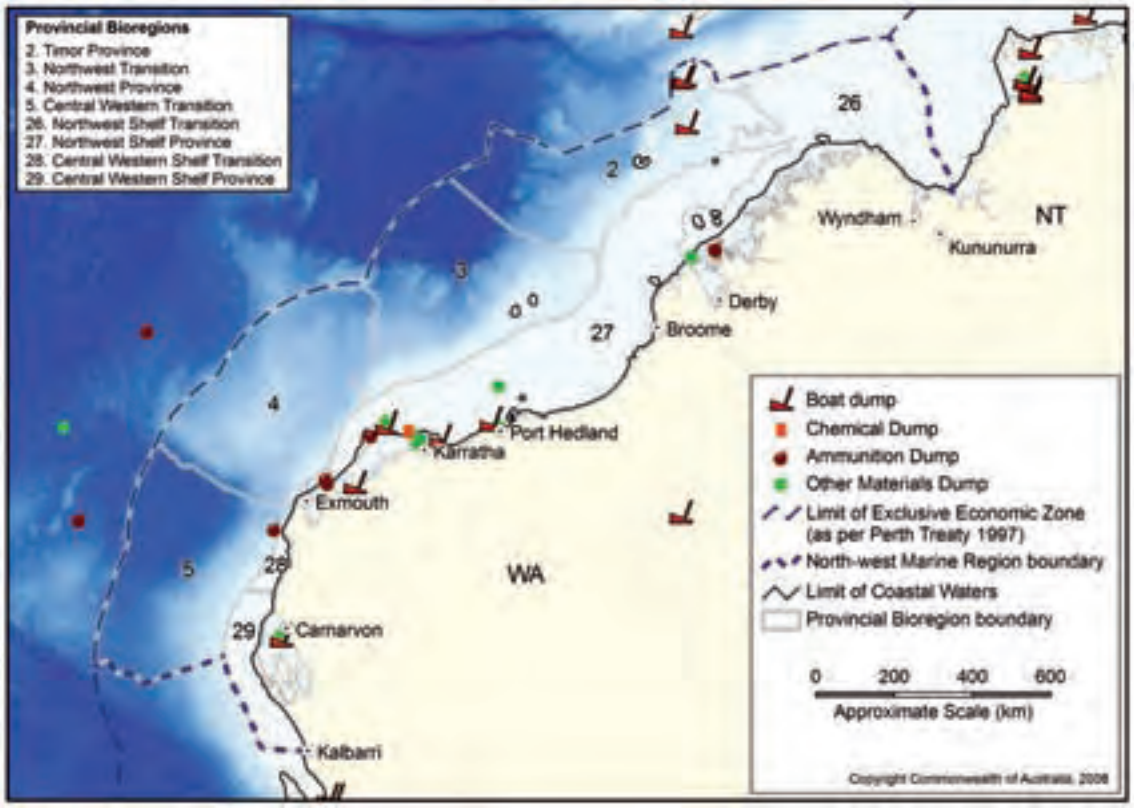
Dredged material is dumped at a number of ports adjacent to the Region including Port Hedland, Dampier and Cape Lambert. This is a result of ongoing maintenance, upgrading and expansion of the ports. Dredging and hence dumping is likely to increase markedly in the future as ports increase in size to handle the significant rise in exports as a result of the resources boom.

Generally, no spatial closures or exclusion zones are in effect around dump sites, but the location of dredge material disposal sites and vessel placements are reported on hydrographic charts. The past disposal of ammunition, boats and chemicals has largely been in State waters and occurred prior to the enactment of the *Environment Protection (Sea Dumping) Act 1981*. There are also some boat dump sites in the Timor Province (Figure 5.12).

Further information on the *Environment Protection (Sea Dumping) Act* can be found in Appendix B and at <www.environment.gov.au/coasts/pollution/dumping>.

Operational discharges from ships, such as sewage and galley scraps, are regulated by the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* administered by the Australian Maritime Safety Authority (AMSA 2007).

Figure 5.12 Sea-dumping in the Region prior to the 1996 amendment to the Environment Protection (Sea Dumping) Act 1981



5.3.9 Offshore oil and gas exploration and production

Offshore oil and gas exploration and production is a large and rapidly growing industry in the North-west Marine Region. It contributes significantly to regional, State and national economies, provides new investment, infrastructure development, employment, and a range of other socio-economic benefits. Rapid growth of the industry in the Region is likely to continue, driven by high global demand for oil and gas and concomitant high prices.

In 2007, there were 68 petroleum producing fields in Western Australia, with most of these occurring within the Region (Jonasson 2008). Nineteen new offshore exploration permits were granted across Australia in 2007, with 12 of these in the Region (DITR 2007). Around 67 per cent of Australia's oil and condensate and 69 per cent of its gas reserves are located in Western Australia (Jonasson 2008). Figure 5.13 shows the petroleum leases current in the Region as at July 2007.

Value of production

As shown in Table 5.8, the value of petroleum sales in Western Australia in 2006–2007 was $16.4 billion (DoIR 2007). This was an increase of 11 per cent (or $1.6 billion) over 2005–2006 and reflects high world oil prices and increased LNG shipments. The strong growth in LNG production is likely to continue, as it is anticipated that global demand for LNG will increase by more than eight per cent per annum to 2015. In the absence of any new major discoveries, Australian crude oil and condensate production is projected to remain flat over the longer term despite the expected continuation of strong world demand for crude oil.

Petroleum basins, exploration and major projects in the North-west Marine Region

There are seven sedimentary petroleum basins in the North-west Marine Region: the Northern and Southern Carnarvon basins, Perth, Browse, Roebuck, Offshore Canning and Bonaparte basins (Figure 5.14). Of these, the Northern Carnarvon, Browse and Bonaparte basins hold large quantities of gas, and comprise most of Australia's reserves of natural gas (Figure 5.15).

Figure 5.13 Offshore petroleum exploration and production permits in the Region

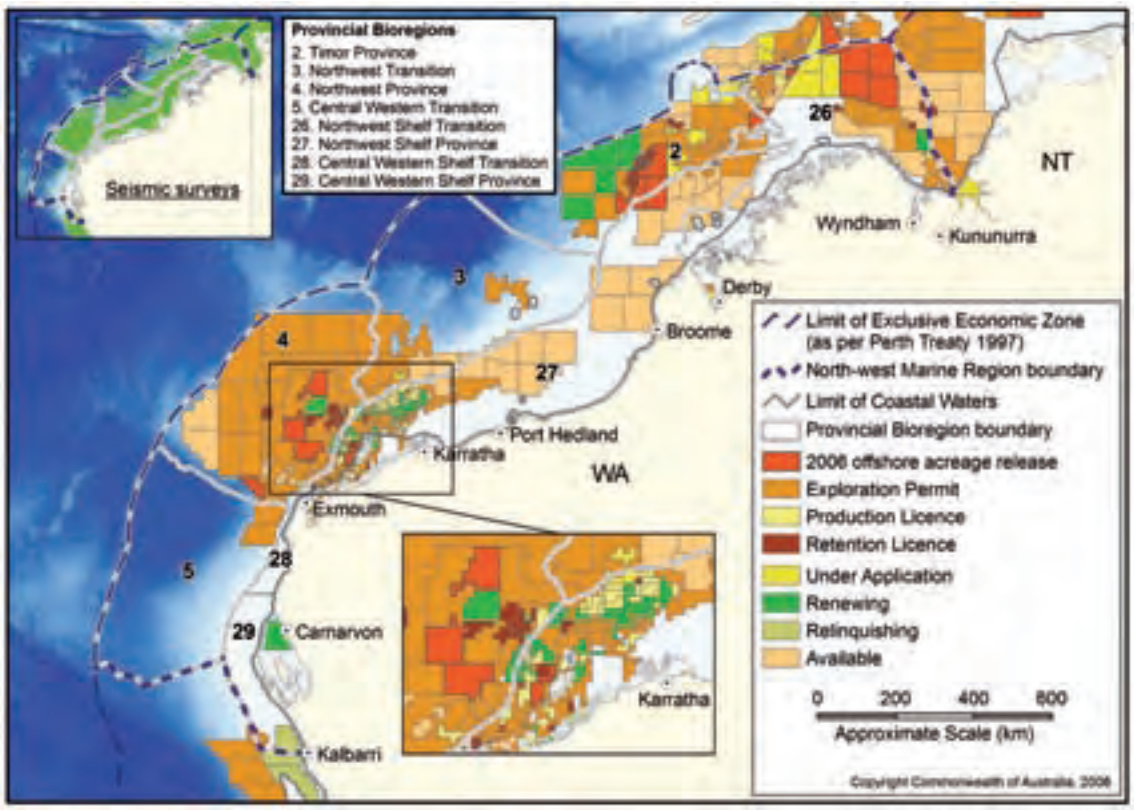


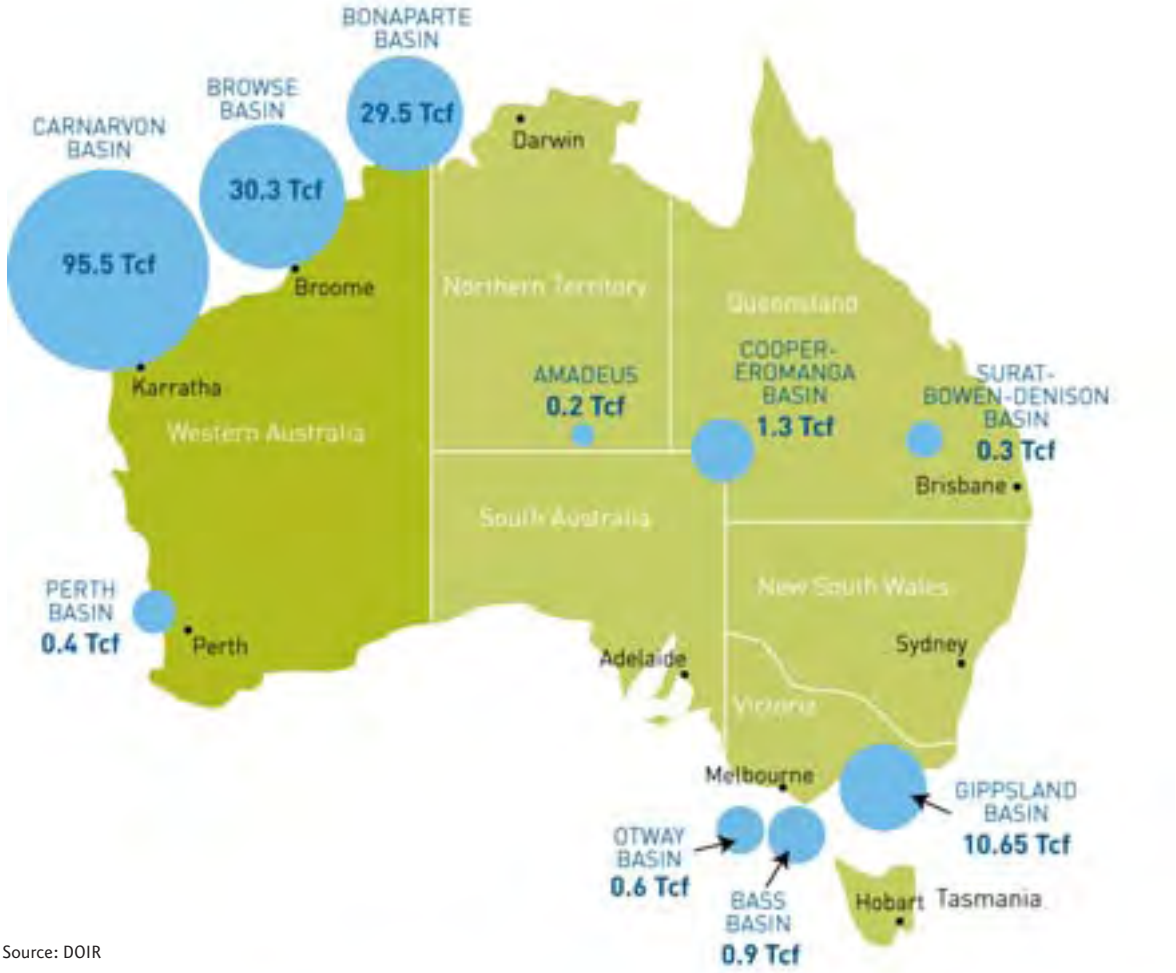
Table 5.8 Value and quantity of petroleum products for 2004-2005, 2005–2006 and 2006–2007

		2004-2005		2005–2006		2006–2007	
	Unit	Quantity	Value ($M)	Quantity	Value ($M)	Quantity	Value ($M)
PETROLEUM							
Condensate	Gigalitre (Gl)	5.63	2 203.11	5.63	2 791.73	5.86	2 972.29
Crude oil	Gigalitre (Gl)	12.80	5 146.61	11.516	5 935.12	14.49	7 621.48
LNG	Million Tonnes (Mt)	11.04	3 953.10	11.68	4 625.22	12.21	4 237.23
LPG - butane and propane	kilotonnes (kt)	77.17	421.74	871.98	654.42	898.61	605.09
Natural gas	Giga cubic meters (Gm^3)	7.64	678.72	7.71	703.28	8.71	919.42
TOTAL			12 403.29		14 709.77		16 355.51

Source: (DoIR 2007)

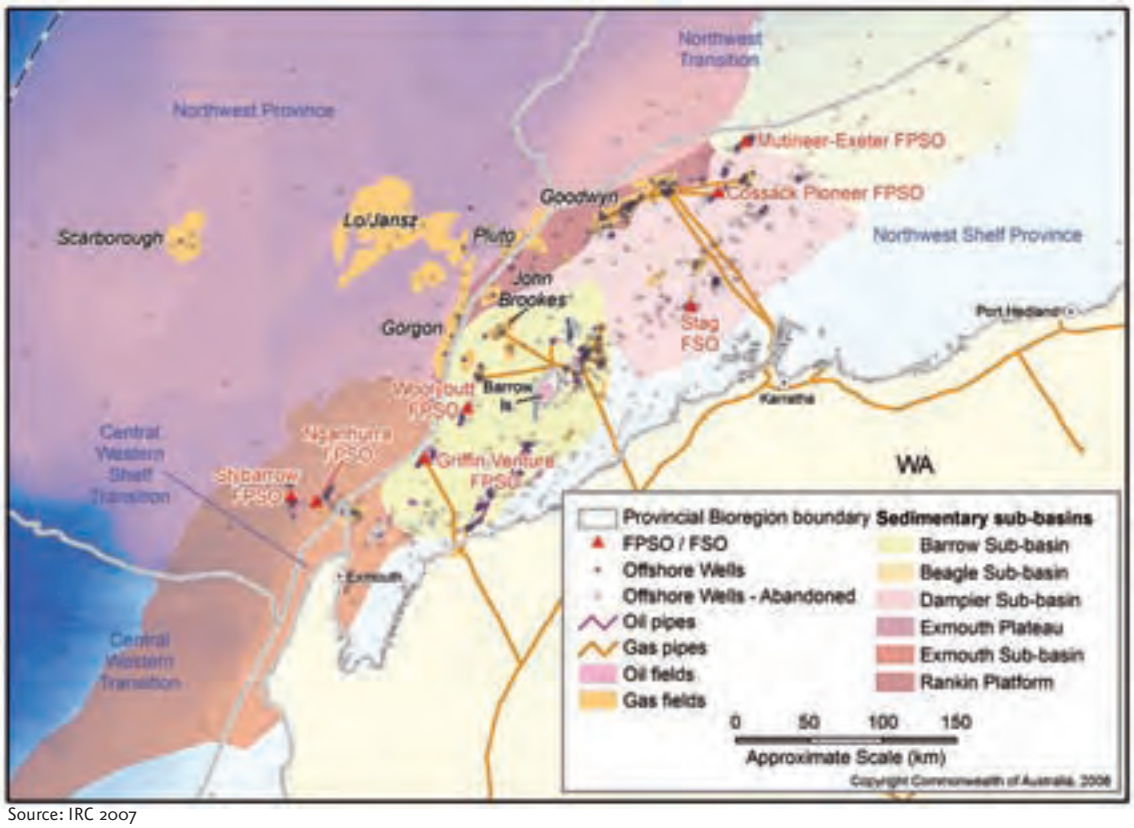
Figure 5.14 Sedimentary basins in the Region

Figure 5.15 *Australian gas resources - 2006 in trillion cubic feet (Tcf)*



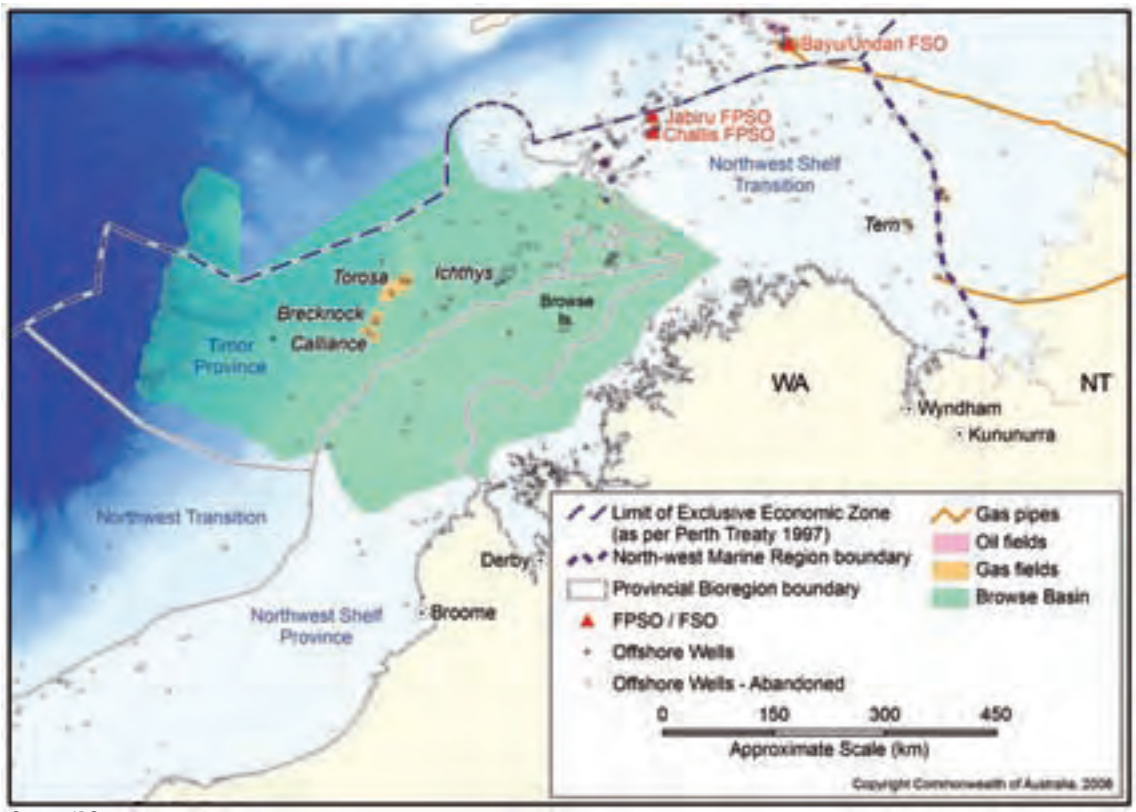
Source: DOIR

Figure 5.16 *Petroleum fields and operations in the North West Shelf*
(Northwest Shelf Province)



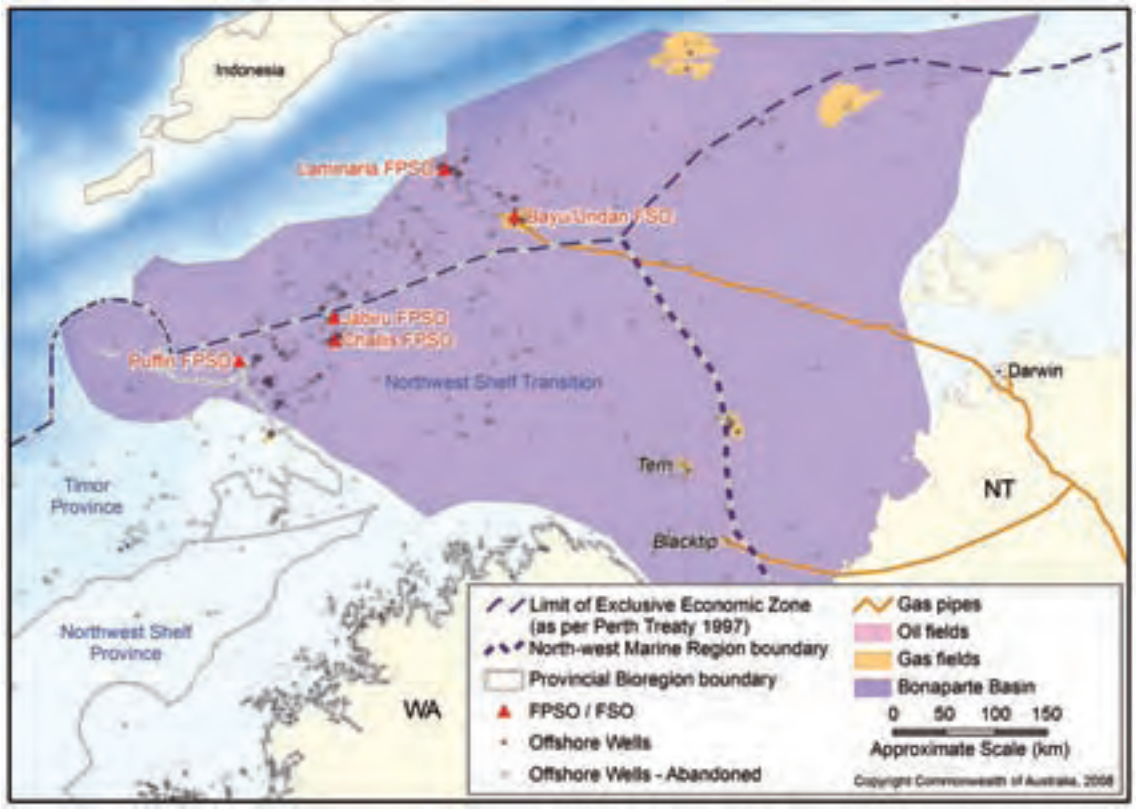
Source: IRC 2007

Figure 5.17 Petroleum fields and operations in the Browse Basin
(Northwest Shelf Province, Timor Province and Northwest Shelf Transition)



Source: IRC 2007

Figure 5.18 Petroleum fields and operations in the Bonaparte Basin
(Timor Province and Northwest Shelf Transition)



Carnarvon Basin

The Carnarvon Basin is the most important producing area. It supports more than 95 per cent of Western Australia's oil and gas production, and accounts for 63 per cent of Australia's total production of crude oil, condensate and LNG. It is also the most heavily explored, with almost 80 per cent of the oil and gas wells drilled in Western Australia.

Most of the petroleum production and development in the Carnarvon Basin occurs in the Northern Carnarvon Basin on the North West Shelf (Northwest Shelf Province – Figure 5.16). One of the major established projects in this area is the North West Shelf Venture (see Box 5.2). Significant new gas fields including Gorgon and Pluto are currently undergoing development in the Northwest Province. These two future projects are discussed further below. Enfield, Vincent, Pyrenees, Stybarrow and Laverda (in the Northwest Province) are recent oil field discoveries and, combined, contain over 48 gigalitres.

Browse Basin

The Browse Basin is offshore of the Kimberley region and traverses the Northwest Shelf Province, Timor Province and Northwest Shelf Transition bioregions (Figure 5.17). It is considered to be relatively under-explored, but is expected to be Australia's biggest LNG province outside the Carnarvon Basin. It holds more than 30 trillion cubic feet of gas, which is sufficient to provide more than 600 million tonnes of LNG (DoIR 2006). It includes the yet-to-be-developed large and remote Torosa (Scott Reef), Brecknock, Calliance and Icthys gas fields. The Browse Basin is likely to be a focus of intense development in the next decade.

The need to develop the gas reserves of the Browse Basin while protecting the natural and cultural values of the Kimberley prompted the Australian Minister for the Environment, Heritage and the Arts and the Western Australian Minister for State Development in February 2008 to jointly announce a strategic assessment of the Kimberley, under Section 146 of the EPBC Act. The first part of the assessment will identify a common-user LNG site for the Browse Basin. The strategic assessment will provide certainty for industry and reduce the impacts that would otherwise occur if piecemeal development of onshore LNG processing facilities were to occur along the Kimberley coastline. More information on the strategic assessments under the EPBC Act can be found in Appendix B.

Bonaparte Basin

The Bonaparte Basin is located in the Timor Sea (in the Northwest Shelf Transition bioregion) and is considered to be a highly prospective region. It contains significant oil and gas fields under various stages of operation, construction and consideration. These include the Blacktip, Tern, and Petrel fields (Figure 5.18). This basin extends into the North Marine Region.

Future projects

The Greater Gorgon gas fields (Gorgon and Jansz), located in the Northwest Province, contain approximately 40 trillion cubic feet of gas, making them Australia's largest known undeveloped gas resource. The project operator, Chevron, plans to process 5 Mtpa of LNG at facilities on Barrow Island. Socio-economic benefits of the project include an initial $11 billion investment, $17 billion in taxes and royalties, additional export income of $2.5 billion per annum, and 6000 direct and indirect jobs, 1700 of which will be located in Western Australia (Chevron 2007). Chevron was granted approval to undertake the project by the Western Australian and Australian Governments in late 2007.

Barrow Island is home to a number of endemic and rare species, and is free of introduced predators such as foxes and cats. Development of the Gorgon LNG processing facility will need to manage quarantine risks to ensure species are protected from potential pest species. Migratory whales, dolphins and dugongs are also common around the island and it is a nesting site for flatback and hawksbill turtles. As part of the environmental approvals process, the developers have been required to put in place actions to mitigate potential impacts on terrestrial and marine species.

Greenhouse gas emissions associated with LNG projects are an increasing concern for government, industry and the broader community. The carbon dioxide emissions from Gorgon are estimated to be 4 Mtpa, and Chevron plans to geosequester carbon dioxide into aquifers under Barrow Island to reduce emissions (IRC 2007). Geosequestration on this scale has not been attempted in Australia before.

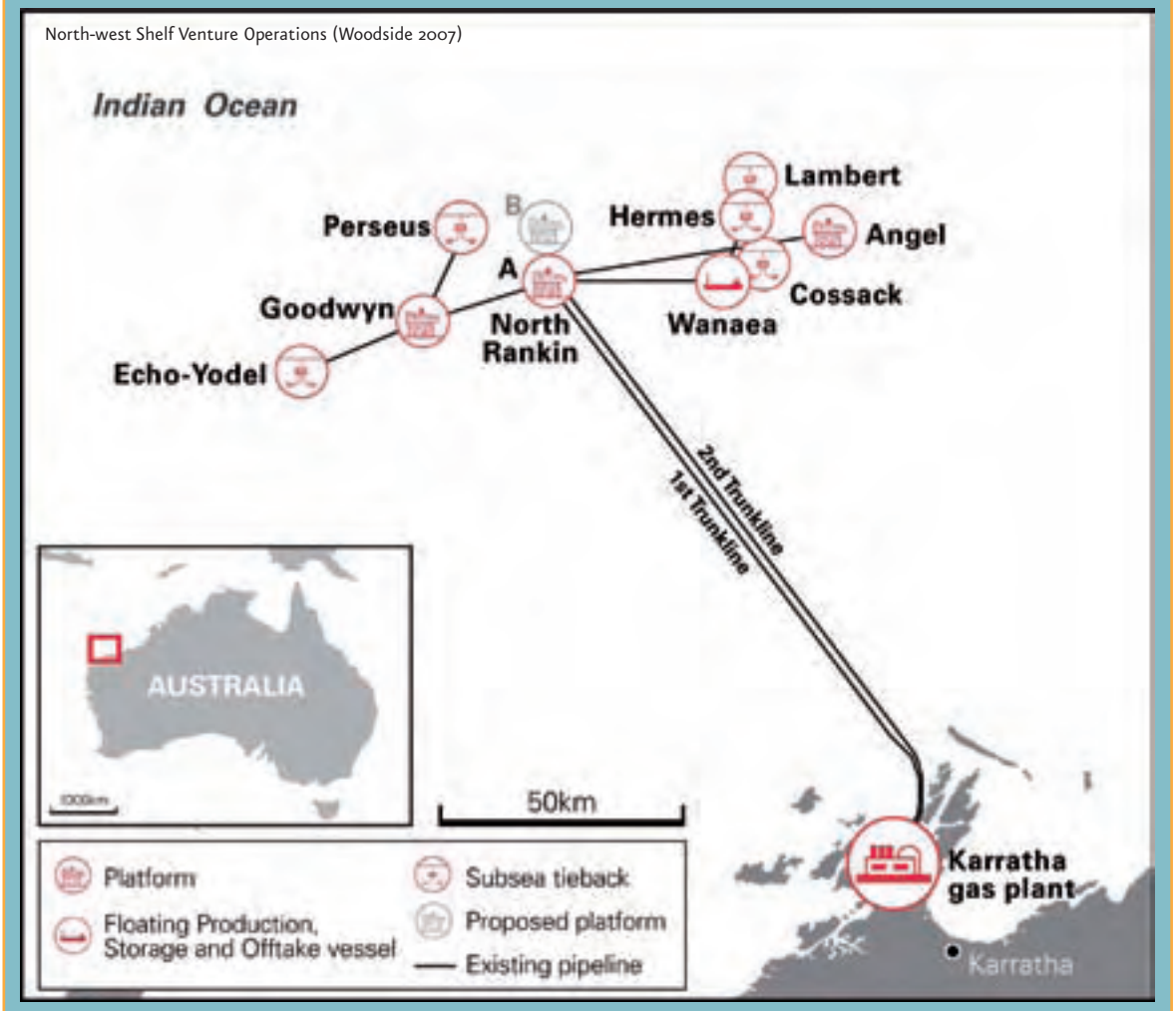
The Woodside-owned Pluto gas field is also situated in the Northwest Province, and contains approximately 5 trillion cubic feet of gas. The project is expected to produce 4.3 Mtpa of LNG at an onshore gas processing plant located on the Burrup Peninsula. In addition to Woodside's $11.2 billion investment, the development

Box 5.2 North West Shelf Venture

The North West Shelf Venture is Australia's largest resource development project, with investment in onshore and offshore oil and gas facilities valued at more than $20 billion. The venture involves six equal share companies: BHP Billiton Petroleum (North West Shelf) Pty Ltd, BP Developments Australia Pty Ltd, ChevronTexaco Australia Pty Ltd, Japan Australia LNG (MIMI) Pty Ltd, Shell Development (Australia) Pty Ltd and Woodside Energy Limited, which is also the project operator (Woodside 2007).

More than 40 per cent of Australia's oil and gas production comes from the North West Shelf Venture and it supplies Western Australia with 65 per cent of its gas needs.

North-west Shelf Venture Operations (Woodside 2007)



The North West Shelf Venture has three offshore facilities: North Rankin A, which is one of the world's largest gas producing platforms, Goodwyn A, which produces large volumes of gas and condensate, and Cossack Pioneer floating production, storage and off-take facility, which produces oil. The project also produces crude oil from the Cossack, Wanaea, Lambert and Hermes oil and gas fields.

North West Shelf Venture gas is piped onshore to the Burrup Industrial Estate on the Burrup Peninsula near Karratha. The Burrup Industrial Estate processing facility includes four LNG production trains with a current output of 11.7 million tonnes of LNG a year. Development of a fifth LNG production train is due for completion in 2008. When completed, it will increase the project's annual capacity to about 16.3 million tonnes, making it one of the biggest LNG plants in the world. The venture has significant LNG export arrangements with countries including Japan, China and Korea. An agreement to deliver more than 3 Mtpa of LNG to China over 25 years represents Australia's single largest dollar value export agreement and is worth $20–25 billion.

is expected to provide 300 direct jobs and to inject $28 billion into the national economy over the life of the project (Woodside 2007). Potential impacts on the marine environment associated with the project include noise emissions from offshore drilling and platform construction, and light spill from facility operations that could affect nesting turtles and migratory species.

The Burrup Peninsula, which is part of the Dampier Archipelago, is a National Heritage listed site that contains one of the world's largest and most important collections of Aboriginal petroglyph galleries, standing stones, camp sites and middens, which date back as far as the last ice age. Combined, these features make this area one of the world's most important monuments of prehistoric culture. To ensure the Pluto operations do not have significant impacts on the heritage listed values of the site, Woodside has entered into a conservation agreement with the Commonwealth under the EPBC Act.

Employment

The petroleum production sector in Western Australia is a significant employer, with approximately 5000 people working in petroleum operations in 2005–2006 (DoIR 2006). This figure does not take into account those industries or individuals employed servicing the sector, such as engineers or those employed in the construction of the sector's infrastructure. While a very capital intensive industry, the significant oil and gas projects currently underway or planned for the near future will result in continued high demand for labour. Finding sufficient skilled workers for projects is a growing problem for the industry (APPEA 2006) and is likely to intensify.

Petroleum administration and legislation

Onshore and in coastal waters, management of the petroleum industry in the North-west Marine Region is overseen by the Australian Government in partnership with the Western Australian Government. The Australian Government is responsible for broad economic policy settings including tax, foreign investment guidelines, international agreements and trade. The Western Australian Government owns and allocates petroleum rights, administers petroleum operations and collects royalties from operations onshore and in coastal waters.

Petroleum titles within the Territory of Ashmore and Cartier islands are administered by the Northern Territory Department of Industry, Fisheries and Mines on behalf of the Australian Government.

Offshore petroleum operations beyond 5.5 km (3 nautical miles) from the territorial sea baseline are governed by the Commonwealth's Offshore Petroleum Act 2006 which replaced the Petroleum (Submerged Lands) Act 1967 in 2008.

The Commonwealth owns the petroleum rights in Commonwealth waters, while the operation of the permit system is jointly administered by the Australian Government and the Western Australian Government. The Commonwealth's Petroleum Resource Rent Tax applies to all petroleum projects in Commonwealth waters, except the North West Shelf project, to which royalty and crude oil excise applies. Fees are collected by the Commonwealth and distributed to the Western Australian Government to cover the cost of administering petroleum titles in the area.

In the North-west Marine Region, petroleum companies are required to conduct their activities to a high standard of environmental performance and protection. Current Australian Government legislation relevant to environmental management of offshore petroleum exploration and development activities includes:

- The EPBC Act;
- *Petroleum (Submerged Lands) (Management of Environment) Regulations 1999;*
- *Environment Protection (Sea Dumping) Act 1981*;
- *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*; and
- *Historic Shipwrecks Act 1976*.

More information on these acts can be found in Appendix B.

Petroleum activities such as seismic surveys have the potential to cause physical, behavioural and perceptual effects on whales. Seismic operations are regulated by the Australian Government's *Interaction Between Offshore Seismic Exploration and Whales, EPBC Act Policy Statement 2.1, March 2007* (DEW 2007). The petroleum industry has taken an active role in the development and implementation of measures to minimise the potential impacts of exploration on cetaceans.

5.3.10 Offshore mineral occurrences and mining

The occurrence of offshore minerals and prospective mining locations in the Region is uncertain as systematic mineral exploration has not occurred outside State waters. However, it is possible that iron ore deposits extend offshore both as hard-rock and as heavy mineral magnetite sand deposits.

The technology of offshore mineral exploration and mining in deeper waters is still in very early stages of development although it is undergoing trials elsewhere in the world.

In State waters adjacent to the Region, mining is occurring at both Koolan and Cockatoo Islands where iron ore deposits extend offshore. At the Cockatoo Islands site, significant iron ore deposits extend in depth to at least 200 m below the sea level.

Recorded offshore mineral occurrences within the Region or in adjacent State Waters include diamonds at the north-eastern end of the Region in the Joseph Bonaparte Gulf (GA 2008). Other offshore mineral occurrences include heavy mineral sands in the King Sound and the Fortescue River Mouth.

5.3.11 Submarine cables and pipelines

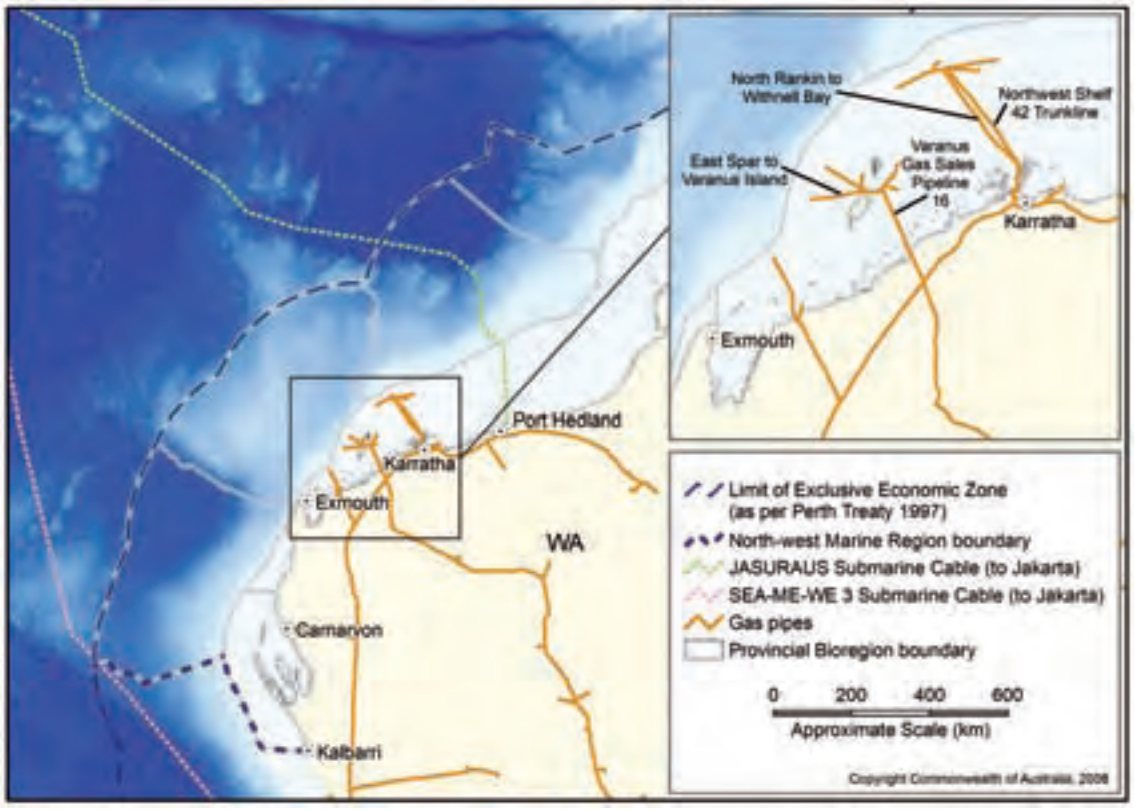
Cables

Submarine telecommunications cables are the underwater infrastructure linking Australia with other countries. Australia's submarine communications cables carry the bulk of our international voice and data traffic and are a vital component of our national infrastructure.

The JASURAUS and the SEA_ME_WE3 cables are two submarine telecommunications cables of national significance currently in service in the Region (Figure 5.19). Under the *Telecommunications and Other Legislation Amendment (Protection of Submarine Cables and Other Measures) Act 2005* protection zones cover the cables to prohibit and/or restrict activities that may damage them. Protection zones are generally the area within 1.8 km (1 nautical mile) on either side of the cable and include the waters above the area and the seabed and subsoil under the area (ACMA 2007).

The JASURAUS Cable is a fibre optic cable routed from Jakarta through the Sunda Strait to Port Hedland. It then has a dedicated terrestrial link to Perth. The cable traverses through the Northwest Shelf Province and Northwest Transition bioregions where the seabed is

Figure 5.19 Submarine telecommunication cables and pipelines in the Region



hard limestone. The cable is buried from the coast to 100 km offshore to protect it from damage and breakage in shallower water. The JASURAUS Cable was laid in 1997 has a technical life of 25 years.

The South East Asia, Middle East and Western Europe submarine cable 3 (SEA-ME-WE3) Cable, established in 2000, is also a fibre optic cable. It is a spur of the greater SMW3 system, which travels from Japan to the Middle East and Western Europe; the longest cable in the world. The relevant section for Western Australia travels from Singapore via Jakarta to Perth. The SEA_ME_WE3 cable dissects the boundary between the North-west Marine Region and the South-west Marine Region at the outer edge of the EEZ and hence is almost entirely outside the Region (see Figure 5.19). The cable has a protection zone and extends to a depth of 2000 m (approximately 94.5 km from land). Two submarine cables currently proposed for Western Australia will travel through the Region. These are the Singapore-Indonesia-Australia Cable which will connect Western Australia, Indonesia and Singapore, and the Ochre networks cable between Perth and Singapore which will enhance the broadband infrastructure for each country (Ridder *et al*. 2006).

Pipelines

There are a large number of offshore gas pipelines that either enter or pass through the Region, as shown in Figure 5.19. Many of these are located on the North West Shelf (Northwest Shelf Province) and are associated with connecting the North West Shelf Venture petroleum fields with the onshore Karratha Gas Plant located on the Burrup Peninsula. The biggest of these is the WA-10PL, which is the largest offshore LNG pipeline installed in Australia. Another is the North Rankin A gas and condensate pipeline, which travels 134 km from the North Rankin A platform in Commonwealth waters to the Karratha Gas Plant. Onshore, the North Rankin A pipeline is connected to the Dampier to Bunbury Natural Gas pipeline, which travels 1500 km overland to provide natural gas to Perth and other major regional centres along its route (IRC 2007).

The East Spar pipeline is also located in the Northwest Shelf Province and connects oil and gas fields to processing facilities on Varanus Island in State waters. Oil and gas is then transmitted to the mainland via the Varanus Export Gas pipeline where it connects to the terrestrial Goldfields Gas Transmission pipeline (IRC 2007).

The Bayu-Undan to Darwin Gas pipeline is predominantly in the North Marine Region and Timor Gap Zone but just passes through the top of the Northwest Shelf Transition bioregion. It pipes gas and condensate from the Bayu-Undan gas field to Darwin (Santos 2007).

The construction, operation and decommissioning of pipelines is administered in Commonwealth waters pursuant to the *Offshore Petroluem Act 2006* and the *Petroleum (Submerged Lands) (Pipelines) Regulations 2001*. In Western Australian waters, the *Petroleum Pipelines Act 1969* and *Petroleum Pipelines Regulations 1970* apply.

The EPBC Act is the main legislative instrument concerned with the environmental impact of cables and pipelines. Under the Act, any proposals for submarine cables and pipelines must be referred to the Minister for the Environment, Heritage and the Arts for assessment and approval if they are considered likely to have a significant impact on the Commonwealth marine environment or other matters of national environmental significance.

5.3.12 Defence and border protection

The North-west Marine Region, and the land adjacent to it, is generally sparsely populated and distant from major population centres. This vast coastline and marine area requires ongoing surveillance, reporting and response mechanisms to guard against offshore maritime threats including illegal fishing, unauthorised immigration, prohibited imports/exports, biosecurity breaches, illegal activities in protected areas and pollution. The defence of Australia from maritime threats is coordinated through the Border Protection Command, established in 2005. It is a multi-agency command centre that utilises the resources and expertise of Customs, the Australian Defence Force, the Australian Fisheries Management Authority, the Australian Quarantine and Inspection Service and other Australian Government agencies, to deliver a coordinated approach to the protection of Australia's maritime borders (Border Protection Command 2007)

The principal military component of Border Protection Command is Headquarters Northern Command based in Darwin. The Headquarters coordinates and controls military operations in Australia's north, including waters adjacent to the Northern Territory, northern Western Australia and northern Queensland. It also coordinates Defence's regional relationships with Indonesia and Papua New Guinea. The Headquarters also collates and analyses information on illegal immigrants and fishers as well as having responsibility for operational control of the Australian Defence Force surveillance and response efforts.

Customs operations in northern Australia include Coastwatch aircraft missions, which provide aerial surveillance of Australia's coastline and offshore maritime areas. Australian Customs patrol vessels also operate in collaboration with the Australian Fisheries Management Authority, the Royal Australian Air Force and the Royal Australian Navy to combat illegal foreign fishing in Australia's northern waters.

There are few Australian Defence Force bases or training areas located in the North-west Marine Region (Figure 5.20), although as a result of the Australian Government's Securing Australia's North West Shelf Policy, an operating logistics base has recently been established at Dampier to support vessels patrolling the waters around offshore oil and gas facilities in the Region. A dedicated navy administrative support facility is also being constructed at the nearby township of Karratha.

The Royal Australian Air Force currently maintains two 'bare bases' in remote areas of Western Australia: The Royal Australian Air Force Base Learmonth is located near Ningaloo Marine Park at Exmouth, and the Royal Australian Air Force Base Curtin is located further north at Derby. The Royal Australian Air Force maintains the

The Customs Coastwatch Dash 8 air fleet detect and report unlawful activity in Australian waters. Photo: Australian Customs Service.

Commonwealth Heritage listed Learmonth Air Weapons Range Facility (Lyndon Location 97), which is located between Ningaloo Station and the Cape Range National Park. This facility is used for military exercises and as a bombing range (Defence 2007a).

The Naval Communications Station Harold E. Holt is also located at North West Cape in Exmouth (Defence 2007b). The main role of the station is to communicate at very low frequencies with Australian and United States submarines in the Indian Ocean and the western Pacific.

The Australian Defence Force has policies in place to ensure maritime activities are conducted in accordance with their environmental obligations and responsibilities under the EPBC Act and relevant international conventions (Defence 2007c). Mitigation procedures have been developed to avoid interference with whales when operations are conducted in areas frequented by whales. These procedures provide guidance to ships and exercise planners, and include establishing safe distances from whales within which certain activities (e.g. sonar operations) are not conducted (Royal Australian Navy 2007).

Figure 5.20 Defence bases/training areas within and adjacent to the Region

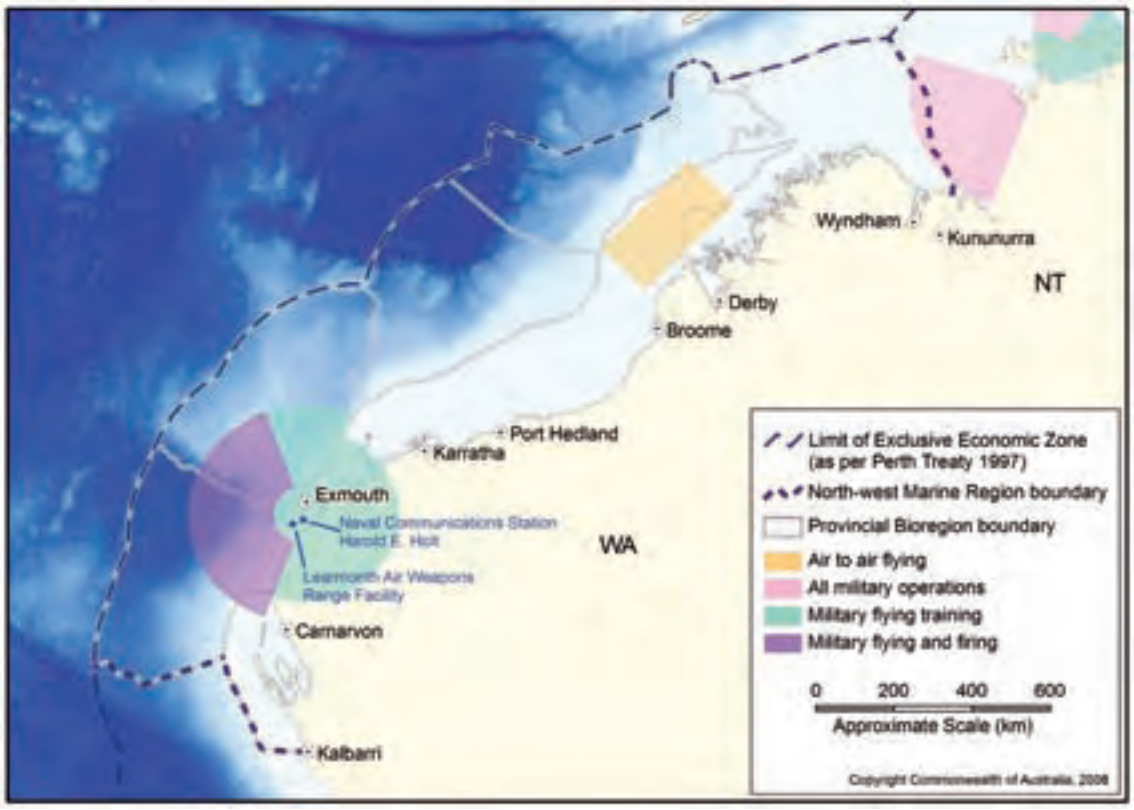


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Figure 5.6 Boundary of Australian-Indonesian MoU Box

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Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

International Risk Consultants (2007): Facilities, Ports, Moorings Points of Interest – North-west Marine Region

Projection: Geographics, Datum: GDA94

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Figure 5.9 Main shipping routes 2006

Australian Bureau of Statistics (1991): Australia, Populated Places

Australian Maritime Safety Authority (2006): Australian Ship Reporting Records

Department of the Environment, Water, Heritage and the Arts (2006):

Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006):

Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

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Figure 5.12 Sea dumping prior to the 1996 amendment to the *Environment Protection (Sea Dumping) Act 1981*

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (1998): Sea Dumped Waste Material off Australia and its Territories

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

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Figure 5.13 Offshore petroleum exploration and production permits in the Region

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

Encom Petroleum Information (2008): GPinfo Petroleum Exploration Database

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

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Figure 5.14 Sedimentary basins in the Region

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2004): Australian Geological Provinces

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

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Figure 5.16 Petroleum fields and operations in the North West Shelf (Northwest Shelf Province)

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

Encom Petroleum Information (2008): GPinfo Petroleum Exploration Database

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2004): Australian Geological Provinces

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

International Risk Consultants (2007): Facilities, Ports, Moorings Points of Interest – North-west Marine Region

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Figure 5.17 Petroleum fields and operations in the Browse Basin (Northwest Shelf Province, Timor Province and Northwest Shelf Transition)

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

Encom Petroleum Information (2008): GPinfo Petroleum Exploration Database

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2004): Australian Geological Provinces

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

International Risk Consultants (2007): Facilities, Ports, Moorings Points of Interest – North-west Marine Region

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Figure 5.18 Petroleum fields and operations in the Bonaparte Basin

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

Encom Petroleum Information (2008): GPinfo Petroleum Exploration Database

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2004): Australian Geological Provinces

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

International Risk Consultants (2007): Facilities, Ports, Moorings Points of Interest – North-west Marine Region

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Figure 5.19 Submarine telecommunication cables and pipelines in the Region

Australian Bureau of Statistics (1991): Australia, Populated Places

Department of the Environment, Water, Heritage and the Arts (2004): Submarine cables

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

Encom Petroleum Information (2008): GPinfo Petroleum Exploration Database

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Projection: Geographics, Datum: GDA94

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Figure 5.20 Defence bases/training areas within and adjacent to the Region

Australian Bureau of Statistics (1991): Australia, Populated Places

Australian Hydrographic Office (2007): Military Practice and Exercise Areas

Department of the Environment, Water, Heritage and the Arts (2006): Commonwealth Marine Planning Regions

Department of the Environment, Water, Heritage and the Arts (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0 - Provincial Bioregions

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Projection: Geographics, Datum: GDA94

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Dolphins and yacht, Shark Bay World Heritage Area. Photo: Ian Anderson, Department of Environment and Conservation, WA.

Chapter 6 Developing a North-west Marine Bioregional Plan: Next Steps

This Bioregional Profile describes the characteristics and conservation values of the North-west Marine Region and the adjacent coastal waters and land. This information will guide development of a Marine Bioregional Plan for the Region.

The environment of the North-west Marine Region experiences relatively little pressure from human activities in comparison with many other parts of the ocean in Australia and elsewhere. Large areas of the Region are remote, with human settlement concentrated in relatively restricted stretches of the coast. However, human activities over the last 200 years have had an impact on the marine environment of the North-west Marine Region. Intensive harvesting of whales, sharks and other fish over a relatively short period is thought to have changed the relative distribution of species and is likely to have altered ecologically important relationships between prey and predators.

The Western Australian economy is predicted to experience substantial growth over the coming years. This will be driven primarily by growth in the onshore mining and offshore petroleum sectors, prompted by increasing demand from the fast-growing economies of Asia. The growth in these sectors, together with growth in supporting services and infrastructure sectors, and of the populations of coastal centres, is likely to result in increasing human interactions with the species and habitats of conservation value in the North-west Marine Region.

Concurrent with the marine bioregional planning process, the Australian and Western Australian Governments are undertaking a strategic assessment of the west Kimberley, under Section 146 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This strategic assessment is being undertaken to ensure sustainable development while conserving the Kimberley's unique natural and cultural values. The strategic assessment will be undertaken in two parts, the first relating to the site selection and management of a common-user liquefied natural gas (LNG) hub to service exploitation of the Browse Basin gas reserves. The second part will be a wider assessment of the cultural and environmental values of the Kimberley, to formally identify its national and international heritage values to inform broader land use development in the Kimberley.

The strategic assessment will provide certainty for industry and reduce the impacts that would otherwise occur if piecemeal development of onshore LNG processing facilities were to occur along the Kimberley coastline. More information on the strategic assessments under the EPBC Act can be found in Appendix B.

This Profile provides a summary of what we know about the marine environment of the north-west and the ways in which we use it. This summary and supporting reports (see Section 1.2) provide an information-base for the next stages of marine bioregional planning in the North-west. While the Department of the Environment, Water, Heritage and the Arts has endeavoured to ensure that the information in this Profile is comprehensive, up to date and accurate, we recognise that stakeholders may have additional information that may contribute to our understanding of the Region. The Department welcomes comments on the Profile and any additional information that may assist in developing a bioregional plan for the North-west Marine Region. Comments and additional information can be sent by email to <NW_marine_plan@environment.gov.au>

or to
The Director,
Marine Bioregional Planning - North-west,
Marine and Biodiversity Division,
Department of the Environment, Water, Heritage and the Arts,
203 Channel Highway
Kingston, Tasmania 7050.

All information provided will be considered by the Department in developing the Draft North-west Marine Bioregional Plan.

Trochus. Photo: Australian Institute of Marine Science.

Appendix A International Conventions and Agreements on the Marine Environment

Australia's use and management of its oceans and their resources are subject to a range of international treaties to which Australia is a party. These can be broadly divided into two categories: those concerned with regulating activities to protect the marine environment and those relating specifically to the conservation of biodiversity. The following sections outline the main international agreements that influence Australia's approach to conserving marine biodiversity and protecting the marine environment.

International agreements regulating maritime activities to protect the marine environment

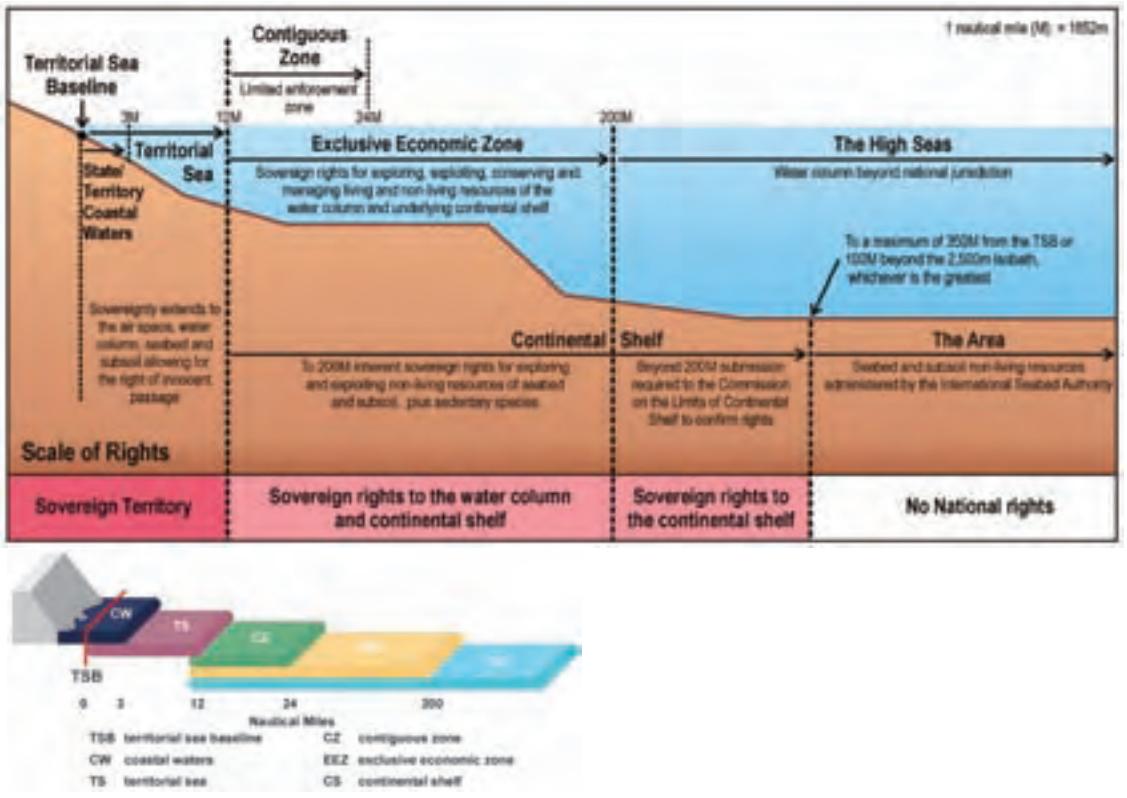
United Nations Convention on the Law of the Sea (UNCLOS) 1982

The Australian Government has rights and responsibilities under the *United Nations Convention on the Law of the Sea (UNCLOS) 1982* (in force since 1994) to manage the sea and seabed adjacent to its coastline. Under UNCLOS, coastal states are able to claim rights and responsibilities for seas out to 200 nautical miles from the territorial sea baseline, and to the edge of the continental shelf (Figure A.1). Within this area coastal states can exploit, develop, manage and conserve all resources (associated with the water column, seabed or subsoil). Under UNCLOS, all parties have the obligation to protect and preserve the marine environment.

Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks 1995 (Fish Stocks Agreement)

This implementing agreement to UNCLOS provides additional and enhanced rules on the conservation and management of highly migratory and straddling fish stocks that occur on the high seas and within areas of national jurisdiction. The Fish Stocks Agreement promotes cooperation with other states parties, particularly through the establishment of regional fisheries management bodies. The Fish Stocks Agreement also includes application of the precautionary approach and requires consideration of impacts on the broader ecosystem.

Figure A.1 Maritime zones for management arrangements under UNCLOS



Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties 1969 and the *1973 Protocol to the Convention*

This convention affirms the right of coastal states to take such measures on the high seas as may be necessary to prevent, mitigate or eliminate danger to their coastline or related interests from pollution by oil or the threat thereof, following upon a maritime casualty. The 1973 Protocol extended the convention to cover substances other than oil.

Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) 1972 and the *1996 Protocol to the Convention*

The objective of the London Convention is to promote the effective control of all sources of marine pollution and take all practicable steps to prevent pollution of the sea by dumping of wastes and other matter. Under this convention, dumping is defined as deliberate disposal of wastes or other matter in the sea that does not constitute normal operations. In Australia, the convention has been updated by the *1996 Protocol to the Convention* (the London Protocol), which Australia ratified in 2000, and which entered into force internationally in 2006. The London Protocol is more restrictive than the original convention and applies a precautionary approach to the dumping of waste or other matter that is likely to cause harm to the marine environment. The protocol prohibits dumping of all waste and other matter except material identified in Annex I of the protocol. The convention is implemented under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Environment Protection (Sea Dumping) Act 1981*, which have been amended to reflect the London Protocol. These Acts require permits to be issued for the dumping of materials at sea.

Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention) 1972

This convention, which came into force in 1975, provides for the protection of the world's cultural and natural heritage places. The convention is administered by the World Heritage Committee whose functions are to:

- identify nominated cultural and natural properties of outstanding universal value, which are to be protected under the convention, and to list them on the World Heritage List;
- decide if properties on the list should be inscribed on the List of World Heritage in Danger; and
- determine how and under what conditions the World Heritage Fund can be used to assist countries in the protection of their World Heritage property.

Under the EPBC Act, the Commonwealth has the power to submit properties for inclusion on the World Heritage List. This may be exercised if the Minister for the Environment, Heritage and the Arts is satisfied that the Commonwealth has endeavoured to reach agreement on the listing and management arrangements for the property with the owner or occupier of the property, or with the government of the State or Territory in which the property is located.

International Convention for the Prevention of Pollution from Ships (MARPOL)

Under the terms of this convention, regulatory controls are placed on pollution from ships. The convention has six annexes that specifically address different sources of pollution from shipping:

- Annex I addresses the discharge of oil from ships and regulates how and when a ship may discharge oil into the sea;
- Annex II addresses the discharge or escape of noxious liquid substances (i.e. chemicals);
- Annex III addresses harmful substances carried in packaged forms (i.e. freight containers);
- Annex IV addresses the discharge of sewage from ships;
- Annex V addresses discharge of garbage from ships into the sea; and
- Annex VI addresses air pollution from ships, including engine emissions.

International Convention on Oil Pollution Preparedness, Response and Cooperation 1990, as amended by the Protocol on Preparedness, Response and Cooperation to Pollution Incidents by Hazardous and Noxious Substances 2000

This convention facilitates international cooperation to prepare for, and respond to, major oil and chemical pollution incidents and encourages countries to develop and maintain an adequate capability to deal with oil

and chemical pollution emergencies. In Australia, the provisions of the convention are given effect through the *National Plan to Combat Pollution of the Sea by Oil and Other Noxious and Hazardous Substances* and administrative arrangements of the Australian Maritime Safety Authority and other Government agencies.

International Convention on Civil Liability for Oil Pollution Damage 1992

This convention requires oil tankers to have compulsory insurance against pollution damage liabilities. The convention applies to an oil spill occurring in the territory of a state party to the convention (e.g. the Australian Exclusive Economic Zone (EEZ)), and sets the upper limits of liability, which depend on the size of the vessel.

International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage 1992

This convention applies if the cost for a clean-up of an oil spill exceeds the upper limit of liability set under the *International Convention on Civil Liability for Oil Pollution Damage 1992*. Under the convention, any person or entity that receives, by sea, more than 150 000 tonnes of oil in a year must contribute to the fund. In Australia, all major oil companies contribute to the scheme.

International Convention on the Control of Harmful Anti-Fouling Systems on Ships

This convention prohibits the use of harmful organotins in anti-fouling paints used on ships and establishes a mechanism to prevent the potential future use of other harmful substances in anti-fouling systems. This convention will enter into force on 17 September 2008, as will relevant legislation that implements the convention in Australia. See Appendix B for more information on the *Protection of the Sea (Harmful Anti-fouling Systems) Act 2006*.

International Convention on Civil Liability for Bunker Oil Pollution Damage 2001

This convention requires ships over 1000 gross tons, other than oil tankers, to have compulsory insurance against pollution damage liabilities. The convention is similar to the 1992 Convention on Civil Liability for Oil Pollution Damage outlined above in that it applies to an oil spill occurring in the territory of a state party (e.g. the Australian EEZ), and sets the upper limits of liability, which depend on the size of the vessel.

International Convention for the Control and Management of Ship's Ballast Water and Sediments

This convention has not yet entered into force internationally. When in force, it will provide technical standards and requirements for the control and management of ships' ballast water and sediments. Australia signed the convention on 27 May 2005 and has commenced undertaking the processes necessary for ratification.

Regional Fisheries Management Organisations

The Australian Government Department of Agriculture, Fisheries and Forestry develops policies and programs to address Australia's international rights and obligations in regard to fisheries, and represents Australia's interests in a number of international fora. Chief amongst these are Regional Fisheries Management Organisations, which are established to govern the management of fish stocks on the high seas and fish stocks which migrate through the waters of more than one country.

Commission for the Conservation of Southern Bluefin Tuna 1994

The *Convention for the Conservation of Southern Bluefin Tuna* formalised the management arrangements between Australia, Japan and New Zealand that had been established on a voluntary basis. The convention created the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) in 1994. The Republic of Korea and the Fishing Entity of Taiwan have since joined the commission. Cooperating non-members participate fully in the business of the CCSBT but cannot vote. Since 2003, the Philippines, South Africa and the European Community have been formally accepted as cooperating non-members.

The commission establishes binding conservation and management measures for the southern bluefin tuna fishery, including a total allowable catch and national allocations. A range of monitoring, control and surveillance measures are being developed by the commission. The commission also considers issues related to the impact of the fishery on ecologically-related species.

Agreement for the Establishment of the Indian Ocean Tuna Commission 1993

The *Agreement for the Establishment of the Indian Ocean Tuna Commission* (IOTC) has been in force since 1996. This agreement promotes cooperation in the conservation of tuna and tuna-like species in the Indian Ocean, including waters within national jurisdiction of coastal states (including Australia). The commission promotes optimum utilisation and sustainable development of Indian Ocean tuna fisheries. The IOTC overlaps with the CCSBT in the southern Indian Ocean and has deferred management of the southern bluefin tuna fishery in this area to the CCSBT. The IOTC currently has 26 members, which include the coastal states of the region and nations from distant waters that fish in the Indian Ocean.

Other fisheries arrangements

Australia also participates in a number of fora that aim to promote regional development through sustainable fisheries management. These include:

- the United Nations Food and Agriculture Organisation (FAO), through its Committee on Fisheries;
- the Asia-Pacific Economic Cooperation (APEC) Fisheries Working Group; and
- Pacific Fisheries Fora, including Australia's involvement in the Pacific Island Countries-US Treaty.

To promote regional fisheries cooperation, Australia maintains a strong and productive dialogue with its close neighbours. Australia conducts bilateral meetings with its neighbours to tackle issues such as shared and highly migratory fish stock management, illegal, unreported and unregulated fishing, and fisheries and aquaculture development. There are also a number of bilateral agreements or arrangements between Australia and neighbouring countries to ensure the sustainable use of shared resources. The neighbouring countries with which Australia shares cooperative ties include Indonesia, East Timor, Papua New Guinea (including Torres Strait issues), and New Zealand. One of these agreements, the *Memorandum of Understanding Between the Government of Australia and the Government of the Republic of Indonesia Regarding the Operations of Indonesian Traditional Fishermen in Areas of the Australian Exclusive Fishing Zone and Continental Shelf*, has particular relevance in the North-west Marine Region, and is detailed below under Agreements between Australia and Indonesia related to the North-west Marine Region.

In addition to the *United Nations Convention on the Law of the Sea* and subsidiary agreements, there are several other overarching multilateral agreements and arrangements of relevance to fisheries management to which Australia is a signatory or a party. These include:

- *United Nations Food and Agriculture Organisation's Code of Conduct for Responsible Fisheries*; and
- *Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas* (Compliance Agreement).

International agreements for the conservation of biodiversity

International Convention for the Regulation of Whaling 1946

This convention was signed on 2 December 1946. The initial purpose of the convention was "to provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry". Over the decades, most member countries have abandoned whaling, but have continued to view the International Whaling Commission (IWC) as an appropriate forum to focus on the conservation of whales. The Australian Government has opposed commercial whaling both domestically and internationally since 1978, and has strongly supported the global moratorium on commercial whaling imposed by the IWC in 1986.

Convention on International Trade in Endangered Species of Wild Fauna and Flora 1973 (CITES)

This convention aims to ensure that international trade in specimens of wild animal and plant species does not threaten their survival. CITES works by providing a legally binding framework whereby parties adopt their own legislation to implement CITES measures at the national level. The convention also allows parties to adopt national legislation that is stricter than CITES measures.

All international trade – imports, exports, re-exports and introduction – of species listed under the convention is controlled through a licensing system. The species covered by CITES are listed in three appendices, according to the degree of protection they require. Appendix I includes species threatened with extinction.

Trade in specimens of these species is permitted only in exceptional circumstances. Appendix II includes species not necessarily threatened with extinction, but in which trade must be controlled to avoid exploitation that could threaten their survival. Appendix III lists species that are protected in at least one country, which has asked other CITES parties for assistance in controlling the trade.

Bilateral Migratory Bird Agreements

For nearly 30 years, Australia has played an important role in international cooperation to conserve migratory birds in the East Asian-Australasian Flyway, which stretches from Alaska and the east of Russia, through the countries of East and South-East Asia, to Australia and New Zealand. Australia has negotiated and entered into bilateral agreements with Japan, China and Korea to protect migratory birds. These are:

- The *Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment 1974* (JAMBA);
- The *Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986* (CAMBA); and
- The *Agreement between the Government of Australia and the Government of the Republic of Korea on the Protection of Migratory Birds 2007* (ROKAMBA).

The Partnership for the Conservation of Migratory Waterbirds and the Sustainable Use of their Habitats in the East Asian–Australasian Flyway, launched in Bogor, Indonesia on 6 November 2006, represents an important new step in international efforts to conserve migratory waterbirds and their habitats in the flyway. Established as a Type II Partnership initiative of the 2002 World Summit on Sustainable Development, the Partnership is the major international framework for the conservation of migratory waterbirds in the East Asian–Australasian Flyway, promoting dialogue, cooperation and collaboration between stakeholders. To date, the Partnership has been endorsed by 17 governments and organisations.

Convention on Wetlands of International Importance especially as Waterfowl Habitat 1971 (Ramsar Convention)

This international agreement is more commonly known as the Ramsar Convention on Wetlands, and originally aimed to conserve and wisely use wetlands primarily as habitat for waterbirds. Over the years, the Ramsar Convention's scope has broadened to cover all aspects of wetland conservation and wise use, recognising that wetland ecosystems are important for both biodiversity conservation and the well-being of human communities.

To achieve its aims, the Ramsar Convention requires international cooperation, policy making, capacity building and technology transfer from its members. Under the Ramsar Convention, a wide variety of natural and human-made habitat types can be classified as wetlands, including features in the marine environment.

All wetlands listed under the Ramsar Convention are recognised as matters of national environmental significance under the EPBC Act. As such, approval is required for actions that will have, or are likely to have a significant impact on the ecological character of a Ramsar listed wetland. The implications of this are discussed in more detail in Appendix B.

Convention on the Conservation of Migratory Species of Wild Animals 1979

The Convention on the Conservation of Migratory Species of Wild Animals (CMS; also known as the Bonn Convention) aims to conserve terrestrial, marine and avian migratory species throughout their range. The CMS has two appendices. Appendix I lists migratory species that have been categorised as being in danger of extinction throughout all or a significant portion of their range. Appendix II is for migratory species that have an unfavourable conservation status and would benefit significantly from international cooperation. For species listed under Appendix I, signatory nations strive to take action to protect the animals, conserve or restore the places where they live, mitigate obstacles to migration and control other factors that might endanger them. For species listed under Appendix II, the convention encourages the development of regional conservation instruments.

Since becoming a party to the CMS in 1991, Australia has been an active participant in implementing the convention through the development of regional conservation instruments under the CMS. Australia played a key role in the development of the *Agreement for the Conservation of Albatross and Petrels* (ACAP) and the *Indian Ocean and South-East Asian Memorandum of Understanding for Sea Turtles* (IOSEA-Turtles), and has significantly supported their implementation. For

instance, Australia has hosted the interim Secretariat of ACAP since its inception and the headquarters will be established in Australia in due course.

On 31 October 2007, Australia signed the *Memorandum of Understanding on the Conservation and Management of Dugongs and their Habitats throughout their Range* under the CMS at a meeting in Abu Dhabi, United Arab Emirates held from 28-31 October 2007. The MoU is a non-legally binding arrangement that acknowledges the shared responsibility of signatory states for the conservation and management of dugongs and their habitat. The associated *Conservation Management Plan for Dugong* sets out key priority objectives and actions for the conservation and management of dugong populations across their migratory range and is consistent with plans for other species developed under CMS.

Australia has also taken the lead in progressing the development of new regional conservation arrangements for marine mammals in the South Pacific. All species listed under the CMS that occur naturally in Australia are listed under the EPBC Act and are thereby protected.

Convention on Biological Diversity 1992

Australia signed the *Convention on Biological Diversity* at its inception at the 1992 Earth Summit in Rio de Janeiro. The convention establishes three main goals: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits from the use of genetic resources. A significant provision of the *Convention on Biological Diversity* is the requirement that environmental impact assessments be performed for proposed activities likely to have significant adverse impacts on the environment. The EPBC Act is the mechanism by which the Australian Government undertakes this provision of the *Convention on Biological Diversity*. Much of the work of the convention is founded on 'Programs of Work' across many of the convention's cross-cutting and thematic issues. The program of work on marine and coastal biodiversity focuses on implementing the *Jakarta Mandate on Marine and Coastal Biological Diversity*. This includes integrated marine and coastal area management, the sustainable use of living resources, the establishment and maintenance of marine and coastal protected areas, minimising the negative effects of mariculture on marine and coastal biodiversity, and preventing the introduction and minimising the impact of alien species into the marine and coastal environment. The marine and coastal and the protected areas programs of work together provide an important platform for pursuing policy and initiatives on marine protected areas and other related tools to conserve marine biodiversity, coral reef ecosystems and global fish stocks. Obligations and guidelines for action on marine and coastal biodiversity are primarily based on the Conference of the Parties (COP) 7 Decisions VII/5 (marine and coastal diversity) and VII/28 (protected areas).

Racoon butterflyfish on Mermaid Reef. Photo: Naomi Wolfe, Department of the Environment, Water, Heritage and the Arts.

Agreements between Australia and Indonesia related to the North-west Marine Region

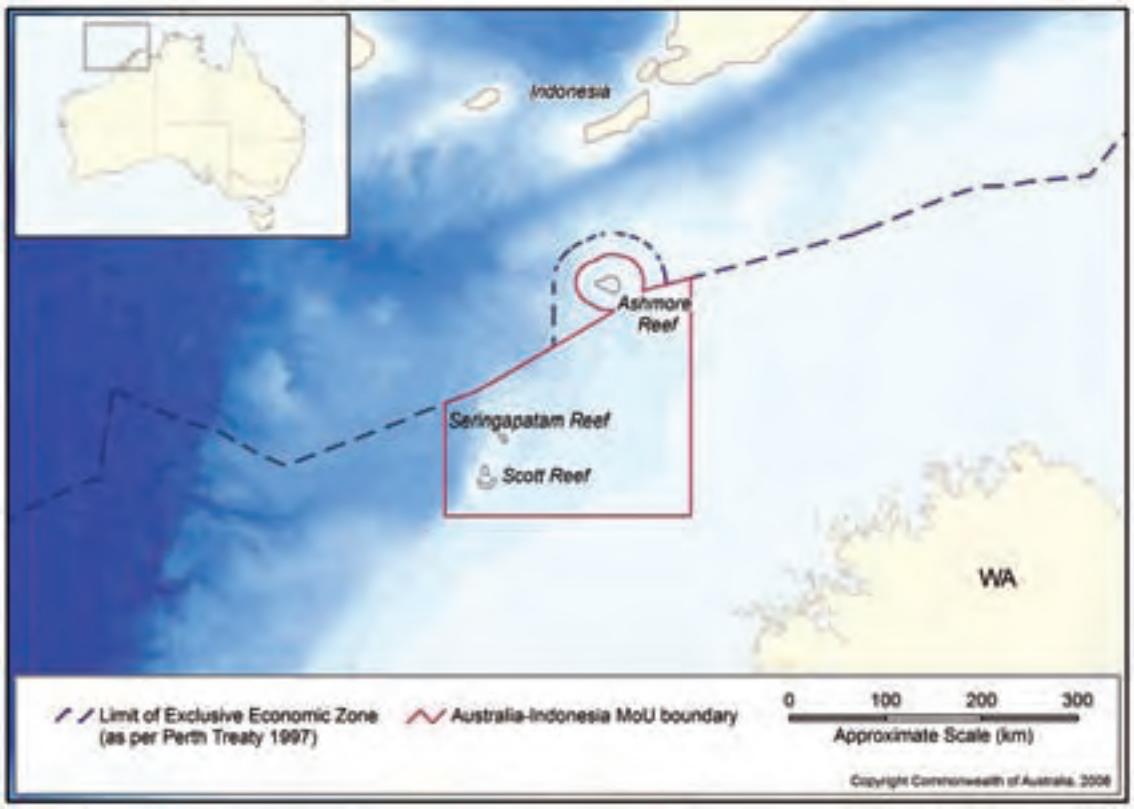
Memorandum of Understanding Between the Government of Australia and the Government of the Republic of Indonesia Regarding the Operations of Indonesian Traditional Fishermen in Areas of the Australian Exclusive Fishing Zone and Continental Shelf

Traditional fishers from the Indonesian Archipelago have an historic and ongoing association with the islands and reefs of the northern part of the Region. This Memorandum of Understanding (MoU) was established to administer the activities of Indonesian traditional fishers operating in Australia's territorial waters, following establishment of Australia's offshore territorial waters.

The original MoU was signed in 1974 and allowed Indonesian traditional fishermen to collect and fish certain species within a 12 nautical mile radius of Ashmore Reef, Cartier Island, Scott Reef, Seringapatam Reef and Browse Island.

The MoU was reviewed in 1989 following the declaration of Australian territorial waters out to 200 nautical miles from shore. Under the provisions of the revision of the MoU, traditional fishers, defined as using only paddle or wind powered boats and using nets and lines, are permitted to take fish and certain sedentary species (trepang and trochus) within a 'box' defined under the MoU (referred to as the 'MoU Box'; Figure A.2). Indonesian fishers cannot use motorised vessels or motorised fishing gear in the MoU Box, and fishers must adhere to the prescriptions of the Ashmore Reef National Nature Reserve and the Cartier Island Marine Reserve. No fishing or collecting is allowed in either reserve except in a small area near West Lagoon (within the Ashmore reserve) which is open to the public and where finfish may be taken by traditional fishers for immediate consumption. The MoU does not permit traditional fishers to take species listed under the *Convention on International Trade in Endangered Species*, including marine turtles, seabirds, dolphins, dugongs and giant clams.

Figure A.2 ***Boundary of Australian-Indonesian MoU Box***



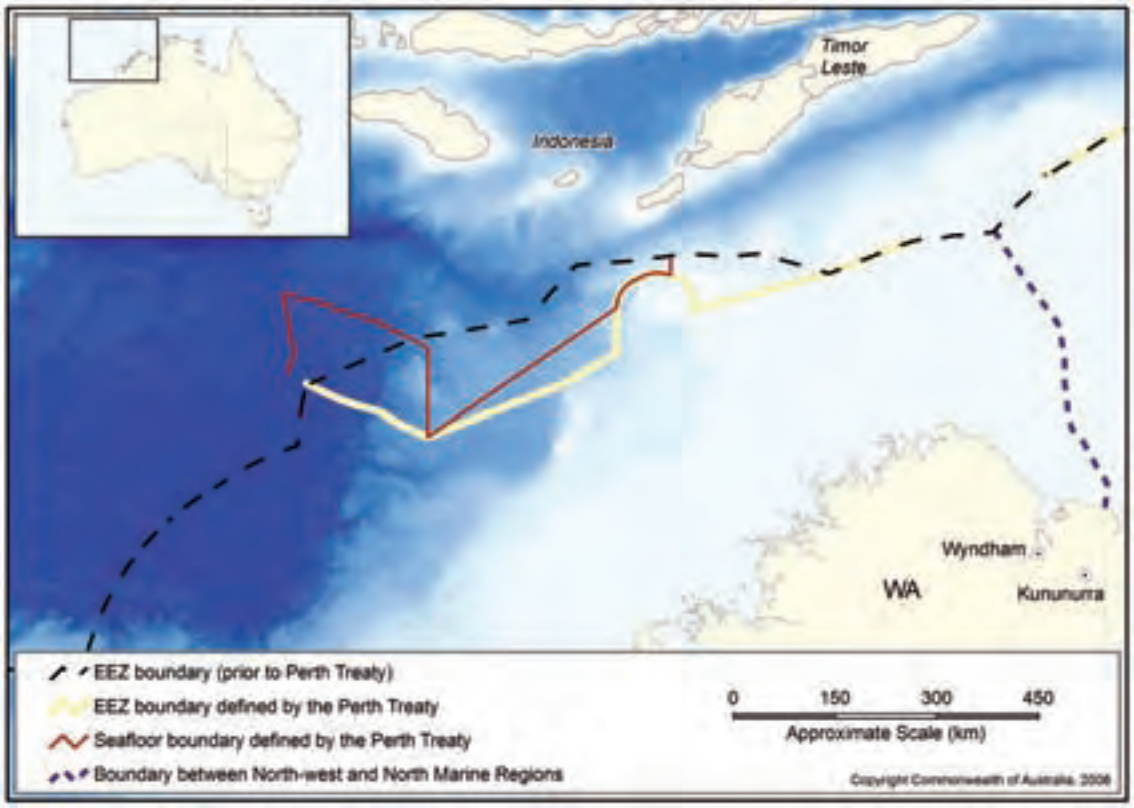
Treaty between the Government of Australia and the Government of the Republic of Indonesia establishing an Exclusive Economic Zone Boundary and Certain Seabed Boundaries 1997

This treaty is commonly known as the Perth Treaty. It was signed by the governments of Australia and the Republic of Indonesia in 1997 but has not yet entered into force. When ratified, the treaty will finalise the EEZ boundary between Australia and Indonesia, taking into account the *United Nations Convention on the Law of the Sea*. The Perth Treaty builds on previous agreements to complete the seabed boundary between Australia and Indonesia (with the exception of the area covered by the Timor Gap Treaty). This agreement establishes an area of overlapping jurisdiction, where the Indonesian EEZ (water column) overlays the Australian continental shelf (seabed). See Figure A.3.

The Perth Treaty reaffirms the general duty to prevent, reduce and control pollution in the marine environment and obligations to cooperate in relation to exercising each country's rights and jurisdiction. The treaty also directs its parties to find agreement on the most effective means of exploiting and equitably sharing any hydrocarbon deposit that straddles the maritime boundaries of the treaty. The overlapping EEZ/continental shelf jurisdiction establishes a zone in which Australia and Indonesia share responsibility for protection and preservation of the marine environment.

The North-west Marine Bioregional Plan only relates to Australian waters in which the Commonwealth exercises jurisdiction over both the seabed and water column. It does not, therefore, relate to the Joint Petroleum Development Area established by the Timor Sea Treaty.

Figure A.3 Seabed and EEZ boundaries as defined by the Perth Treaty



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Map data

Figure A.2 Boundary of Australian-Indonesian MoU Box

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2005): Australian Bathymetry and Topography

Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Projection: Geographics, Datum: GDA94

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Figure A.3 Seabed and EEZ boundaries as defined by the Perth Treaty

ESRI Australia Pty Ltd (Canberra) (2001): ARCWORLD Map of the World 1:20 million

Geoscience Australia (1998): Australia, TOPO-2.5M Topographic Data - Coast and State Borders

Geoscience Australia (2005): Australian Bathymetry and Topography

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Projection: Geographics, Datum: GDA94

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Snorkeller at Mermaid Reef. Photo: Naomi Wolfe, Department of the Environment, Water, Heritage and the Arts.

Trepang boat, Scott Reef. Photo: Australian Institute of Marine Science.

Appendix B An Overview of the Legislative Framework for Environmental Protection and Biodiversity Conservation in Commonwealth Waters

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) streamlines national environmental assessment and approvals processes, protects Australian biodiversity and integrates the management of important natural and cultural places. Alongside the EPBC Act, the *Environment Protection (Sea Dumping) Act 1981* (Sea Dumping Act) and the *Historic Shipwrecks Act 1976* are the main pieces of legislation that give effect to the Australian Government's responsibilities to protect and conserve the environmental and heritage assets that exist in the Commonwealth marine environment. Like the EPBC Act, these Acts are also the responsibility of the Minister for the Environment, Heritage and the Arts.

Other key pieces of legislation and regulations that include provisions for the protection of the marine environment are the *Petroleum (Submerged Lands) (Management of Environment) Regulations 1999*, the *Fisheries Management Act 1991*, the *Great Barrier Reef Marine Park Act 1975*, the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* and the *Sea Installations Act 1987*. In addition, the *Native Title Act 1993* interacts with the EPBC Act in areas of environmental protection.

The legislative context in which marine bioregional planning takes place is summarised below.

Environment Protection and Biodiversity Conservation Act 1999

Marine bioregional planning

Marine Bioregional Plans are being developed for the Commonwealth marine area under Section 176 of the EPBC Act. The Commonwealth marine area generally stretches from three nautical miles to 200 nautical miles from the coast.

The States and the Northern Territory are responsible for managing the marine environment in State and Northern Territory coastal waters. Coastal waters include the waters between the territorial sea baseline (normally the low water mark along the coast) and a line three nautical miles seaward of it. As many ecological processes occur across both State and Commonwealth waters, the Australian Government aims to work cooperatively with the States and the Northern Territory in developing and implementing Marine Bioregional Plans.

Marine Bioregional Plans will bring together comprehensive information and provide guidance to sectoral managers and industry in relation to decisions made under the EPBC Act about key conservation issues and priorities in each marine region. The EPBC Act requires the Minister for the Environment, Heritage and the Arts to have regard to Bioregional Plans when making any decision under the EPBC Act for which the Plan has relevance. Marine Bioregional Plans also aim to streamline conservation and environmental management and to create Marine Protected Areas (MPAs) in Commonwealth waters that will further the development of the National Representative System of MPAs.

Marine bioregional planning is being undertaken by the Department of the Environment, Water, Heritage and the Arts in consultation with all Commonwealth agencies responsible for marine-based activities, and with input from the State and Northern Territory governments and non-government stakeholders.

Referral, assessment and approval

Central to the EPBC Act is the concept of matters of national environmental significance. Matters of national environment significance 'trigger' the referral, assessment and approval of activities under the EPBC Act. The EPBC Act requires that proposals for actions that have, will have or are likely to have a significant impact on a matter of national environmental significance be referred to the Minister for the Environment, Heritage and the Arts for assessment and approval (unless an exemption has been provided under another provision of the EPBC Act).

The EPBC Act identifies seven matters of national environmental significance:

- World Heritage properties;
- National Heritage places (from 1 January 2004);

- wetlands listed under the *Convention on Wetlands of International Importance especially as Waterfowl Habitat 1971* (Ramsar Convention);
- listed threatened species and ecological communities (excluding species listed as extinct or conservation dependent);
- listed migratory species;
- the Commonwealth marine environment; and
- nuclear actions (including uranium mining).

Of these, three are particularly relevant to marine bioregional planning: *listed threatened species*, *listed migratory species* and the *Commonwealth marine environment*. Further information on the Commonwealth marine area, and its status as a matter of national environmental significance, is provided in Box B1.

Part 5 of the EPBC Act enables the Minister for the Environment, Heritage and the Arts (on behalf of the Commonwealth) to enter into bilateral agreements with a State or Territory. A bilateral agreement may provide for the accreditation or authorisation of a State or Territory process to satisfy the requirements for assessment under the EPBC Act, provided the Minister is satisfied that the State or Territory process meets the criteria prescribed by the Regulations under the Act.

A number of EPBC Act policy statements have been developed to provide guidance on when actions should be referred to the Minister for the Environment, Heritage and the Arts for assessment and approval under the Act. The following EPBC Act policy statements provide guidance about the types of actions that should be referred for assessment and approval:

- *EPBC Act Policy Statement 1.1 Significant Impact Guidelines – Matters of National Environmental Significance* (May 2006). This statement provides proponents of activities in Commonwealth marine areas with guidance about whether or not the actions they propose to take will require assessment and approval under the EPBC Act.
- *EPBC Act Policy Statement 1.2 Significant Impact Guidelines – Actions On, or Impacting Upon, Commonwealth Land and Actions by Commonwealth Agencies* (May 2006). This statement provides guidance on land-based actions which should be referred for approval under the EPBC Act and should be read in conjunction with the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines – Matters of National Environmental Significance*.
- *EPBC Act Policy Statement 2.1 – Interactions between Offshore Seismic Exploration and Whales* (May 2007). This policy statement updates the previous cetacean interaction guidelines (produced in 2001) based on operational experience and public and expert comments. This policy statement should be read in conjunction with the associated background paper and *EPBC Act Policy Statement 1.1*. It seeks to:

  1) provide practical standards to minimise the risk of acoustic injuries to whales in the vicinity of seismic survey operations;

  2) provide a framework that minimises the risk of biological consequences from acoustic disturbance from seismic surveys to whales in biologically important habitat areas or during critical behaviours; and

  3) provide advice to proponents of offshore seismic operations on their legal responsibilities under the EPBC Act.
- *EPBC Act Policy Statement 2.2 Industry – Offshore Aquaculture* (August 2006) This policy statement provides guidance to proponents of marine aquaculture activities to determine whether or not the actions they propose will require assessment and approval under the EPBC Act. These guidelines should be read in conjunction with the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines – Matters of National Environmental Significance*.
- Nationally threatened species and ecological community guidelines have been prepared for a number of land-based threatened species and ecological communities. To date, no guidelines for nationally threatened marine species or ecological communities have been developed.

Copies of the EPBC Act policy statements and guidelines are available at <www.environment.gov.au/epbc/guidelines-policies.html>.

Protecting marine biodiversity

A number of instruments, measures and programs are in place under the EPBC Act for the protection, conservation and recovery of marine biodiversity. The EPBC Act contains provisions that protect listed threatened species, listed migratory species, listed marine species and cetaceans. Species listed under the Act are commonly referred to as 'protected' species because it is an offence to kill, injure, take, trade, keep or move a listed species without authorisation.

These provisions apply generally in the Commonwealth marine area (as well as other Commonwealth areas), and to members of species taken in the Commonwealth marine area (as well as other Commonwealth areas) and subsequently moved from the area.

Species listed as threatened under the EPBC Act are those identified as facing serious risk of extinction in the wild (as determined in accordance with criteria specified under Part 7 of the *Environment Protection and Biodiversity Conservation Regulations 2000*). Under the EPBC Act, listed threatened species must be classified into one of the following six categories: extinct, extinct in the wild, critically endangered, endangered, vulnerable, and conservation dependent (Table B1).

Box B1 The Commonwealth marine area

The Commonwealth marine area is defined in the EPBC Act as any part of the sea, including the waters, seabed, and airspace, within Australia's Exclusive Economic Zone (EEZ) and/or over the continental shelf of Australia, excluding State and Northern Territory coastal waters. Generally, the Commonwealth marine area stretches from three nautical miles from the territorial sea baseline (normally the low water mark) to the outer limit of the EEZ, 200 nautical miles from the baseline.

Under the EPBC Act, a person must not take an action within the Commonwealth marine area that has, will have, or is likely to have a significant impact on the environment without approval from the Commonwealth Minister for the Environment, Heritage and the Arts. In addition, a person must not take an action outside the Commonwealth marine area that has, will have, or is likely to have a significant impact on the Commonwealth marine area without approval.

Table B1 Criteria for listing threatened species (from Division 7.01 of the EPBC Regulations)

Item	Criterion	Category		
		Critically endangered	Endangered	Vulnerable
1	It has undergone, is suspected to have undergone or is likely to undergo in the immediate future:	a very severe reduction in numbers	a severe reduction in numbers	a substantial reduction in numbers
2	Its geographic distribution is precarious for the survival of the species and is:	very restricted	restricted	limited
3	The estimated total number of mature individuals is:	very low	low	Limited
	and:			
	(a) evidence suggests that the number will continue to decline at: or	a very high rate	a high rate	a substantial rate
	(b) the number is likely to continue to decline and its geographic distribution is:	precarious for its survival	precarious for its survival	precarious for its survival
4	The estimated total number of mature individuals is:	extremely low	very low	low
5	The probability of its extinction in the wild is at least:	50 per cent in the immediate future	20 per cent in the near future	10 per cent in the medium-term future

The EPBC Act also allows for the listing of threatened ecological communities. As of April 2008, no ecological communities in the marine environment have been listed under the EPBC Act. The Commonwealth Minister for the Environment, Heritage and the Arts can also identify and list habitat critical to the survival of a listed threatened species or ecological community on the Register of Critical Habitat. As of April 2008, no habitats in the North-west Marine Region have been listed on the Register of Critical Habitat. In relation to threatened species and communities, the EPBC Act also provides for the identification and listing of key threatening processes and the preparation of threat abatement plans and species recovery plans.

All whales, dolphins and porpoises are protected under the EPBC Act through the establishment of the Australian Whale Sanctuary, which includes all Commonwealth waters. Within the Australian Whale Sanctuary it is an offence to kill, injure or interfere with cetaceans. They are also protected in State and Territory waters.

Migratory species listed under the EPBC Act are species listed under international agreements (to which Australia is a signatory) as species whose protection requires, or would significantly benefit from, international cooperation. These international agreements are discussed in more detail in Appendix A.

Marine species listed under the EPBC Act are species occurring naturally in the Commonwealth marine area that the Australian Government recognises require protection to ensure their long-term conservation. Species listed as marine species are identified in Section 3.3 of the Act.

In Australia, the EPBC Act controls the international movement of wildlife, wildlife specimens and products made or derived from wildlife. These controls apply to all transactions undertaken by commercial and non-commercial organisations and individuals. In addition, controls under the *Quarantine Act 1908* may apply. Under the EPBC Act a permit is required to:

- import or export CITES listed specimens (CITES is the *Convention on International Trade in Endangered Species of Wild Fauna and Flora 1973* – see Appendix A for more detail);
- export specimens derived from native species not included in the list of exempt native specimens; or
- import live plants or animals included in part two of the list of plants and animals suitable for live import.
- See <www.environment.gov.au/biodiversity/trade-use/permits> for more detail.

Protected areas

Part 15 of the EPBC Act provides for the protection of a number of protected areas, including:

- World Heritage listed places;
- wetlands listed under the Ramsar Convention;
- places listed on the National Heritage List;
- places listed on the Commonwealth Heritage List; and
- Commonwealth marine reserves.

The Australian Government has responsibilities under international agreements to protect places on the World Heritage list and wetlands listed under the Ramsar Convention. Both these international agreements are further discussed in Appendix A. The Australian Government can submit places for inclusion in the World Heritage List and the List of Wetlands of International Importance under the Ramsar Convention. Part 15 of the EPBC Act provides protection for World Heritage places by ensuring that an environmental impact assessment process is undertaken for proposed actions that will have, or are likely to have, a significant impact on the World Heritage values of a declared World Heritage place.

The National Heritage List includes places of natural, Indigenous or historic heritage value to Australia. Places nominated for inclusion on the National Heritage List are assessed by the Australian Heritage Council, which makes recommendations to the Minister for the Environment, Heritage and the Arts. The Commonwealth Heritage List comprises natural, Indigenous and historic heritage places on Commonwealth lands and waters that have been identified by the Minister for the Environment, Heritage and the Arts as having Commonwealth heritage values. Approval is required for actions which have, will have, or are likely to have a significant impact on the heritage values of sites listed on either the National or Commonwealth Heritage Lists.

Under the EPBC Act, the Minister for the Environment, Heritage and the Arts must make plans for managing World Heritage and Ramsar sites that are entirely in

Commonwealth areas, as well as for Commonwealth Heritage listed sites. The Minister must also try to prepare and implement plans for sites on the World Heritage, Ramsar and National Heritage lists in other areas, in cooperation with the relevant State or Territory government. Australian Government agencies must not act in contravention of such plans.

Part 15 of the EPBC Act also provides for declaration of Commonwealth reserves over areas of Commonwealth land or sea, and sets out the legal requirements for establishing and managing Commonwealth reserves, including Marine Protected Areas (MPAs). The EPBC Act also provides for the preparation and enforcement of reserve management plans. Many activities are illegal in Commonwealth reserves unless carried out in accordance with relevant management plans, permits and determinations. Part 12 of the *Environment Protection and Biodiversity Conservation Regulations 2000* details the prohibitions or restrictions on activities in Commonwealth reserves.

Fisheries assessments

Under the EPBC Act, the environmental performance of all fisheries managed under Commonwealth legislation, and State-managed fisheries that have an export component, must be assessed. The purpose of the assessment is to ensure that, over time, fisheries are managed in an ecologically sustainable way. The *Guidelines for the Ecologically Sustainable Management of Fisheries – Second Edition* outline specific principles and objectives that are used to assess fisheries management arrangements. More information on the assessment guidelines can be found at <www.environment.gov.au/coasts/fisheries>.

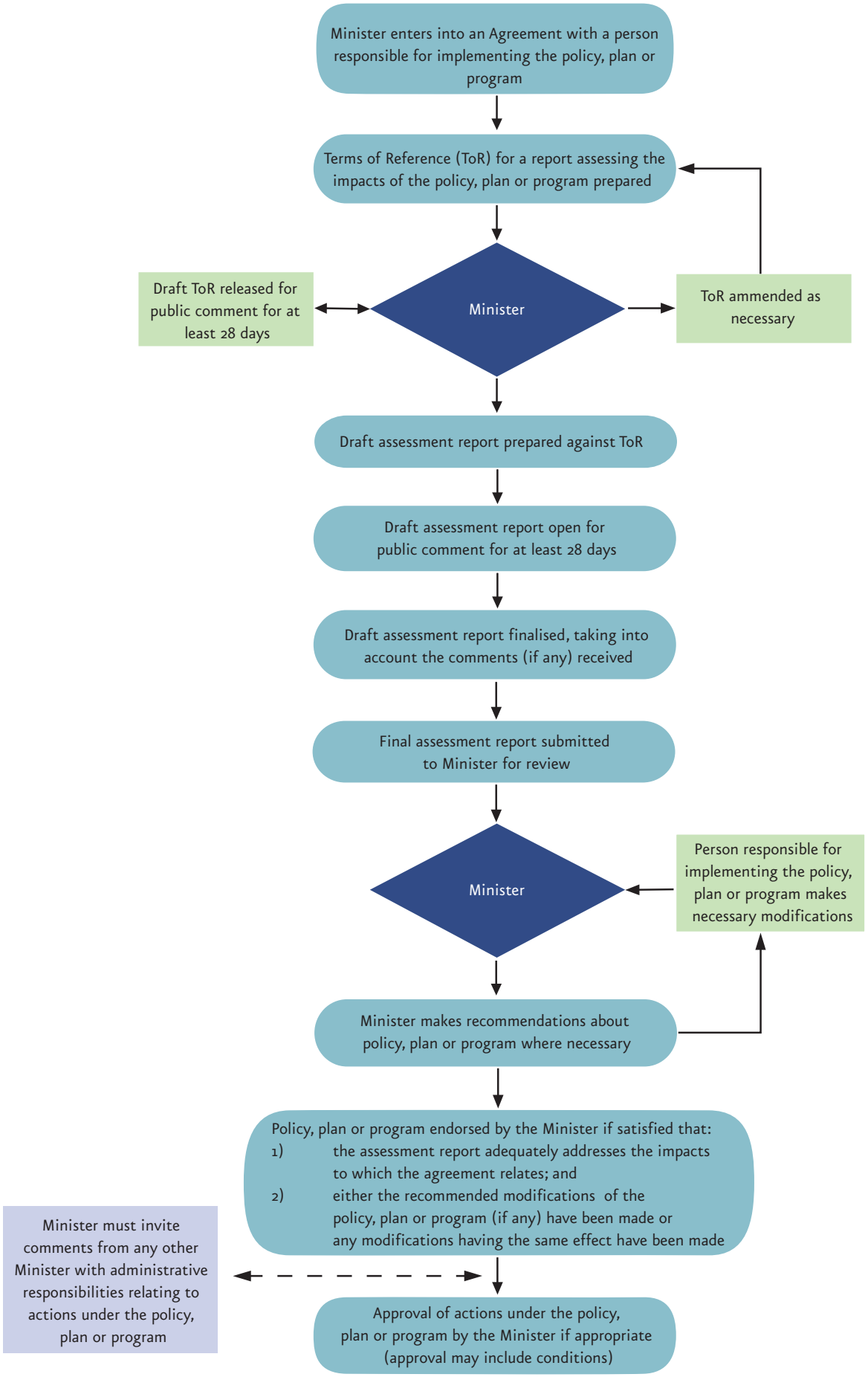
Strategic assessments

The strategic assessment provisions (under Section 146) of the EPBC Act enable the Minister for the Environment, Heritage and the Arts to enter into agreement with a person responsible for the implementation of a plan, policy or program for an assessment of the impacts of the plan policy or program on matters protected under the EPBC Act. The EPBC Act requires the preparation of a report on the impacts to which the agreement relates (see Figure B.1 for a diagram of the strategic assessment process). If the Minister is satisfied that the report adequately addresses the impacts to which the agreement relates, he or she may endorse the policy, plan or program. This process involves extensive consultation with stakeholders and provides opportunity for public comment.

Once the assessment is complete, actions that are taken in accordance with the endorsed policy, plan or program do not require additional approval under the EPBC Act. The strategic assessment provisions of the Act increase certainty and reduce administrative burden for industry, while providing better environmental outcomes by reducing the potential for cumulative impacts arising from the separate assessments of individual projects.

Gulls and ghost crab, Dirk Hartog Island. Photo: Nicola Bryden, Department of the Environment, Water, Heritage and the Arts.

Figure B.1 ***Strategic assessment process under the EPBC Act***



Historic Shipwrecks Act 1976

Australia's historic shipwrecks are an invaluable and irreplaceable heritage resource. The *Historic Shipwrecks Act 1976* protects historic wrecks and relics in the territorial sea, including State and Territory coastal waters, and waters above the continental shelf. The Act does not apply to wrecks and relics in internal waters, such as rivers, lakes, bays or harbours of a State. Each State has complementary legislation that protects historic shipwrecks in its internal waters.

The Historic Shipwrecks Act aims to ensure that historic shipwrecks are protected for their heritage values and maintained for recreational and educational purposes. It also seeks to regulate activities that may result in damage, interference, removal or destruction of an historic shipwreck or associated relic. Divers can use historic shipwreck sites for recreational purposes but relics must not be removed from the wreck site and the physical fabric of the wreck must not be disturbed, unless a permit has been obtained.

Under a declaration made under the Historic Shipwrecks Act, all wrecks, known and unknown, that are more than 75 years old are protected, together with their associated relics. The Minister for the Environment, Heritage and the Arts can also make a declaration to protect any historically significant wrecks or articles and relics that are less than 75 years old.

The Act requires anyone who finds the remains of a ship or articles associated with a ship to give notification of the location, as soon as practicable, to the Minister for the Environment, Heritage and the Arts.

Some historic shipwrecks lie within protected or no-entry zones. The protected zone can apply to an area of sea and land not exceeding 200 hectares. These zones may cover an area up to a radius of 500 m around a wreck site, and may be declared where a wreck site is at particular risk of interference. This declaration prohibits all entry into this zone without a permit. Permits are also required to undertake any activities otherwise prohibited or restricted by the Act.

The Act is administered by the Australian Government in conjunction with delegates in each of the States, the Northern Territory and on Norfolk Island.

Environment Protection (Sea Dumping) Act 1981

The Environment Protection (Sea Dumping) Act 1981 was enacted to fulfil Australia's international responsibilities under the London Convention of 1972 and has been amended to implement the *1996 Protocol to the London Convention* (London Protocol), which entered into force internationally in 2006. The objective of the London Protocol is to prevent and reduce marine pollution resulting from dumping of wastes and other matter, and is discussed further in Appendix A.

Under the Sea Dumping Act, Australia prohibits ocean disposal of waste materials considered harmful to the marine environment and regulates the deliberate loading and dumping of wastes at sea to ensure the environmental impact is minimised. People can apply to the Minister for the Environment, Heritage and the Arts for a sea dumping permit. In deciding whether to grant a permit, consideration is given to the type of material proposed to be dumped, the disposal site and the potential impacts on the marine environment. Marine Bioregional Plans will provide additional information specific to a Region which will be taken into account in decisions about sea dumping.

If the sea dumping activity is likely to have a significant impact on the environment, the Department of the Environment, Water, Heritage and the Arts will also refer the proposal for assessment under the EPBC Act, in accordance with Part 11 of the Act. In such cases, the Department seeks to undertake assessments under both the Sea Dumping Act and EPBC Act concurrently.

Permits are required for all sea dumping operations. Currently, about 30 permits are issued in Australia each year, mainly for the dumping of uncontaminated dredged material, disposal of vessels and burials at sea. The *National Ocean Disposal Guidelines for Dredged Material* (2002) have been prepared to assist proponents with the assessment and management of dredged material. Another relatively uncommon activity that requires a permit under the Act is the creation of artificial reefs.

The administration of the Sea Dumping Act is the responsibility of the Minister for the Environment, Heritage and the Arts and applies to all Australian waters (other than waters within the limits of a State or the Northern Territory, such as harbours and river estuaries) from the low water mark out to the edge of the EEZ.

The Sea Dumping Act applies to all vessels, aircraft or platforms in Australian waters (other than vessels or aircrafts belonging to the naval, military or air forces of a foreign country) and to all Australian vessels or aircraft in any part of the sea. The Act does not cover operational discharges from ships, such as sewage and galley scraps, which are regulated by the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*.

Fisheries Management Act 1991

The *Fisheries Management Act 1991* establishes the Australian Fishing Zone and underpins the domestic compliance and enforcement powers that enable Australia to protect its valuable fishery resources. The Australian Fishing Zone is the area of sea from the coast out to 200 nautical miles, including the waters surrounding external territories. Under the Fisheries Management Act and the *Fisheries Administration Act 1991*, the Australian Fisheries Management Authority (AFMA) has an obligation to develop plans and implement policies to manage Commonwealth fisheries in the Australian Fishing Zone. The Fisheries Management Act also sets the legislative basis for statutory fishing rights, licences and permits.

The Fisheries Management Act requires that management plans are prepared for all fisheries unless AFMA has determined that a management plan for a particular fishery is not warranted. Each management plan sets out the objectives of the plan, measures by which the objectives are to be attained, and performance criteria against which the measures taken may be assessed. These plans are prepared in consultation with participants in the fishery and all draft plans are made available for public comment before they are finalised.

Section 3(1)(b) of the Fisheries Management Act sets out the Australian Government's responsibilities regarding the pursuit of ecologically sustainable development. The Act requires fisheries to be managed for the long-term sustainability of fisheries resources for the benefit of all users and interest groups, both now and into the future. This requires that stocks be maintained at a sustainable level and, where necessary, rebuilt to ensure inter-generational equity. It also requires that fisheries management minimises the impact of fishing on biological diversity, ecosystems and habitats.

The Fisheries Management Act interacts with the EPBC Act through the requirement under the EPBC Act for all Commonwealth-managed fisheries, and State-managed fisheries with an export component, to be independently assessed to ensure they are managed in an ecologically sustainable way.

In 2007, the Australian Government released the *Commonwealth Fisheries Harvest Strategy Policy* as well as guidelines for its implementation. The policy is designed to provide the Australian community with a high degree of confidence that commercial fish species are being managed for long-term biological sustainability and economic profitability. The policy provides a more strategic and science-based approach to setting total allowable catch levels in Commonwealth fisheries.

Offshore Petroleum Act 2006

Responsibility for petroleum exploration and development in Commonwealth waters and the extended continental shelf rests with the Australian Government. These activities are regulated by the Offshore Petroleum Act 2006, which replaced the Petroleum (Submerged Lands) Act 1967 in 2008. The Australian Government and the States/Northern Territory jointly administer and supervise industry activities in Commonwealth waters through Joint Authority arrangements. Under the Offshore Petroleum Act, the Petroleum (Submerged Lands)(Management of Environment) Regulations 1999 require that an operator submits an environment plan before commencing any petroleum activity. An environment plan, once approved, establishes the legally binding management conditions that must be met by the operator of an offshore petroleum activity.

Petroleum activities onshore and in coastal waters are regulated by relevant State and Territory legislation.

Sea Installations Act 1987

The *Sea Installations Act 1987* provides the legislative basis for the Commonwealth to:

- ensure that sea installations are operated with regard to the safety of the people using them, and the people, vessels and aircraft near them;
- apply appropriate laws in relation to such sea installations; and
- ensure that such sea installations are operated in a manner that is consistent with the protection of the environment.

A sea installation refers to any man-made structure that when in contact, or brought into physical contact,

with the seabed, or when floating, can be used for an environment-related activity.

An environment-related activity is defined as any activity relating to tourism or recreation; the carrying on of a business; exploring; exploiting or using the living resources of the sea, sea bed or subsoil of the sea bed; marine archaeology; or any other prescribed activity. Examples of structures that are defined as sea installations include floating hotels, tourism pontoons and artificial islands. There are also a number of exclusions that are set out under the Act, including resource industry infrastructure.

The *Sea Installations Act 1987* applies to waters within the outer limits of the EEZ or the continental shelf (where this extends beyond the EEZ), excluding State and Territory coastal waters. It applies from the coast outwards in the case of external Territories.

Proponents wishing to install and/or operate a sea installation must apply for a permit or exemption certificate to the Department of the Environment, Water, Heritage and the Arts, or the Great Barrier Reef Marine Park Authority (GBRMPA) if the installation is proposed to be installed or operated within the Great Barrier Reef Marine Park.

Applications for permits and exemption certificates are assessed on the environmental implications and the safety of the proposal. If the installation or operation of the installation is likely to have a significant impact on the environment, the Department of the Environment, Water, Heritage and the Arts or GBRMPA will also refer the proposal for assessment under the EPBC Act, in accordance with Division 4 of Part 11 of that Act. In such cases, the Department seeks to undertake both assessments concurrently.

Protection of the Sea (Prevention of Pollution from Ships) Act 1983

The *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* is the key legislation that gives effect to Australia's commitments under the International Maritime Organisation's *International Convention for the Prevention of Pollution from Ships, 1973* (also known as MARPOL). More information on MARPOL can be found in Appendix A.

Protection of the Sea (Harmful Anti-fouling Systems) Act 2006

On 9 January 2007, Australia became a contracting party to the *International Convention on the Control of Harmful Anti-fouling Systems on Ships*, which has been implemented in Australian domestic legislation by the *Protection of the Sea (Harmful Anti-fouling Systems) Act 2006*.

The Convention on the Control of Harmful Anti-fouling Systems on Ships will enter into force internationally on 17 September 2008. This convention prohibits the use of harmful organotins in anti-fouling paints used on ships and establishes a mechanism to prevent the potential future use of other harmful substances in anti-fouling systems.

Broadly, the convention applies to ships of 400 gross tonnage and above engaged in international voyages, and to facilities used by the oil production industry. Surveys are required before a mandatory International Anti-fouling System Certificate can be issued and when an anti-fouling system is changed or replaced.

When the convention enters into force, it will be an offence for any ship bearing harmful chemical compounds on their hulls or external parts or surfaces to enter an Australian port, shipyard or offshore terminal, unless the ship bears a coating to prevent such compounds leaching into the water. A similar offence will apply to Australian ships entering a port, shipyard or offshore terminal elsewhere in the world.

Native Title Act 1993

The *Native Title Act 1993* provides a framework for recognising and protecting native title in Australia. Native title rights and interests are the communal, group or individual rights and interests of Aboriginal people or Torres Strait Islanders in relation to land or waters. The Native Title Act seeks to regulate acts that affect the native title rights of Indigenous Australians. Under Section 227 of the Native Title Act, an act affects native title if it extinguishes native title rights and interests, or if it is otherwise wholly or partly inconsistent with their continued existence, enjoyment or exercise.

The Native Title Act and the EPBC Act

The EPBC Act does not affect the operation of the Native Title Act, which provides for the recognition and protection of native title and establishes ways in

which dealings affecting native title may proceed. In making decisions under the EPBC Act the Minister for the Environment, Heritage and the Arts is bound by the provisions of the Native Title Act.

The Department of the Environment, Water, Heritage and the Arts, in administering the EPBC Act, has responsibilities to promote the involvement of Indigenous people and their knowledge of biodiversity in developing strategies for ecologically sustainable development and biodiversity conservation, including development of Marine Bioregional Plans and their associated conservation measures. The Department also has responsibilities under the heritage provisions of the EPBC Act to assess and manage listed Indigenous heritage values, including in the marine environment.

The application of native title legislation to the offshore area

'Offshore place' is defined in the Native Title Act as any land or waters other than those lands and waters within the limits of a State or Territory. Section six of the Act extends the operation of the Native Title Act to each external Territory, to the coastal sea of Australia and of each external Territory, and to any waters over which Australia asserts sovereign rights under the *Seas and Submerged Lands Act 1973*. Under the Native Title Act, coastal sea is defined in accordance with section 15B(4) of the *Acts Interpretation Act 1901*.

The recognition of native title offshore was confirmed by the High Court case in *The Commonwealth* v *Yarmirr* [2001] High Court of Australia 56 (11 October 2001). In this case, the majority of the High Court concluded that non-exclusive native title could exist in offshore areas. The native title rights over areas of water may include the right to use and enjoy the reefs and associated water; the right to hunt and gather, including for dugong and marine turtle; and the right to use resources for food, trapping fish, religious, cultural and ceremonial purposes. Exclusive native title (which would allow the native title holders to control access to the area) was not found to exist because exclusivity of title would be inconsistent with the right of innocent passage under international law, and the common law rights to navigate and fish.

Preservation of Indigenous fishing rights

The Native Title Act recognises that there may be Commonwealth, State or Territory laws that could prohibit or restrict native title holders from hunting, fishing, gathering or carrying out cultural and spiritual activities offshore. Under section 211, native title holders are not prohibited or restricted from carrying on such activities, or gaining access for those purposes, so long as they are carrying out these activities as an exercise of their native title rights and only for the purpose of satisfying their personal, domestic or non-commercial communal needs. As a result, the relevant law's validity is unimpaired but its operation will be suspended in relation to the exercise of native title rights and interests. This exemption does not apply in relation to legislation aimed at environmental protection, research or public health or safety.

Key references and further reading

Legislation

Available from the Commonwealth of Australia Law website <www.comlaw.gov.au>:

Acts Interpretation Act 1901

Environment Protection and Biodiversity Conservation Act 1999

Environment Protection and Biodiversity Conservation Regulations 2000

Environment Protection (Sea Dumping) Act 1981

Fisheries Administration Act 1991

Fisheries Management Act 1991

Great Barrier Reef Marine Park Act 1975

Historic Shipwrecks Act 1976

Native Title Act 1993

Offshore Petroleum Act 2006

Petroleum (Submerged Lands) (Management of Environment) Regulations 1999

Protection of the Sea (Prevention of Pollution from Ships) Act 1983

Protection of the Sea (Harmful Anti-fouling Systems)

Quarantine Act 1908

Sea Installations Act 1987

Seas and Submerged Lands Act 1973

Policies and guidelines

Department of Agriculture, Fisheries and Forestry (DAFF), 2007, *Commonwealth Fisheries Harvest Strategy Policy*, Commonwealth of Australia, Canberra, <www.daff.gov.au/fisheries/domestic/harvest_strategy_policy>, accessed 27/03/2008.

The following EPBC Act policy statements are available from <www.environment.gov.au/epbc/guidelines-policies.html> unless otherwise stated.

Department of Environment and Heritage (DEH), 2006, *EPBC Act Policy Statement 1.1 Significant Impact Guidelines – Matters of National Environmental Significance*, Commonwealth of Australia, Canberra.

Department of the Environment and Heritage (DEH), 2006, *EPBC Act Policy Statement 1.2 Significant Impact Guidelines – Actions On, or Impacting Upon, Commonwealth Land and Actions by Commonwealth Agencies*, Commonwealth of Australia, Canberra.

Department of the Environment and Water Resources (DEW), 2007, *EPBC Act Policy Statement 2.1 Interactions Between Offshore Seismic Exploration and Whales*, Commonwealth of Australia, Canberra.

Department of the Environment and Heritage (DEH), 2006, *EPBC Act Policy Statement 2.2 Industry Guidelines – Offshore Aquaculture*, Commonwealth of Australia, Canberra.

Department of the Environment and Water Resources (DEW), 2007, *Guidelines for the Ecologically Sustainable Management of Fisheries – Second Edition*, Commonwealth of Australia, Canberra <www.environment.gov.au/coasts/fisheries/publications/guidelines.html>, accessed 27/03/2008.

Environment Australia (EA), 2002, National Ocean Disposal Guidelines for Dredged Material, Commonwealth of Australia, Canberra, <www.environment.gov.au/coasts/pollution/dumping/guidelines>, accessed 27/03/2008.

Loggerhead turtle laying eggs in the Shark Bay World Heritage Area. Photo: Lochman Transparencies.

Appendix C Nationally Protected Species in the North-west Marine Region

Current at December 2007. For updates see <www.environment.gov.au/coasts/mbp/north-west>.

Species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) are commonly referred to as 'protected species' because it is an offence to kill, injure, take, trade, keep or move a listed species without authorisation. Under the EPBC Act, species can be listed as threatened, migratory, cetaceans, or as marine species.

- Threatened species are those species that have been identified as being in danger of becoming extinct;
- Migratory species are those species that are listed under:
    - the *Convention for Migratory Species of Migratory Species of Wild Animals 1979* (CMS or Bonn Convention);
    - the *Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment 1974* (JAMBA);
    - the *Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986* (CAMBA);
    - the *Agreement between the Government of Australia and the Government of the Republic of Korea on the Protection of Migratory Birds 2007* (ROKAMBA);
    - the *Partnership for the Conservation of Migratory Waterbirds and the Sustainable Use of their Habitats in the East Asian Australasian Flyway* (Flyway Partnership); or
    - any other international agreement, or instrument made under other international agreements approved by the Minister for the Environment, Heritage and the Arts. Further information on the CMS, JAMBA, CAMBA and ROKAMBA is provided in Appendix A;
- Cetaceans – whales, dolphins and porpoises – are protected under the EPBC Act to ensure their future survival;
- Listed marine species are those species that the Australian Government recognises as requiring protection to ensure their long-term conservation (in accordance with Section 248 of the EPBC Act). Listed marine species occurring in the North-west Marine Region include species of:
    - sea snakes (family Hydrophiidae);
    - dugongs (genus Dugong);
    - marine turtles (families Cheloniidae and Dermochelyidae);
    - seahorses, sea-dragons, pipefish and ghost pipefish (families Syngnathidae and Solenostomidae); and
    - birds (seabirds, shorebirds, waterbirds and other coastal or migratory species that occur naturally in Commonwealth marine areas).

All protected species are also included under Part 13A of the EPBC Act which regulates the international movement of wildlife and wildlife products, including the:

- export of Australian native species other than those identified as exempt;
- export and import of species included in the appendices to the *Convention on International Trade in Endangered Species of Wild Fauna and Flora 1973* (CITES); and
- import of live plants and animals that (if they became established in Australia) could adversely affect native species or their habitats.

This appendix lists species protected under the EPBC Act that are known to occur (Table C1), or that may occur or occur infrequently (Table C2), in the North-west Marine Region. Species that *may occur* or *occur infrequently* are defined as those:

- for which the Region falls within their known or presumed range; or
- that have been recorded only infrequently in the Region.

Table C1 Protected species known to occur in the North-west Marine Region

Further information on these species is provided in the Protected Species Group Report Cards in Appendix D.

Species group – Sharks				
Species	**Conservation status**	**Distribution**	**Known use of the Region**	**Important areas in or adjacent to the Region**
Whale shark (*Rhincodon typus*)	Vulnerable, Migratory Listed under CITES (Appendix II) and CMS (Appendix II)	Found in tropical and warm temperate seas across the world. The range of this species includes the whole Region.	Large seasonal aggregations occur at Ningaloo Reef between March and June annually. They are also known to migrate through parts of the region, including Scott Reef, Rowley Shoals and the Exmouth Plateau.	Ningaloo Reef provides important feeding habitat.
Grey nurse shark (west coast population) (*Carcharias taurus*)	Vulnerable	Found in tropical and temperate waters of the Atlantic, Indian and western Pacific Oceans. Their range does include the whole Region, but they are not commonly found north of North West Cape.	Data deficient. Likely to be resident south of North West Cape for part of the year.	None identified.
White shark (*Carcharodon carcharias*)	Vulnerable, Migratory Listed under CITES (Appendix II) and CMS (Appendix I & II)	Found in temperate waters across the world, normally close inshore or on the continental shelf. The range of this species extends into the southern portion of the Region, south of North West Cape.	Data deficient. Possibly resident in the Region in some parts of the year.	None identified.
Green sawfish (*Pristis zijsron*)	Vulnerable	Found in tropical and temperate waters inshore, and occasionally to 70 m depth. Found across most of the Region, but more common north of Broome.	Data deficient.	None identified.

Species group – Bony Fish				
Species	**Conservation status**	**Distribution**	**Known use of the Region**	**Important areas in or adjacent to the Region**
Robust ghost pipefish, robust ghostpipefish, blue-finned ghost pipefish (*Solenostomus cyanopterus*)	Marine	Tropical Indo-West Pacific. Region falls within the known range of the species.	Data deficient. Likely to feed and breed in the Region.	None identified. Has been recorded from Rowley Shoals area.

Species group – Bony Fish				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Winged seahorse (*Hippocampus alatus*)	Marine Listed under CITES (Appendix II)	Recorded from south-eastern Papua New Guinea to northern Australian waters from Exmouth Gulf north-eastwards throughout NT and Gulf of Carpentaria to the tip of Cape York Peninsula in Qld. Region falls within the known range of the species.	Data deficient. Likely to feed and breed in the Region.	None identified. Has been recorded from waters to 50 m depth, off the Dampier Archipelago and Montebello Islands, and to 80 m depth off Port Hedland.
Thorny seahorse (*Hyppocampus histrix*)	Marine Listed under CITIES (Appendix II)	Widespread throughout Indo-Pacific. Known range extends into Region.	Data deficient. Likely to feed and breed in the Region	None identified
Barbed pipefish / corrugated pipefish (*Bhanotia fasciolata*)	Marine	East Indian Ocean and western Pacific. Region falls within the known range of the species.	Data deficient. Likely to feed and breed in the Region.	None identified. Has been recorded at Scott Reef.
Pacific short-bodied pipefish, Pacific shortbody pipefish, short-bodied pipefish (*Choeroichthys brachysoma*)	Marine	Indo-West Pacific. Region falls within the known range of the species.	Data deficient. Likely to feed and breed in the Region.	None identified. Has been recorded from Mermaid Reef, Scott Reef and Ashmore Reef.
Red-banded pipefish, brown-banded pipefish, Fijian banded pipefish, Fijian pipefish (*Corythoichthys amplexus*)	Marine	Indo-West Pacific. Region falls within the known range of the species.	Data deficient. Likely to feed and breed in the Region.	None identified. Has been recorded from Scott Reef.
Reticulate pipefish, yellow-banded pipefish, network pipefish (*Corythoichthys flavofasciatus*)	Marine	Northern Red Sea to the Central Pacific. Region falls within the known range of the species.	Data deficient. Likely to feed and breed in the Region.	None identified. Has been recorded from Rowley Shoals, Clerke Reef and Scott Reef.
Messmate pipefish, Australian messmate pipefish, banded pipefish (*Corythoichthys intestinalis*)	Marine	Western and Central Pacific. Region falls within the known range of the species.	Data deficient. Likely to feed and breed in the Region.	None identified. Has been recorded from Clerke Reef, Mermaid Reef and Scott Reef.
Schultz's pipefish, guilded pipefish, gilded pipefish (*Corythoichthys schultzi*)	Marine	Indo-Pacific. Region falls within the known range of the species.	Data deficient. Likely to feed and breed in the Region.	None identified. Has been recorded from Mermaid Reef and Ashmore Reef.
Rough-ridge pipefish, roughridge pipefish, Banner's pipefish (*Cosmocampus banneri*)	Marine	Indo-West Pacific, from Red Sea and East Africa to Fiji, north to the Marshall Islands. Region falls within the known range of the species.	Data deficient. Likely to feed and breed in the Region.	None identified. Has been recorded from Rowley Shoals and Ashmore Reef.

Species group – Bony Fish				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Banded pipefish, ringed pipefish (*Doryrhamphus dactyliophorus*)	Marine	Indo-Pacific. Region falls within the known range of the species.	Data deficient. Likely to feed and breed in the Region.	None identified. Has been recorded from Mermaid Reef, Clerke Reef, Scott Reef and Ashmore Reef.
Blue-stripe pipefish, bluestripe pipefish (*Doryrhamphus melanopleura*)	Marine	Widest distribution of any syngnathid species. Occurs throughout the Indo-Pacific region. Region falls within the known range of the species.	Data deficient. Likely to feed and breed in the Region.	None identified. Has been recorded from Rowley Shoals.
Negros pipefish, flagtail pipefish (*Doryrhamphus negrosensis negrosensis*)	Marine	Western Pacific. Region falls within the known range of the species.	Data deficient. Likely to feed and breed in the Region.	None identified. Has been recorded from Clerke Reef.
Ridge-nose pipefish, ridgenose pipefish, red-hair pipefish, Duncker's pipefish (*Halicampus dunckeri*)	Marine	Indo-West Pacific. Region falls within the known range of the species.	Data deficient. Likely to feed and breed in the Region.	None identified. Has been recorded from the Rowley Shoals area.
Glittering pipefish (*Halicampus nitidus*)	Marine	Western Pacific. Region falls within the known range of the species.	Data deficient. Likely to feed and breed in the Region.	None identified. The species has been recorded from Rowley Shoals area, and Scott Reef.
Western pipehorse (*Solegnathus* sp. 2)	Marine	Sub-tropical and tropical Indo-West Pacific. Region falls within the known range of the species.	Data deficient. Likely to feed and breed in the Region.	None identified. Has been recorded from Mermaid Reef and Clerke Reef.
Double-ended pipehorse, double-end pipehorse, alligator pipefish (*Syngnathoides biaculeatus*)	Marine	Widespread in Indo-West Pacific. Region falls within the known range of the species.	Data deficient. Likely to feed and breed in the Region.	None identified. Has been recorded from Ashmore Reef.

Species group – Sea snakes and marine turtles				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Horned seasnake (*Acalyptophis peronii*)	Marine	Occurs in tropical northern Australia, New Caledonia, the south coast of Papua New Guinea, Thailand and Hong Kong.	Resident in the Region throughout the year.	Ashmore Reef, Scott Reef and Cartier Island.
Short-nosed seasnake (*Aipysurus apraefrontalis*)	Marine	Endemic to the Region. Recorded from Exmouth Gulf and the reefs of the Sahul Shelf.	Resident in the Region throughout the year.	Exmouth Gulf, Ashmore Reef and Hibernia Reef.
Dubois' seasnake (*Aipysurus duboisii*)	Marine	Found in tropical northern Australia, Papua New Guinea and New Caledonia.	Resident in the Region throughout the year.	Scott Reef, Ashmore Reef and Cartier Island.

Species group – Sea snakes and marine turtles				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Spine-tailed seasnake (*Aipysurus eydouxii*)	Marine	Found in tropical northern Australia, Indonesia, Papua New Guinea and Thailand.	Resident in the Region throughout the year.	None identified.
Leaf-scaled seasnake (*Aipysurus foliosquama*)	Marine	Endemic to the Region. Restricted to the reefs of the Sahul Shelf, in particular, Ashmore and Hibernia Reefs.	Resident in the Region throughout the year.	Ashmore Reef and Hibernia Reef.
Dusky seasnake (*Aipysurus fuscus*)	Marine	Endemic to the Region. Restricted to the reefs of the Sahul Shelf, in particular, Ashmore, Hibernia, Seringapatam and Scott Reefs.	Resident in the Region throughout the year.	Ashmore Reef, Hibernia Reef, Seringapatam Reef and Scott Reef.
Olive seasnake (*Aipysurus laevis*)	Marine	Inhabits tropical and subtropical coastal and coral reef waters in Northern Australia and the South West Pacific Ocean.	Resident in the Region throughout the year.	Ashmore Reef and Cartier Island.
Shark Bay seasnake (*Aipysurus pooleorum*)	Marine	Endemic to the Region. Restricted to the mid-west coast of WA.	Resident in the Region throughout the year.	Shark Bay.
Brown-lined seasnake (*Aipysurus tenuis*)	Marine	Endemic to the Region. Recorded only from the northwest coast of WA.	May be resident in the Region throughout the year.	Data deficient. None identified.
Stokes' seasnake (*Astrotia stokesii*)	Marine	Occurs in tropical coastal areas from the Arabian Sea to the Taiwan Strait and the north coast of Australia.	Resident in the Region throughout the year.	Ashmore Reef.
Spectacled seasnake (*Disteira kingii*)	Marine	Restricted to Australian waters between Barrow Island, WA, and Gladstone, Qld.	Resident in the Region throughout the year.	Ashmore Reef.
Olive-headed seasnake (*Disteira major*)	Marine	Widely distributed in tropical northern Australia and southern Papua New Guinea and in the south-west Pacific to New Caledonia.	Resident in the Region throughout the year.	None identified.
Turtle-headed seasnake (*Emydocephalus annulatus*)	Marine	Found in tropical northern Australia, to the Chesterfield Reefs in the Coral Sea and New Caledonia.	Resident in the Region throughout the year.	Ashmore Reef, Cartier Island, Hibernia Reef, Scott Reef and Seringapatam Reef.
Slender-necked seasnake (*Hydrophis coggeri*)	Marine	Occurs at Ashmore Reef, the reefs of the Sahul Shelf, New Caledonia, Vanuatu and Fiji.	Resident in the Region throughout the year.	Ashmore Reef, Scott Reef and reefs of the Sahul Shelf.
Fine-spined seasnake (*Hydrophis czeblukovi*)	Marine	Only recorded from WA and northern Australian waters including the northern coast of New Guinea.	May be resident in the Region throughout the year.	Data deficient. None identified.

Species group – Sea snakes and marine turtles				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Elegant seasnake (*Hydrophis elegans*)	Marine	Restricted to tropical Australian waters from Shark Bay, WA, to Moreton Bay, Qld.	Resident in the Region throughout the year.	Shark Bay.
Small-headed seasnake (*Hydrophis mcdowelli*)	Marine	Restricted to northern Australian and Western Australian waters.	May be resident in the Region throughout the year.	None identified.
Ornate seasnake (*Hydrophis ornatus*)	Marine	Widely distributed throughout tropical coastal areas of northern Australia, southern Papua New Guinea, New Caledonia, Indonesia, the Phillipines and the South China Sea.	Resident in the Region throughout the year.	None identified.
Spine-bellied seasnake (*Lapemis curtus*)	Marine	Occurs in the region encompassed by the Persian Gulf, Bay of Bengal, Gulf of Siam, the Phillipines, Borneo, eastern Indonesia and northern Australia.	Resident in the Region throughout the year.	None identified.
Yellow-bellied seasnake (*Pelamis platurus*)	Marine	Most widely distributed of all snakes, ranging from the east coast of Africa through the Indian and Pacific Oceans to the west coast of the Americas.	May be resident in the Region throughout the year.	Slicks and driftlines caused by the convergence of ocean currents.
Loggerhead turtle (*Caretta caretta*)	Endangered, Migratory, Marine Listed under CITES (Appendix I) & CMS (Appendix I & II)	Global distribution throughout tropical, subtropical and temperate waters. Region falls within the known range of the species.	Known to breed and feed in the Region.	Shark Bay contains the largest breeding population of loggerhead turtles in Australia and the third largest in the world. The maintenance of this population is critical for the continued viability of the species globally. Ningaloo Reef and the Muiron Islands also support important breeding populations.

Species group – Sea snakes and marine turtles				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Green turtle (*Chelonia mydas*)	Vulnerable, Migratory, Marine Listed under CITES (Appendix I) & CMS (Appendix I & II)	Global distribution throughout tropical, subtropical and temperate waters. Region falls within the known range of the species.	Known to breed and feed in the Region.	Aggregations occur off the west coast of Barrow Island, within the Montebello group of islands and within the Mangrove Island group. Possible feeding grounds over the Barrow Shoals and near Serrurier Island and Thevenard Island. Major nesting sites at the Lacepede Islands, North West Cape, the Muiron Islands, Serrurier Island, the west coast of Barrow Island,the Dampier Archipelago Browse Island, Ashmore Reef, and Sandy Islet on Scott Reef.
Hawksbill turtle (*Eretmochelys imbricata*)	Vulnerable, Migratory, Marine Listed under CITES (Appendix I) & CMS (Appendix I & II)	Global distribution throughout tropical, subtropical and temperate waters. Region falls within the known range of the species.	Known to breed and feed in the Region.	Major rookeries on Varanus Island in the Lowendal group, the Montebello Islands, and Rosemary Island in the Dampier Archipelago.
Olive ridley, Pacific ridley (*Lepidochelys olivacea*)	Endangered, Migratory, Marine Listed under CITES (Appendix I) & (CMS (Appendix I & II)	Global distribution throughout tropical, subtropical and temperate waters. Region falls within the known range of the species.	Data deficient. Known to feed in northern half of the Region.	None identified.
Flatback turtle (*Natator depressus*)	Vulnerable, Migratory, Marine Listed under CITES (Appendix I) & CMS (Appendix II)	Endemic to the northern Australian-southern New Guinea continental shelf.	Known to breed and feed in the Region.	Important breeding areas on Barrow Island, the Montebello Islands, Thevenard Island, Varanus Island, the Dampier Archipelago, areas around Port Hedland, Eighty Mile Beach, some islands in the Kimberley region, and Cape Domett.
Leatherback turtle, leathery turtle (*Dermochelys coriacea*)	Vulnerable, Migratory, Marine Listed under CITES (Appendix I) & CMS (Appendix I & II)	This species has the widest distribution of any marine turtle, occurring from the North Sea and the Gulf of Alaska in the Northern Hemisphere, to Chile and New Zealand in the Southern Hemisphere. Region falls within the known range of the species.	Known to feed and migrate through the Region.	None identified.

Species group – Birds				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Southern giant-petrel (*Macronectes giganteus*)	Endangered, Migratory, Marine Listed under CMS (Appendix II)	Breeds in the Antarctic and sub-antarctic islands. Winter migrant to coastal seas north to Ningaloo. Known non-breeding distribution extends into southern parts of the Region.	Forages in Region during non-breeding season.	None identified.
Tahiti petrel (*Pseudobulweria rostrata*)	Marine	Recorded mostly in the Southern Hemisphere in tropical and subtropical Pacific, extending west into east Indian Ocean. Regularly recorded between Broome and Ashmore. Region falls within known range of the species.	May spend non-breeding season in Region. Migrates through Region.	None identified.
Soft-plumaged petrel (*Pterodroma mollis*)	Vulnerable, Marine	Found in temperate and subantarctic waters of the South Atlantic, southern Indian and western South Pacific oceans. Common visitor to southern Australian waters. Known range of the species extends into southern parts of the Region.	Spends non-breeding period foraging in the Region.	None identified. Recorded on the western North West Shelf and areas north and west of the Montebello Islands.
Bulwer's petrel (*Bulweria bulwerii*)	Marine	Tropical and subtropical zones of Atlantic, Indian and Pacific oceans and East China Sea. Numerous records from waters between Broome and Ashmore Reef. Region falls within known range of the species.	May spend non-breeding season in Region. Migrates through offshore waters of the Region.	None identified. Concentrations observed near Scott Reef.
Streaked shearwater (*Calonectris leucomelas*)	Migratory, Marine Listed under CAMBA (as *Puffinus leucomelas*), JAMBA & ROKAMBA	Breeds in Northern Hemisphere in north-west Pacific Ocean. Spends non-breeding season in tropical west Pacific. Regularly recorded offshore from Broome to Timor Sea, and from Barrow Island to the Houtman Abrolhos Islands. Region falls within known range of the species.	May spend non-breeding season in region. Migrates through Region.	None identified.

Species group – Birds				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Wedge-tailed shearwater (*Puffinus pacificus*)	Migratory, Marine Listed under JAMBA	Found throughout tropical and subtropical Pacific and Indian oceans.	Known to breed and feed in and adjacent to the Region.	Ashmore Reef, Dampier Archipelago, Lowendal Islands, Barrow Island, Montebello Islands, Shark Bay and islands north of North West Cape (Muirons, Serrurier, Airlie, Anchor, Solitary, Locker, North-East Regnard, North Sandy, and Fortescue islands).
Hutton's shearwater (*Puffinus huttoni*)	Marine	Breeds in New Zealand, occur around entire Australian coast on migration. Region falls within known range of the species.	Migrates through the Region. Spend non-breeding season foraging in Region.	Western North West Shelf, areas north and west of Montebello Islands.
Indian yellow-nosed albatross (*Thalassarche carteri*)	Vulnerable, Migratory, Marine Listed under CMS (Appendix II; as *Diomedea chlororhynchos*)	Occurs in the southern Indian Ocean.	Known to forage in the Region.	None identified.
Wilson's storm-petrel (*Oceanites oceanicus*)	Migratory, Marine Listed under JAMBA	Breeds on the Antarctic continent. Migrates north in autumn to north of the equator in Atlantic, Indian and Pacific oceans. Region falls within known range of the species.	Forages in the Region on migration.	None identified. Regularly encountered on the North West Shelf and south-west of Scott Reef.
Matsudaira's storm-petrel (*Oceanodroma matsudairae*)	Marine	Breeds in north-west Pacific Ocean and migrates to the Indian Ocean and waters to the north of Australia. Known non-breeding range extends into the Region.	Forages in offshore waters of the Region during non-breeding migration.	None identified. Regular visitor to deep waters south of Scott Reef and waters off the Lacapede Islands, Montebello Islands and Dampier Archipelago.
Red-tailed tropicbird (*Phaethon rubricauda*)	Marine	Occurs in tropical and subtropical Indian and Pacific oceans. Region falls within known range of the species.	Known to breed and feed in and adjacent to the Region.	Ashmore Reef, Rowley Shoals.
White-tailed tropicbird (*Phaethon lepturus*)	Migratory, Marine Listed under CAMBA & JAMBA	Widely distributed in tropical oceans of the world. Region falls within known range of the species.	Known to breed and feed in and adjacent to the Region.	Ashmore Reef, Rowley Shoals.
Masked booby (*Sula dactylatra*)	Migratory, Marine Listed under JAMBA & ROKAMBA	Widespread in tropical waters between 30°N and 30°S.	Known to breed (most months) and feed in and adjacent to the Region.	Breeding populations on Bedout Island, Adele Island and Ashmore Reef.
Red-footed booby (*Sula sula*)	Migratory, Marine Listed under CAMBA & JAMBA	Confined to tropical waters between 30°N and 30°S.	Known to breed (most months) and feed in and adjacent to the Region.	Small breeding populations on Adele Island and Ashmore Reef.

Species group – Birds				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Brown booby (*Sula leucogaster*)	Migratory, Marine Listed under CAMBA, JAMBA & ROKAMBA	Widespread in tropical waters between 30°N and 30°S. Region falls within known range of the species.	Known to breed (most months) and feed in and adjacent to the Region.	Large breeding populations on Adele Island, Ashmore Reef, Bedout Island, Lacepede Island and White Island. Smaller breeding population on the Lowendal Islands. Common visitor to the Montebello Islands.
Australian pelican (*Pelecanus conspicillatus*)	Marine	Found in Australia and Papua New Guinea. Known range extends into the Region.	Known to breed (autumn-winter) and feed in and adjacent to the Region.	None identified. Breeding records from Pelican Island in Shark Bay, Exmouth Gulf, Mangrove Island (Little Rocky Islet), North Turtle Island (Port Hedland), Middle Island (Lacepedes) and Sandy Island (Holothuria Reefs).
Great frigatebird, greater frigatebird (*Fregata minor*)	Migratory, Marine Listed under CAMBA & JAMBA	Confined to the tropical waters of the Indian and Pacific oceans with an isolated population in the Atlantic Ocean off Brazil. Region falls within known range of the species.	Known to breed and feed in and adjacent to the Region.	Breeding records from Ashmore Reef and Adele Island.
Lesser frigatebird, least frigatebird (*Fregata ariel*)	Migratory, Marine Listed under CAMBA, JAMBA & ROKAMBA	Found throughout the tropical waters of the Indian and west and central Pacific oceans with an isolated population in the Atlantic Ocean off Brazil. Region falls within known range of the species.	Known to breed and feed in and adjacent to the Region.	Breeding populations on Adele Island, the Lacepede Islands, Ashmore Reef, Bedout Island, Sunday and Swan islands (King Sound).
Little egret (*Egretta garzetta*)	Marine	Occurs in Africa, Europe, Japan, New Guinea and Australia. Known range extends into Region.	Known to breed and feed in and adjacent to the Region.	None identified. Breeding records from Ashmore Reef and the Kimberley.
Eastern reef egret (*Egretta sacra*)	Migratory, Marine Listed under CAMBA	Occurs widely in Asia through South–East Asia and New Guinea to most of the Pacific Is, Australia and New Zealand. Known range extends into Region.	Known to breed (summer) and feed in and adjacent to the Region.	None identified. Breeding populations on Ashmore Reef, the Lowendal Islands and the Montebello Islands.
Osprey (*Pandion haliaetus*)	Migratory, Marine Listed under CMS (Appendix II) & CITES (Appendix II)	Cosmopolitan species. Known range extends into the Region.	Known to breed (April-July) and feed in and adjacent to the Region.	None identified. Breeds on islands of the Lowendal group, Barrow Island, the Montebello Islands, Serrurier Island and Airlie Island.

Species group – Birds				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Whistling kite (*Haliastur sphenurus*)	Marine Listed under CITES (Appendix II)	Widespread on Australian mainland, Tasmania and offshore islands, also Papua New Guinea and New Caledonia. Known range extends into Region.	Known to breed (February-May) and feed in and adjacent to the Region.	None identified. Resident at Roebuck Bay.
Brahminy kite (*Haliastur indus*)	Marine Listed under CITES (Appendix II)	Found from India and Sri Lanka though Asia and South–East Asia to New Guinea, Solomon Islands and Australia. Known range extends into Region.	Known to breed (April-August) and feed in and adjacent to the Region.	None identified. Breeding records from Barrow Island, the Montebello Islands and the mangroves of Roebuck Bay.
White-bellied sea-eagle (*Haliaeetus leucogaster*)	Migratory, Marine Listed under CAMBA, CMS (Appendix II) & CITES (Appendix II)	Found in western India, southern China and South–East Asia to New Guinea (including Bismark Archipelago) and Australia. Known range extends into Region.	Known to breed (May-August) and feed in and adjacent to the Region.	None identified.
Australian kestrel, nankeen kestrel (*Falco cenchroides*)	Marine Listed under CITES (Appendix II)	Occurs in Australia, Papua New Guinea, and Indonesia. Known range extends into Region.	Known to breed (August-December) and feed in coastal areas and offshore islands in and adjacent to the Region.	None identified. Common on large islands of the Lowendals and Montebellos, Barrow Island and Serrurier Island.
Black-tailed godwit (*Limosa limosa*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in Russia. Spends non-breeding season throughout Africa, the Persian Gulf, the Indian subcontinent and Asia, south to New Guinea and Australasia. Region falls within the known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Roebuck Bay, Barrow Island.
Bar-tailed godwit (*Limosa lapponica*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in Scandanavia, Russia and Alaska. Some spend non-breeding season in China, Indonesia, Thailand, south-west Pacific islands, Micronesia, and Australasia, including New Guinea. Region falls within the known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	None identified. Regular visitor to Roebuck Bay, the Lowendal Islands and the Montebello Islands in summer.
Little curlew, little whimbrel (*Numenius minutus*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in Siberia. Most of the population spends the non-breeding season in Australia. Region falls within known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Roebuck Bay, Barrow Island.

Species group – Birds				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Whimbrel (*Numenius phaeopus*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in Alaska. Non-breeding distribution includes the USA, Central and South America, Africa and Asia as well as Australia and New Zealand. Region falls within the known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Roebuck Bay, Barrow Island.
Eastern curlew (*Numenius madagascariensis*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in Russia and China. Most of the population spends non-breeding season in Australia. Region falls within known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Roebuck Bay.
Common redshank (*Tringa totanus*)	Migratory, Marine Listed under CAMBA, ROKAMBA & CMS (Appendix II)	Breeds in Europe, Siberia, Russia and China. Non-breeding distribution in Europe, Africa and Asia north of the equator. Small numbers migrate regularly to Australia. Region falls at the edge of the known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Coral Bay, Port Hedland saltworks.
Marsh sandpiper, little greenshank (*Tringa stagnatilis*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in Europe, Siberia and China. During non-breeding season, occurs throughout Africa, India, Asia and Australia. Region falls within known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Port Hedland saltworks, Eighty Mile Beach, Roebuck Bay.
Common greenshank, greenshank (*Tringa nebularia*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in Eurasia. During non-breeding season, occurs throughout Europe, Africa, Asia, Melanesia and Australasia. Region falls within the known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Eighty Mile Beach, Roebuck Bay, Barrow Island, the Montebello Islands and the Lowendal Islands.
Wood sandpiper (*Tringa glareola*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in east Asia and Siberia. Most of the population spends non-breeding season in South–East Asia. Part of the known migration route extends into the Region.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	None identified.

Species group – Birds				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Terek sandpiper (*Xenus cinereus*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in Eurasia. During non-breeding season, occurs throughout Africa, Asia, Australia and New Zealand. Region falls within known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Eighty Mile Beach, Roebuck Bay.
Common sandpiper (*Actitis hypoleucos*)	Migratory, Marine Listed under CAMBA, JAMBA (as *Tringa hypoleucos*), ROKAMBA (as *Tringa hypoleucos*) & CMS (Appendix II)	Breeds in Eurasia. Non-breeding distribution mostly Africa or Asia. Regularly occurs in New Guinea and Australia. Region falls within the known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Roebuck Bay, the Lowendal Islands, Montebello Islands and Barrow Island.
Grey-tailed tattler (*Heteroscelus brevipes*)	Migratory, Marine Listed under CAMBA, JAMBA (as *Tringa brevipes*), ROKAMBA (as *Tringa brevipes*) & CMS (Appendix II)	Breeds in Siberia. During non-breeding season, occurs from Asia and Indonesia, to Australasia, Micronesia, Fiji and Tuvalu. Region falls within known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Eighty Mile Beach, Roebuck Bay.
Ruddy turnstone (*Arenaria interpres*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in Siberia. Almost cosmopolitan during non-breeding season. Region falls within known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Eighty Mile Beach, Roebuck Bay.
Asian dowitcher (*Limnodromus semipalmatus*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds from central Siberia to north-east China. Most of the population spends non-breeding period in South–East Asia, especially Sumatra and Java; small numbers migrate regularly to Australia. Region falls within known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	None identified. Recorded at Ashmore Reef and Roebuck Bay.
Great knot (*Calidris tenuirostris*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in Siberia. Most of the population spends non-breeding season in Australia. Region falls within known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Eighty Mile Beach, Roebuck Bay.
Red knot, knot (*Calidris canutus*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in the Arctic. During non-breeding season, occurs in the Americas, Africa, Europe and Australasia. Region falls within the known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Roebuck Bay.

Species group – Birds				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Sanderling (*Calidris alba*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in Siberia. During non-breeding season, occurs on sandy coastal shores of all continents except Antarctica. Region falls within known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Eighty Mile Beach, Roebuck Bay.
Red-necked stint (*Calidris ruficollis*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in Siberia. During non-breeding season occurs mostly in Australia with smaller numbers in New Guinea and New Zealand. Region falls within the known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Eighty Mile Beach, Roebuck Bay, Port Hedland saltworks. Common visitor to the Lowendal Islands, the Montebello Islands and Barrow Island.
Sharp-tailed sandpiper (*Calidris acuminata*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in Siberia. Spend their non-breeding season in Australia with small numbers occurring regularly in New Zealand. Region falls within the known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Anna Plains near Eighty Mile Beach, Port Hedland saltworks, Roebuck Bay.
Curlew sandpiper (*Calidris ferruginea*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in Siberia. Spends non-breeding season in Africa, Asia, India, China and Australasia. Region falls within the known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Port Hedland saltworks, Roebuck Bay and Eighty Mile Beach.
Broad-billed sandpiper (*Limicola falcinellus*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	During the non-breeding season occurs in Africa, the Persian Gulf, the Indian subcontinent, Indonesia, and northern Australia. Region falls within the known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Roebuck Bay.
Beach stone-curlew (*Esacus neglectus*)	Marine	Found around the coast and on offshore islands in north and east Australia. Known range extends into the Region.	Known to breed (July-October) and feed in and adjacent to the Region.	None identified. Breeds on many of the offshore islands of the Region. Resident at the Montebello Islands and the Lowendal Islands.
Pacific golden plover (*Pluvialis fulva*)	Migratory, Marine (as *Pluvialis dominica*) Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in the Arctic. During the non-breeding season, occurs in Africa and the Red Sea, over most of Asia, also Indonesia, New Guinea, Australia, New Zealand and islands of Pacific Ocean. Region falls within the known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	None identified. Visitor to Roebuck Bay and the Lowendal Islands.

Species group – Birds				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Grey plover (*Pluvialis squatarola*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in Siberia (July-October). During non-breeding season, widespread on coasts of North and South America, Africa, Asia and Australasia. Region falls within the known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Eighty Mile Beach, Roebuck Bay.
Red-capped plover (*Charadrius ruficapillus*)	Marine	Occurs in suitable coastal and inland habitat throughout Australia. Known range extends into the Region.	Known to breed (year round) and feed in and adjacent to the Region.	None identified. Breeds in coastal areas and offshore islands in and adjacent to the Region. Breeds at Roebuck Bay.
Lesser sand plover, Mongolian plover (*Charadrius mongolus*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in central and north-east Asia. During non-breeding season, recorded from Africa, the Arabian Sea and Indian subcontinent, the Malay Peninsula, Indonesian Archipelago and northern and eastern Australia. Region falls within the known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Roebuck Bay, Port Hedland Saltworks, regular summer visitor to the Lowendal Islands.
Greater sand plover, large sand plover (*Charadrius leschenaultii*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in Siberia, Mongolia and China (March-July). Non-breeding birds mainly recorded from Africa through Persian Gulf to India and South–East Asia, Indonesia, New Guinea and Solomon Islands to Australia and New Zealand. Region falls within the known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Eighty Mile Beach, Roebuck Bay. Regular visitor to the Lowendal Islands, Montebello Islands and Barrow Island between October and April.
Oriental plover, oriental dotterel (*Charadrius veredus*)	Migratory, Marine Listed under JAMBA, ROKAMBA & CMS (Appendix II)	Breeds in Mongolia, spends non-breeding season in coastal and inland areas of northern Australia. Region falls within the known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Eighty Mile Beach, Roebuck Bay, Port Hedland saltworks, Dampier saltworks, regular summer visitor to the Lowendal Islands.
Oriental pratincole (*Glareola maldivarum*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA	Breeds in Pakistan, India, Burma, Thailand and Vietnam. Entire migratory population may spend non-breeding season in Australia. Region falls within known migration route of the species.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	Port Hedland saltworks, Roebuck Plains.

Species group – Birds				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Australian pratincole (*Stiltia isabella*)	Marine	Found in Australia with non-breeding birds recorded in New Guinea and Indonesia. Region falls within known migration route of the species.	Overflies the Region on migration. Known to breed and feed in and adjacent to the Region.	None identified. Occurs near Roebuck Plains and Roebuck Bay.
Pacific gull (*Larus pacificus*)	Marine	Found across southern Australia from Sydney to Shark Bay. Known range extends into southern part of the Region.	Known to breed and feed adjacent to the Region.	None identified. Breeds on Bernier Island and Dorre Island and other islands in the Shark Bay area.
Silver gull (*Larus novaehollandiae*)	Marine	Occurs in Australia, New Zealand and New Caledonia. Known range extends into the Region.	Overflies the region on migration. Known to breed (December-April) and feed in and adjacent to the Region.	Large breeding populations in the Lowendal Islands. Smaller numbers breed on the Montebello Islands, Serrurier Island and Airlie Island.
Gull-billed tern (*Sterna nilotica*)	Marine	Global distribution. Known range extends into the Region.	Known to breed (spring/ summer) and feed in the Region.	None identified. Breeding records from Point Cloates and Barrow Island.
Caspian tern (*Sterna caspia*)	Migratory, Marine Listed under CAMBA (as *Hydroprogne caspia*) & JAMBA (as *Hydroprogne caspia*)	Found on most continents. Known range extends into the Region.	Known to breed (year round) and feed in and adjacent to the Region.	None identified. Breeding records from Shark Bay and islands in the Pilbara region, Fraser Island (Pt Cloates), and the Dampier Archipelago. Breeds in small numbers at the Lowendal Islands, the Montebello Islands, Barrow Island, Serrurier Island and Airlie Island. Also breed on Adele Island and the Lacepedes.
Lesser crested tern (*Sterna bengalensis*)	Migratory, Marine Listed under CAMBA (as *Thalasseus bengalensis*)	This species has a widespread occurrence in Africa, Arabia, India, South-east Asia, Papua New Guinea and northern Australia. Region falls within the known range of the species.	Known to breed (March-June) and feed in and adjacent to the Region.	Breeding populations on Bedout Island, Adele Island, Leseur Island, Ashmore Reef, the Lowendal Islands and the Montebello Islands.
Crested tern (*Sterna bergii*)	Marine	This species has a widespread distribution around the coasts of the Indian Ocean and west-central Pacific Ocean. Region falls within the known range of the species.	Known to breed (March-June) and feed in and adjacent to the Region.	Breeding populations on Shark Bay islands, Fraser Island (Point Cloates), Anchor Island, Bedout Island, Buccaneer Archipelago, Sunday Island (King Sound), Sand Island (Holothuria Reef), Ashmore Reef, Leseur Island, Montebello Islands, Barrow Island and the Lowendal Islands.

Species group – Birds				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Roseate tern (*Sterna dougallii*)	Migratory, Marine Listed under CAMBA & JAMBA (added to revised Annexes)	Global distribution. Region falls within known range of the species.	Known to breed (April-June) and feed in and adjacent to the Region.	Breeding populations on Bonaparte Archipelago, the Lacepede Islands, Meade Island (Shark Bay), Fraser Island (Point Cloates), Bedout Island and the Montebello Islands, occasionally shifting to the Lowendal Islands in some seasons and Ashmore Reef.
Common tern (*Sterna hirundo*)	Migratory, Marine Listed under CAMBA, JAMBA & ROKAMBA	Breeds in North America, Asia and Europe. Almost cosmopolitan during non-breeding season. Region falls within the known non-breeding range of the species.	Known to feed in and adjacent to the Region.	None identified. Large numbers aggregate near Broome, also Scott Reef and Ashmore Reef.
Little tern (*Sterna albifrons*)	Migratory, Marine Listed under CAMBA, JAMBA, ROKAMBA & CMS (Appendix II)	Occurs across much of Europe, Asia and Australasia. Known range extends into the Region.	Known to breed and feed in and adjacent to the Region.	None identified. Breeding records from Rowley Shoals and islands of the Kimberley coast.
Fairy tern (*Sterna nereis*)	Marine	Occurs in coastal areas of Australia, New Zealand and New Caledonia. Known range extends into the Region.	Known to breed (March-June) and feed in and adjacent to the Region.	None identified. Breeds in Shark Bay, Blowholes (north of Carnarvon), Bird Island (Dampier Archipelago), the Lacapede Islands and the Montebello Islands. Very occasional breeder at the Lowendal Islands, Barrow Island, Serrurier Island and Airlie Island.
Bridled tern (*Sterna anaethetus*)	Migratory, Marine Listed under CAMBA & JAMBA	Occurs in tropical and subtropical coasts and waters off Africa, Asia, the Americas and Australia. Region falls within the known range of the species.	Known to breed and feed in and adjacent to the Region.	Breeding populations at Ashmore Reef, islands of the Kimberley, (Sunday Island, Montalivet Islands, Low Rocks, Lacepede Island), Montebello Islands, Barrow Island, Lowendal Islands and islands of Shark Bay.
Sooty tern (*Sterna fuscata*)	Marine	Pan-tropical. Most abundant tropical tern. Occurs in tropical and subtropical Indian, Atlantic and Pacific oceans. Region falls within the known range of the species.	Known to breed and feed in and adjacent to the Region. Feeds in pelagic waters north of 30°S.	Breeding populations on Ashmore Reef, Rowley Shoals, Lacepede Island and Bedout Island.

Species group – Birds				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
White-winged black tern, white-winged tern (*Chlidonias leucopterus*)	Migratory, Marine Listed under CAMBA, JAMBA & ROKAMBA (as *Sterna leucoptera*)	Breeds from eastern Europe to South-East Asia. Occurs in Africa, south Asia and Australia during non-breeding period (August-May). Known non-breeding range extends into the Region.	Known to feed in and migrate through the Region.	None identified. Occurs in Port Hedland, Eighty Mile Beach and Dampier Archipelago.
Common noddy (*Anous stolidus*)	Migratory, Marine Listed under CAMBA & JAMBA	Widespread in tropical and subtropical seas throughout the world. Region falls within known range of the species.	Known to breed and feed in and adjacent to the Region.	Breeding populations at Ashmore Reef, the Lacepede Islands and Bedout Island. Foraging grounds adjacent to the Montebello Islands.
Black noddy (*Anous minutus*)	Marine	Breeds mainly in central and south-west Pacific Ocean. Other breeding populations in tropical and subtropical Atlantic Ocean, Caribbean Sea, east Pacific, Philippines and Indonesia. During non-breeding periods found mostly in seas around breeding islands. Widespread in central and south-west Pacific Ocean. Region falls within known range of the species.	Known to breed and feed in and adjacent to the Region.	Breeding population on Ashmore Reef.
Australian lesser noddy (*Anous tenuirostris melanops*)	Vulnerable, Marine	Usually found only around its breeding islands in the Houtman Abrolhos Islands in WA. Part of the known range extends into the Region.	Possibly feeds in and adjacent to the Region.	None identified.
Oriental cuckoo (*Cuculus sturatus*)	Migratory, Marine Listed under CAMBA, JAMBA & ROKAMBA	Breeds in Europe and east Asia. Spends non-breeding season in India, South–East Asia, Papua New Guinea and Australia. Frequent visitor to the Kimberley coast, occasional to the Pilbara coast. Region falls within known migration route of the species.	Migrates through the Region.	None identified.
Common koel (*Eudynamys scolopacea*)	Marine	Occurs in south Asia, Papua New Guinea and Australia. Region falls within known migratory route of the species.	Migrates through the Region.	None identified.

Species group – Birds				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Fork-tailed swift (*Apus pacificus*)	Migratory, Marine Listed under CAMBA, JAMBA & ROKAMBA	Breeds in Asia (April-October) and is widespread during the non-breeding season through India, South-East Asia and Australasia. Known non-breeding range extends into the Region.	Overflies the Region on migration. Known to feed in and adjacent to the Region.	None identified.
Sacred kingfisher (*Todiramphus sanctus*)	Marine	Found in Australia, Indonesia and Pacific Islands. Known range extends into Region.	Known to breed (September-March) and feed in and adjacent to the Region.	None identified. Breeding records from Ashmore Reef.
Rainbow bee-eater (*Merops ornatus*)	Migratory, Marine Listed under JAMBA	Found throughout Australia, eastern Indonesia, Papua New Guinea and the Bismarck Archipelago. Region falls within known migration path of the species.	Known to overfly the Region on migration.	None identified.
Dollarbird (*Eurystomus orientalis*)	Marine	Widespread through Asia, South–East Asia, Papua New Guinea and Australia. Region falls within the known migration route of the species.	Migrates through the Region.	None identified.
Magpie-lark (*Grallina cyanoleuca*)	Marine	Found in mainland Australia with vagrants to Tasmania, Papua New Guinea and Timor. Known range extends into the Region.	Known to breed and feed in coastal areas and on offshore islands in and adjacent to the Region.	None identified. Occurs on the Lowendal Islands, the Montebello Islands and Barrow Island.
Richard's pipit (*Anthus novaeseelandiae*)	Marine	Widespread throughout Australia and Tasmania. Also found in eastern Europe, Africa, Asia, Indonesia, Papua New Guinea, New Zealand and sub-Antarctic islands. Known range extends into the Region.	Known to breed (August-December) and feed in coastal areas and offshore islands in and adjacent to the Region.	None identified. Common throughout the Dampier Archipelago and at the Lowendal Islands and the Montebello Islands, Barrow Island, Serrurier Island and Airlie Island.
Yellow wagtail (*Motacilla flava*)	Migratory, Marine Listed under CAMBA, JAMBA & ROKAMBA	Breeds in the Northern Hemisphere. Non-breeding distribution includes South Africa, India, Indonesia, New Guinea and northern Australia. Region falls within known migration route of the species.	Migrates through the Region.	None identified.

Species group – Birds				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Barn swallow (*Hirundo rustica*)	Migratory, Marine Listed under CAMBA, JAMBA & ROKAMBA	Breeds in north-east Asia, China and Japan. Spends non-breeding season in India, South–East Asia, Indonesia, New Guinea and northern Australia. Region falls within known migration route of the species.	Migrates through the Region.	None identified.
Welcome swallow (*Hirundo neoxena*)	Marine	Found in mainland Australia and Tasmania, may migrate to Torres Strait islands in winter. Known range extends into Region.	Known to breed (August-December) and feed in coastal areas and on offshore islands in and adjacent to the Region.	None identified. Common on the Lowendal Islands and the Montebello Islands. Also occurs on Barrow Island, Serrurier Island and Airlie Island.

Species group - Dugongs				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Dugong (*Dugong dugon*)	Migratory, Marine Listed under CITES (Appendix I) and CMS (Appendix II)	Global distribution in tropical and subtropical coastal and island waters. Region falls within known range of the species.	Breeds and feeds in the Region.	Large, globally significant resident population in Shark Bay.

Species group – Cetaceans				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Humpback whale (*Megaptera novaeangliae*)	Vulnerable, Migratory Listed under CITES (Appendix I) & CMS (Appendix I)	Global species. Region falls within known range of the Southern Hemisphere population.	Important calving and resting areas in the Region.	Calving area between Broome and the northern end of Camden Sound. Resting areas in Shark Bay and Exmouth Gulf. Migration path between Point Cloates and North West Cape.
Dwarf minke whale (*Balaenoptera acutorostrata* subsp.)	Listed under CITES (Appendix I)	Found in tropical and warm temperate waters of the Southern Hemisphere. Region falls within the known range of the species.	Migrate through the Region.	None identified.
Antarctic minke whale, dark-shoulder minke whale (*Balaenoptera bonaerensis*)	Migratory Listed under CITES (Appendix I) & CMS (Appendix II)	Ranges seasonally from tropical to Antarctic waters. Region falls within presumed migration path of the species.	Migrate through the Region.	None identified.
Bryde's whale (*Balaenoptera edeni*)	Migratory Listed under CITES (Appendix I) & CMS (Appendix II)	Found in tropical and warm temperate waters between 40°N and 40°S. Region falls within the known range of the species.	Data deficient. Possibly resident in the Region throughout the year.	None identified.

Species group – Cetaceans				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Fin whale (*Balaenoptera physalus*)	Vulnerable, Migratory Listed under CITES (Appendix I) & CMS (Appendix I & II)	Widely distributed in both hemispheres between latitudes 20–75°. More common in temperate waters. Known range extends into Region.	Data deficient. Possibly migrates through the Region.	None identified.
Blue whale, pygmy blue whale (*Balaenoptera musculus*)	Endangered, Migratory Listed under CITES (Appendix I) & CMS (Appendix I)	Global species. Region falls within known range of the species. (Most likely pygmy blue whales).	Migrates through the Region.	None identified.
Sperm whale (*Physeter macrocephalus*)	Migratory Listed under CITES (Appendix I as *Physeter catodon*) & CMS (Appendix I & II)	Occurs throughout the deep waters of all the world's oceans, from the equator to the edges of the polar pack-ice.	Females with young may reside in the Region all year round. Males may migrate through the Region.	None identified. May be associated with canyon habitats.
Cuvier's beaked whale, goose-beaked whale (*Ziphius cavirostris*)	Listed under CITES (Appendix II)	Worldwide distribution in all temperate and tropical waters between 60°N and 55°S. Region falls within the known range of the species.	Data deficient. May migrate through the Region.	None identified. May be associated with canyon habitats.
Rough-toothed dolphin (*Steno bredanensis*)	Listed under CITES (Appendix II)	Found in tropical and warm temperate waters around the world. Region falls within the known range of the species.	Data deficient. Possibly resident in the Region throughout the year.	None identified.
Indo-Pacific humpback dolphin (*Sousa chinensis*)	Migratory Listed under CITES (Appendix I) & CMS (Appendix II)	Found in tropical waters south to 25°S. Region falls within known range of the species.	Resides in the Region throughout the year.	Resident populations at Ningaloo Reef and Barrow Island.
Bottlenose dolphin (*Tursiops truncatus* s. str.)	Listed under CITES (Appendix II)	Occurs in all temperate and tropical waters around the world in both coastal and offshore waters. Region falls within known range of the species.	Resides in the Region throughout the year.	Resident populations at Shark Bay and Barrow Island.
Indo-Pacific bottlenose dolphin, Indian Ocean bottlenose dolphin, spotted bottlenose dolphin (*Tursiops aduncus*)	Migratory (Arafura/Timor Sea populations) Listed under CITES (Appendix II) & CMS (Appendix II) - Arafura/ Timor Sea populations only	Found in tropical and subtropical coastal and shallow offshore waters of the Indian Ocean, Indo-Pacific Region and western Pacific Ocean. Part of the known range of the species extends into the Region.	Resides in the Region throughout the year.	Resident populations at Shark Bay and Barrow Island.
Spotted dolphin, pantropical spotted dolphin (*Stenella attenuata*)	Listed under CITES (Appendix II)	Found in tropical oceanic zones between about 40°N and 40°S in both near-shore and oceanic habitats. Region falls within known range of the species.	Data deficient. Probably resident in the Region throughout the year.	None identified.

Species group – Cetaceans				
Species	Conservation status	Distribution	Known use of the Region	Important areas in or adjacent to the Region
Long-snouted spinner dolphin (*Stenella longirostris*)	Listed under CITES (Appendix II)	Occurs in all tropical and subtropical waters around the world between approximately 30–40°N and 20–30°S. Region falls within the known range of the species.	Resides in the Region throughout the year.	None identified.
Striped dolphin, Euphrosyne dolphin (*Stenella coeruleoalba*)	Listed under CITES (Appendix II)	Found worldwide in temperate to tropical deep oceanic waters.	Resides in the Region throughout the year.	None identified. Abundant in waters around Barrow Island.
Risso's dolphin, grampus (*Grampus griseus*)	Listed under CITES (Appendix II)	Inhabits tropical, subtropical, temperate and subantarctic waters between 60°N and 60°S. Region falls within known range of the species.	Data deficient.	None identified.
Melon-headed whale (*Peponocephala electra*)	Listed under CITES (Appendix II)	Pan-tropical. All deep oceanic waters between 35°N and 35°S. Region falls within known range of the species.	Data deficient. May be resident in the Region throughout the year.	None identified.
False killer whale (*Pseudorca crassidens*)	Listed under CITES (Appendix II)	Found worldwide in deep tropical and temperate waters between 45°N and 45°S. Region falls within known range of the species.	Data deficient. Probably resident in the Region throughout the year.	None identified.
Killer whale, orca (*Orcinus orca*)	Migratory Listed under CITES (Appendix II) & CMS (Appendix II)	Cosmopolitan. Found throughout all oceans and seas of the world. Region falls within known range of the species.	May feed in the Region. (May prey on humpback whales).	None identified. May be associated with humpback aggregation areas.
Short-finned pilot whale (*Globicephala macrorhynchus*)	Listed under CITES (Appendix II)	Occur in tropical and warm temperate waters worldwide between 41°S and 45°N. Region falls within the known range of the species.	Data deficient. Possibly resident in the Region throughout the year, although species is generally nomadic.	None identified.
Australian snubfin dolphin (*Orcaella heinsohni*)	Migratory Listed under CITES (Appendix I) & CMS (Appendix II)	Occurs on the northern Sahul Shelf including the coastal waters of northen Australia and Papua New Guinea. Presumed range of the species extends into the Region.	May be resident in the Region throughout the year.	Resident populations in Roebuck Bay and along the Kimberley coast.

Table C2 Protected species that may occur or occur infrequently in the North-west Marine Region

Species group – Sharks	
Species	**Conservation Status**
Northern river shark (*Glyphis garricki*)	Endangered
Freshwater sawfish (*Pristis microdon*)	Vulnerable Listed under CITES (Appendix II)

Species group – Bony fish	
Species	**Conservation Status**
Western spiny seahorse, narrow-bellied seahorse (*Hippocampus angustus*)	Marine Listed under CITES (Appendix II)
False-eyed seahorse, false-eye seahorse (*Hippocampus biocellatus*)	Marine Listed under CITES (Appendix II)
Smooth seahorse (*Hippocampus kampylotrachelos*)	Marine Listed under CITES (Appendix II)
Montebello seahorse, Monte Bello seahorse (*Hippocampus montebelloensis*)	Marine Listed under CITES (Appendix II)
Northern spiny seahorse (*Hippocampus multispinus*)	Marine Listed under CITES (Appendix II)
Flat-face seahorse, flatface seahorse (*Hippocampus planifrons*)	Marine Listed under CITES (Appendix II)
Helen's pygmy pipehorse (*Acentronura larsonae*)	Marine
Braun's pughead pipefish, pug-headed pipefish, eel pipefish (*Bulbonaricus brauni*)	Marine
Gale's pipefish (*Campichthys galei*)	Marine
Three-keel pipefish (*Campichthys tricarinatus*)	Marine
Muiron Island pipefish, Muiron pipefish (*Choeroichthys latispinosus*)	Marine
Pig-snouted pipefish, pigsnout pipefish (*Choeroichthys suillus*)	Marine
Reef-top pipefish, reeftop pipefish, dragon pipefish (*Corythoichthys haematopterus*)	Marine
Cleaner pipefish, Janss' pipefish (*Doryrhamphus janssi*)	Marine
Many-banded pipefish, multi-banded pipefish (*Doryrhamphus multiannulatus*)	Marine
Ladder pipefish (*Festucalex scalaris*)	Marine
Tiger pipefish (*Filicampus tigris*)	Marine
Brock's pipefish, tasselled pipefish (*Halicampus brocki*)	Marine
Mud pipefish, Gray's pipefish (*Halicampus grayi*)	Marine
Spiny-snout pipefish, spinysnout pipefish (*Halicampus spinirostris*)	Marine
Ribboned pipehorse, ribboned seadragon, ribboned pipefish (*Haliichthys taeniophorus*)	Marine
Beady pipefish, steep-nosed pipefish (*Hippichthys penicillus*)	Marine

Species group – Bony fish	
Species	**Conservation Status**
Prophet's pipefish (*Lissocampus fatiloquus*)	Marine
Tidepool pipefish (*Micrognathus micronotopterus*)	Marine
Bony-headed pipefish, bonyhead pipefish (*Nannocampus subosseus*)	Marine
Rock pipefish, black rock pipefish (*Phoxocampus belcheri*)	Marine
Indonesian pipehorse, Günther's pipehorse (*Solegnathus lettiensis*)	Marine
Spotted pipefish (*Stigmatopora argus*)	Marine
Wide-bodied pipefish, wide-body pipefish, black pipefish (*Stigmatopora nigra*)	Marine
Bentstick pipefish, bent-stick pipefish, bendstick pipefish, stick pipefish, short-tailed pipefish, double-ended pipefish (*Trachyrhamphus bicoarctatus*)	Marine
Straight stick pipefish, straightstick pipefish, long-nosed pipefish (*Trachyrhamphus longirostris*)	Marine

Species group – Sea snakes and reptiles	
Species	**Conservation Status**
Black-headed seasnake (*Hydrophis atriceps*)	Marine
Plain seasnake (*Hydrophis inornatus*)	Marine
Black-banded robust seasnake (*Hydrophis melanosoma*)	Marine
Estuarine crocodile, salt-water crocodile (*Crocodylus porosus*)	Marine, Migratory Listed under CMS (Appendix II) & CITES (Appendix II)

Species group – Birds	
Species	**Conservation Status**
Magpie goose (*Anseranas semipalmata*)	Marine
Northern giant-petrel (*Macronectes halli*)	Vulnerable, Migratory, Marine Listed under CMS (Appendix II)
Cape petrel (*Daption capense*)	Marine
White-headed petrel (*Pterodroma lessonii*)	Marine
Herald petrel (*Pterodroma heraldica*)	Critically endangered, Marine
Round Island petrel (*Pterodroma arminjoniana*)	Critically endangered, Marine
Australasian gannet (*Morus serrator*)	Marine
Christmas Island frigatebird, Andrews frigatebird (*Fregata andrewsii*)	Vulnerable, Migratory, Marine Listed under CAMBA
Great egret, white egret (*Ardea alba*)	Migratory, Marine Listed under CAMBA (as *Egretta alba*) & JAMBA (as *Egretta alba*)

Species group – Birds	
Species	**Conservation Status**
Intermediate egret (*Egretta intermedia*)	Marine (as *Ardea intermedia*)
Cattle egret (*Ardea ibis*)	Migratory, Marine Listed under CAMBA (as *Bubulcus ibis*) & JAMBA (as *Ardeola ibis*)
Nankeen night heron (*Nycticorax caledonicus*)	Marine
Swamp harrier (*Circus approximans*)	Marine Listed under CITES (Appendix II)
Brown goshawk (*Accipiter fasciatus*)	Marine Listed under CITES (Appendix II)
Black-winged stilt (*Himantopus himantopus*)	Marine
Great skua (*Catharacta skua*)	Marine
Pallid cuckoo (*Cuculus pallidus*)	Marine
Horsfield's bronze-cuckoo (*Chrysococcyx basalis*)	Marine
Little bronze-cuckoo (*Chrysococcyx minutillus*)	Marine
Channel-billed cuckoo (*Scythrops novaehollandiae*)	Marine
Rufous fantail (*Rhipidura rufifrons*)	Marine
Black-faced cuckoo-shrike (*Coracina novaehollandiae*)	Marine
Grey wagtail (*Motacilla cinerea*)	Migratory, Marine Listed under CAMBA & ROKAMBA
Tree martin (*Hirundo nigricans*)	Marine
Oriental reed-warbler, great reed-warbler (*Acrocephalus orientalis*)	Migratory, Marine Listed under CAMBA & ROKAMBA (as *Acrocephalus arundinaceus*)
Arctic warbler (*Phylloscopus borealis*)	Migratory, Marine Listed under CAMBA

Species group – Cetaceans	
Species	**Conservation Status**
Southern right whale (*Eubalaena australis*)	Endangered, Migratory Listed under CITES (Appendix I) & CMS (Appendix I)
Sei whale (*Balaenoptera borealis*)	Vulnerable, Migratory, Listed under CITES (Appendix I) & CMS (Appendix I & II)
Pygmy sperm whale (*Kogia breviceps*)	Listed under CITES (Appendix II)
Dwarf sperm whale (*Kogia simus*)	Listed under CITES (Appendix II)
Gray's beaked whale, Scamperdown whale (*Mesoplodon grayi*)	Listed under CITES (Appendix II)
Gingko-toothed beaked whale, Gingko-toothed whale, Gingko beaked whale (*Mesoplodon ginkgodens*)	Listed under CITES (Appendix II)
Blainville's beaked whale, dense-beaked whale (*Mesoplodon densirostris*)	Listed under CITES (Appendix II)
Short-beaked common dolphin (*Delphinus delphis*)	Listed under CITES (Appendix II)
Fraser's dolphin, Sarawak dolphin (*Lagenodelphis hosei*)	Listed under CITES (Appendix II)
Dusky dolphin (*Lagenorhynchus obscurus*)	Migratory Listed under CITES (Appendix II) & CMS (Appendix II)
Pygmy killer whale (*Feresa attenuata*)	Listed under CITES (Appendix II)
Long-finned pilot whale (*Globicephala melas*)	Listed under CITES (Appendix II)

Red-tailed tropicbird. Photo: Mark Holdsworth.

Appendix D North-west Marine Region Protected Species Group Report Cards

These report cards summarise information on those species that occur in the North-west Marine Region and are protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The report cards present relevant information on species groups and are designed to be updated as new information becomes available. The report cards in this appendix are current at May 2008. Updates of the report cards will be available at <www.environment.gov.au/coasts/mbp/north-west>.

Protected species occurring in the North-west Marine Region for which species group report cards have been compiled include:

D1 Sharks

D2 Bony fish (including seahorses, pipehorses, pipefish and ghost pipefish)

D3 Reptiles – sea snakes

D4 Reptiles – marine turtles

D5 Birds (seabirds and shorebirds)

D6 Mammals – dugongs

D7 Mammals – cetaceans

D1 North-west Marine Region Protected Species Group Report Card – Sharks

Current at May 2008. See <www.environment.gov.au/coasts/mbp/north-west> for updates.

General information

Sharks belong to the taxonomic class Chondrichthyes, which are also known as the cartilaginous fish. As this name suggests, sharks do not have bones, and instead their skeletons are composed of cartilage. Sharks fall within the subclass Elasmobranchii, which are typified by cylindrical, sometimes flattened body forms, and have between five and seven gill openings.

The distribution of sharks is highly varied, and they are found in a wide range of habitats ranging from shallow to deep water, in oceanic, reef, coastal, estuarine and freshwater environments. Sharks can be pelagic (in the upper part of the water column or the open ocean) or demersal (living on or near the seafloor).

The North-west Marine Region has a rich shark fauna owing to the diversity of marine environments found across its waters. Of the 500 shark species found worldwide, 94 are found in the Region – 19 per cent of the world's shark species. A more detailed overview of the chondrichthyan species group in the North-west Marine Region can be found in Heupel & McAuley (2007). This report is available at <www.environment.gov.au/coasts/mbp/north-west>.

Grey reef shark. Photo: Photolibrary.

Table D1.1 Sharks listed as threatened or migratory under the EPBC Act that are known to occur in the North-west Marine Region

Species	Conservation Status	Conservation Plans and Policies
Whale shark (*Rhincodon typus*)	Vulnerable, Migratory Listed under CITES (Appendix II) & CMS (Appendix I & II)	• *Recovery Plan for the Grey Nurse Shark* (Carcharias taurus) *in Australia* (EA 2002a) • *White shark* (Carcharodon carcharias) *Recovery Plan* (EA 2002b) • *National Plan of Action for the Conservation and Management of Sharks* (DAFF 2004) • *Whale shark* (Rhincodon typus) *Recovery Plan 2000–2010* (DEH 2005)
Grey nurse shark (*Carcharias taurus*) – west coast population	Vulnerable Listed under CITES (Appendix II)	
White shark (*Carcharodon carcharias*)	Vulnerable, Migratory Listed under CITES (Appendix II) & CMS (Appendix I and II)	
Green sawfish (*Pristis zijsron*)	Vulnerable Listed under CITES (Appendix I)	

Nationally protected species

Four shark species found in the Region are listed under the EPBC Act (Table D1.1). All these species are also listed under international instruments. Recovery Plans are in place for each of these species and can be found at <www.environment.gov.au/coasts/species/sharks>.

As a signatory to the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS), Australia has an international obligation to protect migratory species, their habitats and their migration routes. Similarly, as a party to the *Convention on the International Trade in Endangered Species of Wild Fauna and Flora* (CITES), Australia has agreed to control the import and export of an agreed list of species that are endangered, or at risk of becoming endangered because of inadequate controls over trade in them or their products. In June 2007, six of the seven species of sawfish (family Pristidae) were listed under Appendix I of CITES. The exception was the freshwater sawfish *Pristis microdon*, which was listed under Appendix II of CITES allowing international trade in live animals to appropriate and acceptable aquaria, primarily for conservation purposes. Further information on CITES and CMS is included in Appendix A.

Ecology of protected species in the North-west Marine Region

White sharks (*Carcharodon carcharias*) are found in temperate and subtropical waters across the world. In Australian waters, their range extends from southern Queensland around the southern Australian coast to North West Cape. They generally inhabit coastal and continental shelf waters to 100 m depth.

In the North-west Marine Region they are occasionally found in waters south of Exmouth, and are rarely found in tropical waters. Non-breeding white sharks tend to have a wider temperature range and may move into tropical waters, and pass through the waters off oceanic islands (EA 2002b). Recent tagging studies recorded a female white shark travelling across the Indian Ocean, from South Africa to waters off Exmouth and back in under 9 months - the fastest trans-oceanic migration recorded among marine fauna (Bonfil *et al*. 2005).

White sharks attain a maximum size of up to 6 m and males and females reach sexual maturity at 350 cm and 400 cm, respectively. Like most other sharks, they are oviphagous. Oviphagous animals hatch from eggs, but the eggs hatch and the young develop inside the female's body. There is no placenta to nourish the pups. Instead,the pups are cannibalistic; eating any unfertilized eggs and their siblings. Very few pups in a litter survive to birth. White sharks have between two and ten young per litter, of 130 cm length (Last & Stevens 1994). They primarily feed on teleosts (bony fish) and other sharks, but adults also feed on marine mammals, such as pinnipeds and whales. They have few natural predators and do not feed continuously; a large meal (such as a seal) may last a medium-sized shark for up to a week (EA 2002b).

Few regions of the world support large white shark populations without a corresponding pinniped (sea lion and seal) population (EA 2002b). There are no known pinniped sites in the Region and no major white shark populations have been recorded in the Region. However, white sharks spend much of their life in pelagic areas away from seal colonies, and also feed on a variety of pelagic species (Boustany *et al*. 2002).

Grey nurse sharks (*Carcharias taurus*) are found in subtropical to cool temperate inshore waters around the much of world, except the western Pacific (Last & Stevens 1994). In Australian waters, they are regularly

sighted from southern Queensland to the New South Wales/Victorian border, and from Esperance in southern Western Australia north to Shark Bay and North West Cape (EA 2002a).

Thus, grey nurse sharks are thought to form two distinct populations in Australian waters: an east coast and a west coast population with a strong genetic difference between the two populations (Stow *et al*. 2006). These populations are listed separately under the EPBC Act: the west coast population is listed as vulnerable and the east coast population as critically endangered.

The range of grey nurse sharks spans the whole Region, but they have rarely been found north of Shark Bay (EA 2002a). An aggregation has recently been discovered at Broome, which represents a significant extension to their range (R. McAuley, pers. comm. 2007). Grey nurse sharks generally inhabit waters between the surf zone and the outer continental shelf to 190 m water depth. The diet of grey nurse sharks is similar to other sharks, and consists of teleost (bony) fish and other sharks.

Whale sharks (*Rhincodon typus*) are found in tropical and warm temperate seas across the world (Last & Stevens 1994; Stewart & Wilson 2005). In Australia they have been reported from waters off the Northern Territory, Queensland and northern Western Australia, but they are primarily found in seasonal aggregations around Ningaloo Reef, between March and June. They have also been reported from oceanic and coastal waters across the Region (Wilson *et al*. 2006).

The whale shark is the largest living fish, with the largest measuring just over 12 m (Stevens 2007). They are thought to be ovoviviparous, retaining their egg cases until hatching, with the females releasing live young. Unlike most sharks, whale sharks are filter-feeders, and their diet includes a wide variety of planktonic and nektonic prey, including small crustaceans, fish eggs and small pelagic fish. They do not rely on forward motion to filter prey, and can hang vertically in the water column and suction feed by opening their mouths and allowing water to rush in (Last & Stevens 1994).

Whale sharks are generally solitary, but can occur in aggregations of up to hundreds of individuals, usually in tropical and subtropical waters between 21–25°C. Seasonal aggregations of whale sharks occur around dense collections of prey such as those found around Ningaloo Reef (Stevens 2007). Around Ningaloo, whale sharks spend daylight hours near the surface and nights at depths of 30–80 m.

In oceanic waters, they routinely move between the sea surface and depth, and spend over half their time at depths greater than 30 m. Off the outer North West Shelf, they spend much of their time swimming near the seafloor, and make dives to over 1000 m depth. They are able to tolerate the colder temperatures (to 5°C) found at these depths, possibly because of the insulation provided by their large body mass (Wilson *et al*. 2006). These dives into deeper oceanic waters are thought to be primarily in search of prey such as krill, lantern fish, squid and jellyfish around the deep scattering layer (Wilson *et al*. 2006).

Whale sharks are highly migratory; their longer-term movements are uncertain, but are likely to include Indonesian and other South–East Asian waters. There is evidence of substantial gene flow among populations of whale sharks, indicating they make broad-scale movements and have a high connectivity among populations (Bradshaw 2007). Their movements are thought to be related to changes in local biological productivity, and they are often associated with schools of pelagic fish. After leaving Ningaloo, most whale sharks probably travel north-east along the continental shelf, before moving offshore into the north-eastern Indian Ocean, around the Dampier Terrace and Argo Abyssal Plain (Wilson *et al*. 2006). Whale sharks have also been recorded moving further north-east toward Scott Reef and Ashmore Reef (Wilson *et al*. 2006).

Green sawfish (*Pristis zijsron*) are found mostly in tropical and subtropical waters, north of Shark Bay across northern Australian waters to Cairns. In terms of their wider distribution, they are found in the northern Indian Ocean and off Indonesia (Heupel & McAuley 2007). This species has mostly been recorded in inshore, coastal environments, as well as estuaries, but unlike other sawfish species, does not move into freshwater. There have been a number of records of this species far offshore, at water depths of up to 70 m. Smaller green sawfish are more likely to be found in inshore waters, whereas larger animals have been found in both inshore and offshore waters (Stevens *et al*. 2005). Like other sawfish species, green sawfish are thought to be long-lived, produce few young and reach sexual maturity late in life.

Important areas for sharks in the North-west Marine Region

While there are a number of known grey nurse shark aggregation sites in eastern Australian, there are no such sites in the North-west Marine Region. Some potentially suitable sites have been identified in waters off the Western Australian coast, based on their similarity to eastern Australian sites. These mostly occur around Exmouth and North West Cape where there are significant vertical and horizontal reef structures, including fringing coral reef with isolated bomboras amongst sand and rubble. However, no aggregations have been recorded from these areas (Chidlow *et al*. 2006).

There are no known aggregation sites for white sharks in the Region, and this species is most likely to be found south of North West Cape only, probably in low densities.

Little is known of important areas for green sawfish in the Region, but inshore waters are likely to be important for this species. Another sawfish species, the freshwater sawfish (*Pristis microdon*), which is listed as vulnerable under the EPBC Act, does not commonly occur in the Commonwealth waters of the North-west Marine Region, but the inshore waters around King Sound and the Fitzroy River are critical habitat for this species (Thorburn *et al*. 2004).

Ningaloo Reef – In Australian waters, Ningaloo Reef is the main known aggregation site for whale sharks, owing to concentrations of krill and other zooplankton associated with seasonal productivity events, which provide an abundant food source (Taylor 1996). The whale shark aggregations at Ningaloo are the largest density of whale sharks per kilometre in the world (Martin 2007).

Generally, whale shark aggregations around Ningaloo are greatest in La Niña years, in association with intensification of the Leeuwin Current in March. This results in the extension of warmer water down the Western Australian coast, and allows whale sharks to exploit more abundant food sources within this seasonally expanded geographic range (Wilson *et al*. 2001).

The Ningaloo region provides a unique habitat for whale sharks, owing to its circular current system of two opposing currents: the Ningaloo Current and the Leeuwin Current (Taylor & Pearce 1999). Offshore from the shelf break, the southerly-flowing Leeuwin Current assists whale shark migration to Ningaloo. Along the inner shelf, the Ningaloo Current flows northward and retains planktonic biomass (which whale sharks feed on) within the Ningaloo region.

Known interactions, threats and mitigation measures

Commercial fishing

None of the shark species listed under the EPBC Act are targeted by commercial fisheries in the Region and the catch of grey nurse sharks and white sharks in commercial fisheries is prohibited. Historically, the major source of grey nurse shark deaths in the Region has been incidental capture in demersal gill-net and line fisheries south of Steep Point near Shark Bay (Chidlow *et al*. 2006). Most of the protected sharks caught as by-catch are returned to the sea alive, but release of sharks after capture is likely to be associated with increased mortality (Stevens *et al*. 2000). However, due to the limited distribution of white sharks and grey nurse sharks in the North-west Marine Region, the risk to these species in the Region is negligible.

Whale sharks have limited interaction with fisheries in the Region, and the greatest threat to this species is associated with fishing pressure outside Australian waters. Whale sharks are vulnerable to over-exploitation by fishing because of their slow growth; delayed, infrequent reproduction; and widespread distribution in small, highly mobile populations. In addition, they are easily caught, as they are slow-swimming and docile when encountered near the sea surface (Stewart & Wilson 2005). Coastal harpoon and net fisheries for whale sharks exist in many countries including Taiwan, Indonesia and Pakistan (Rowat 2007). Despite bans on whale shark capture in many countries, enforcement is minimal, and trade in whale shark products is largely driven by demand for meat and fins. The killing of whale sharks in their seasonal residences, where they are the subject of targeted fisheries, is the largest threat to whale sharks (Rowat 2007). Recent evidence indicates that overseas fishing pressure may be a primary cause in inferred recent declines in whale shark numbers at Ningaloo Reef (Bradshaw *et al*. 2007).

The toothed rostrum of green sawfish (and other sawfish species) make them highly susceptible to capture in all net fisheries. As such, net and trawl fisheries within (and adjacent to) the Region pose a threat to green sawfish. Because of the danger of removing large specimens from nets and lines, fishers may kill sawfish before

removing them from their fishing gear. In addition, the high value of sawfish fins (up to $250 per kg) results in animals being retained, where they would normally be released. Closing some areas to fishing at specific times of the year may decrease the likelihood of green sawfish capture, along with the use of by-catch reduction devices, but these have not been studied in any detail (Stevens *et al*. 2005).

Illegal, unreported and unregulated fishing

Sharks are thought to be major target species for illegal, unreported and unregulated fishing in the Region. Demand and prices for shark products, such as fins and jaws, are both relatively high, which coupled with the low reproductive rate of most sharks, increases the likelihood of over-exploitation. Shark fin markets are especially lucrative, as sellers can receive as much as $AUD300 per kg for dried fin. Most illegal, unreported and unregulated fishing activity in the Region comes from Indonesia. Activity increased dramatically between 2001 and 2006, but has decreased in recent times.

Generally, illegal, unreported and unregulated fishing occurs north-east of Mermaid Reef, and is unlikely to catch white or grey nurse sharks. Whale sharks may be caught by illegal, unreported and unregulated fishers in the Region, but there are no records of this. However, whale sharks are opportunistically and directly targeted for fins and meat in Indonesian waters (White & Cavanagh 2007). Stevens *et al*. (2005) noted that it is possible that green sawfish in Australian waters may be caught by illegal, unreported and unregulated fishers.

There have been some records of white sharks in Australia being caught for trade in trophy products (e.g. jaws and teeth) and fins. Listing of this species under CITES requires traders of this species to issue a Certificate of Origin, stating the origins of white shark products (EA 2002b).

Recreational fishing

There has been limited recreational fishing effort for sharks in Western Australian waters, especially when compared with eastern Australian waters. At current levels of effort, recreational fishing is not thought to be a significant threat to any listed shark species in the Region.

In the past, grey nurse sharks were heavily targeted by recreational fishers on the east coast. However, this did not occur in Western Australia. Recreational game fishing for white sharks in Australia is currently prohibited, but there has been limited recreational fishing for white sharks in Western Australian waters (and, to a more limited extent, adjacent Commonwealth waters) in the past.

Tourism

The seasonal aggregation of whale sharks at Ningaloo Reef has generated a significant tourism industry, including boat tours, flights, and snorkel and dive tours. These activities have the potential to negatively affect whale shark behaviour, habitats and ecology.

Repeated touching of whale sharks by divers or snorkellers and other interactions may result in whale sharks avoiding some waters, which could include critical habitat (Martin 2007). However, whale shark tourism activities around Ningaloo are well managed, and are not thought to have a major impact (Davis *et al*. 1997).

There is a small tourism industry associated with diving with grey nurse sharks in Western Australia. While this industry is not currently seen as a threat to this species, frequent disturbance of grey nurse sharks may displace them from important habitats (EA 2002a).

Shipping and boating

Collisions between shipping vessels and whale sharks have been recorded occasionally. While there have been fewer records in recent times, because of their size modern vessels are less likely to notice the impact of a whale shark against their hull. Studies have noted that many whale sharks have scars that may have been caused by collisions with vessels (Stevens 2007).

Disturbances of important habitat

Whale sharks rely on coral reef habitats around Ningaloo, which attract krill and zooplankton, the whale shark's main prey. Deterioration or destruction of important seasonal coral reef habitat and feeding areas by coral bleaching events, climate change or other anthropogenic disturbances (e.g. oil spills), may pose a threat to whale sharks (Stewart & Wilson 2005).

During the late 1980s, there was a decline in whale shark numbers on Ningaloo Reef, thought to be associated with the destruction of corals caused by the coral-eating sea snail *Drupella cornus* (Taylor 1996). These sea snails mainly targeted the fast growing *Acropora* coral

species, which thrive in shallow water and make a major contribution to coral spawning. Reduced coral spawning is thought to have resulted in less food for krill and zooplankton that whale sharks feed on, and fewer whale sharks migrating to Ningaloo to feed (Taylor 1996).

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D2 North-west Marine Region Protected Species Group Report Card – Bony Fish

Current at May 2008. See <www.environment.gov.au/coasts/mbp/north-west> for updates.

General information

The only bony fish species listed under the EPBC Act that occur in the North-west Marine Region are the Syngnathids (seahorses, seadragons, pipefish and pipehorses), and the Solenostomids (ghost pipefish). Australia has a remarkably high diversity of syngnathid species. It is estimated that between 25 and 37 per cent of the world's syngnathid species occur in Australia, the highest number of syngnathid species recorded in any country (Martin-Smith & Vincent 2006).

Almost all syngnathids live in nearshore and inner shelf habitats. Based on current information on ecology and distribution, 16 species of syngnathid and one species of solenostomid are thought to occur in the North-west Marine Region. To date, most of these have been found in shallow waters of Commonwealth marine reserves such as Ashmore and Mermaid reefs, but at least two, the winged seahorse (*Hippocampus alatus*) and the western pipehorse (*Solegnathus* sp. 2) have also been recorded in deeper shelf waters of the Region (up to 200 m). No species of sea-dragon has been recorded in the North-west Marine Region.

There are approximately 31 additional species of syngnathids that occur in Western Australian State waters adjacent to the Region, although the taxonomy of several is uncertain. These species are listed in Table 2 of Appendix C.

Nationally protected species

All members of the family Syngnathidae and the family Solenostomidae are protected under the EPBC Act as listed marine species. No syngnathid or solenostomid species is listed as threatened or migratory.

The following syngnathids have been recorded in Commonwealth waters of the North-west Marine Region:

- western pipehorse (*Solegnathus* sp. 2)
- barbed/corrugated pipefish (*Bhanotia fasciolata*)

- Pacific short-bodied pipefish (*Choeroichthys brachysoma*)
- red-banded/brown-banded/Fijian banded pipefish (*Corythoichthys amplexus*)
- reticulate/yellow-banded/network pipefish (*Corythoichthys flavofasciatus*)
- messmate/Australian messmate/banded pipefish (*Corythoichthys intestinalis*)
- Schultz's/guilded/gilded pipefish (*Corythoichthys schultzi*)
- rough-ridge/Banner's pipefish (*Cosmocampus banneri*)
- banded/ringed pipefish (*Doryrhamphus dactyliophorus*)
- blue-stripe/bluestripe pipefish (*Doryrhamphus melanopleura*)
- Negros/flagtail pipefish (*Doryrhamphus negrosensis negrosensis*)
- ridge-nose/Duncker's/red-hair pipefish (*Halicampus dunckeri*)
- glittering pipefish (*Halicampus nitidus*)
- double-ended pipehorse/alligator pipefish (*Syngnathoides biaculeatus*)
- thorny seahorse (*Hippocampus histrix*)
- winged seahorse (*Hippocampus alatus*)

The single species of ghost pipefish that is known to occur in the North-west Marine Region is the blue-finned ghost pipefish or robust ghost pipefish (*Solenostomus cyanopterus*).

Of the 31 species of syngnathids found in coastal waters adjacent to the North-west Marine Region (see Table 2 of Appendix C), nine are thought to be endemic to these waters:

- Helen's pygmy pipehorse (*Acentronura larsonae*)
- Muiron Island pipefish/Muiron pipefish (*Choeroichthys latispinosus*)
- ladder pipefish (*Festucalex scalaris*)
- western spiny seahorse/narrow-bellied seahorse (*Hippocampus angustus*)
- flat-face/flatface seahorse (*Hippocampus planifrons*)
- false-eyed/false-eye seahorse (*Hippocampus biocellatus*)
- Montebello/Monte Bello seahorse (*Hippocampus montebelloensis*)
- Prophet's pipefish (*Lissocampus fatiloquus*)
- bony-headed/bonyhead pipefish (*Nannocampus subosseus*)

Within the Syngnathidae, the entire genus *Hippocampus* (the seahorses) is listed on Appendix II of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES). As a signatory to this convention, Australia is obliged to manage international trade to enable the persistence of wild populations. Licences are granted under CITES for trade in these species while the EPBC Act controls international trade in all wild capture and aquarium-raised Australian syngnathid and solenostomid species. More information on CITES can be found in Appendix A.

Ecology of protected species in the North-west Marine Region

There is little knowledge on the distribution, abundance and ecology of syngnathids and solenostomids in the North-west Marine Region. Syngnathids generally have diverse characteristics ranging from apparently rare and localised species, to widely distributed and very common species. Most syngnathids are usually found in shallow, coastal tropical and temperate waters living among seagrasses, mangroves, coral reefs, macroalgae-dominated reefs, and sand/rubble habitats (Dawson 1985; Vincent 1996; Lourie *et al*. 1999, 2004). Temperate water species predominately inhabit seagrasses and macroalgae, while tropical species are primarily found among coral reefs (Foster & Vincent 2004).

The ridge-nose pipefish is known to occur on shallow coral reefs, but also in sandy/rubble areas, and stands of tropical *Sargassum* macroalgae. Sheltered bays, lagoons, and estuaries with seagrass and macroalgae are thought to be important habitats for the double-ended pipehorse. Little is known of the habitat of the pipehorse species currently recorded within the waters of the North-west Marine Region (the western pipehorse), but it is likely that tropical, sub-tropical and warm temperate reef habitats (e.g. with hard and soft coral, sponges and sand) are important. It has been found in waters between 20–200 m, with most records from deeper than 50 m. Research in eastern Australia has shown that *Solegnathus* pipehorses may be more abundant in proximity to reefs in areas having some three-dimensional structure (sessile biota), such as sponges and gorgonian corals (Zeller *et al*. 2003). Similar

habitat preferences might be expected in north-west Australia.

Syngnathids tend to use only certain parts of apparently suitable habitat, for example, occupying the edges of seagrass beds or macroalgae-dominated reefs and leaving large areas unoccupied (Vincent 1996). Most species are strongly site-associated, presumably with localised reproduction, although solenostomids, such as the blue-finned ghost pipefish, may have a prolonged larval stage that may permit longer range dispersal (Kuiter 2000).

In shallower waters, pipefish and seahorses are a dominant group of fish and are important predators on benthic organisms such as mysids in the zooplankton and small amphipods on surfaces. A few species also eat shrimps, and vertebrates such as larval fish. It is thought that they eat enough to affect the structure of benthic invertebrate communities (Lourie *et al*. 1999). As such, removing these species could well disrupt ecosystems (Vincent 1996).

Syngnathid populations may be particularly susceptible to threats because their biology is characterised by:

- relatively low population densities;
- lengthy parental care combined with small brood size limiting reproductive rate;
- strict monogamy, which means that social structure is easily disrupted;
- sparse distribution, which means that lost partners are not quickly replaced;
- typically low rates of adult mortality, which means that fishing exerts a relatively substantial selective pressure;
- strong association with preferred habitat, which can make populations vulnerable to site-specific impacts; and
- low mobility and small home ranges, which restrict recolonisation of depleted areas (Vincent 1996).

Syngnathids can be used as an indicator of ecosystem health, as they are habitat-specific and can provide insights into how habitats differ or relate to each other. Most species are more localised than previously thought, and preserving habitats is one of the most important factors in protecting seahorses for the future (Kuiter 2001). Further *in situ* research is needed to confirm both general habitat-use and specific habitat critical for particular life history stages (e.g. nursery areas, spawning grounds, etc.).

Important areas for syngnathids in the North-west Marine Region

Important areas in the the North-west Marine Region are identified for species listed under the EPBC Act as threatened or migratory, since they are considered matters of national environmental significance. No species of syngnathid occurring in the North-west Marine Region has been listed under the Act as threatened or migratory. However, syngnathids have been recorded in the shallow waters of Commonwealth marine reserves including Mermaid and Ashmore reefs, and in Commonwealth waters around Scott Reef.

Known interactions, threats and mitigation measures

Seahorses (*Hippocampus* spp.) and pipehorses (*Solegnathus* spp.) are among the site-associated fish genera whose life histories might render them vulnerable to overfishing or other disruptions, such as habitat damage (Pogonoski *et al*. 2002; Martin-Smith & Vincent 2006).

In Australia, some syngnathid species are threatened by direct exploitation, incidental capture in non-selective fishing gear (by-catch), and degradation of their habitats (Lourie *et al* 2004; Martin-Smith & Vincent 2006). They are also traded internationally in dried form for traditional medicine and ornaments, and alive for aquarium display (Bruckner *et al*. 2005; Martin-Smith and Vincent 2006). Potential threats to syngnathids in the Region are discussed further below.

Habitat degradation and loss

Inshore habitat degradation is a potential threat to the survival of some populations of syngnathid species because of the decrease in available habitat (Pogonoski *et al*. 2002). Habitat loss and degradation are probably the greatest conservation concerns for most Australian coastal species of syngnathids. Degradation of estuaries and coastal lakes, declines in temperate seagrasses, loss of mangroves and salt marshes, unsustainable coastal development, effects of fishing, introduction of foreign organisms and population increases in native species all pose problems (Martin-Smith & Vincent 2006).

Endemic species with a limited geographic range, such as Helen's pygmy pipehorse, may be particularly susceptible to the impacts of habitat degradation. This is particularly true for those species that occur in the vicinity of urbanised and industrial areas, such as Port

Hedland, or in areas where nearshore waters are subject to pollutant run-off.

Climate change

The long-term effects of global warming on marine species are still speculative; however, possible habitat loss and degradation of shallow water habitats in the North-west Marine Region as a result of climate change may affect syngnathid populations. Seagrass and coral reef habitats are likely to be affected through increasing carbon dioxide levels, water temperature, ultraviolet radiation and storm activity. Changes in rainfall and coastal run off, coastal salinity, currents and winds, and sea level rise will also have an impact on these habitats (Hobday *et al*. 2006).

Over-harvesting

Over-harvesting of wild specimens for the marine aquarium trade and/or the traditional medicine trade is potentially the greatest threat to some species of syngnathids, including two species that are endemic to coastal waters of Western Australia: the flat-face seahorse and the western spiny seahorse (Pogonoski *et al*. 2002).

In Australia, syngnathids are harvested as a target species and caught as by-catch. Seahorses, pipehorses and pipefish are traded in Australia and internationally for traditional medicine and for aquaria (Bruckner *et al*. 2005; Martin-Smith & Vincent 2006). In Western Australia, the Marine Aquarium Fish Managed Fishery operates in State waters. The fishers in the Marine Aquarium Fish Managed Fishery are permitted to take species from the syngnathid family, up to an annual limit of 750 individuals (all species) set by the Department of Fisheries, Western Australia (DoF). However, this number has been slightly exceeded in some recent years (e.g. 833 specimens in 2002, DoF 2004b, 2005), and for some species, the actual catch may be higher than the reported catch (Baker 2006).

Syngnathids are caught by divers using hand-held nets. The fishery has retained at least 14 species of syngnathids, none of which occur in Commonwealth waters of the North-west Marine Region (DoF 2004b, 2005; Newman & Cliff 2006).

Trade in syngnathids is regulated in Australia through licences under CITES and permits under the EPBC Act for the export of wild-capture and aquarium-raised specimens. The Department of the Environment, Water, Heritage and the Arts is the CITES management authority in Australia and the Department relies on the Australian Customs Service to implement CITES at ports of exit and entry for the syngnathid trade.

Commercial fishing

In the Region, fishery interactions with syngnathids are most likely to occur with the Northern Prawn Fishery and the Western Trawl Fisheries (incorporating the Western Deepwater Trawl Fishery and the North-west Slope Trawl Fishery). However, the number of recorded interactions is low and incidental by-catch is not considered to be a significant issue for most syngnathid species in the North-west Marine Region.

The Australian Fisheries Management Authority and CSIRO have recently established a crew member observer program in the Northern Prawn Fishery that aims to emphasise the importance of collecting better data on syngnathids in the fishery. Since April 2001, operators have also been required to report the number of syngnathids caught, and their condition when released, and complete a separate detailed wildlife and protected species information sheet in the logbook. The Australian Fisheries Management Authority (2006) reiterated that syngnathid by-catch is being addressed in the by-catch monitoring program.

Pipehorse species inhabit trawling grounds and generally might be prone to any overfishing of these areas. Trawl by-catch in Western Australia is unquantified, but western pipehorses are caught as by-catch in the Pilbara Fish Trawl Interim Managed Fishery (DoF 2004a). This fishery operates primarily in Western Australian State waters, but may also operate in the Region. During a by-catch survey in 2002, 34 specimens were caught in 427 trawl shots, and most individuals were dead when landed (Stephenson & Chidlow 2003). Data from the survey indicated that approximately 450 pipehorses are caught by the fishery per year (DoF 2004a).

More information is required on trawl by-catch of pipehorses in the Region and adjacent State waters, in both State and Commonwealth-managed fisheries. Monitoring of by-catch of these species taken in trawl fisheries will help to obtain baseline data on their distribution and abundance in Western Australian waters.

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D3 North-west Marine Region Protected Species Group Report Card – Sea Snakes

Current at May 2008. See <www.environment.gov.au/coasts/mbp/north-west> for updates.

General information

This report card discusses those species of sea snake that are listed as marine species under the EPBC Act. While snakes of at least four families can be found in the marine environment, members of only two families, the Hydrophiidae (true sea snakes) and the Laticaudidae (sea kraits) are listed under the EPBC Act. Of these, only members of the Hydrophiidae occur regularly in the North-west Marine Region. A full list of sea snake species known to occur in the Region can be found in Appendix C.

True sea snakes inhabit the tropical waters of the Indian and Pacific oceans. They are characterised by their many adaptations to the marine environment including a paddle-like tail, dorsally positioned nostrils with valves, salt regulating glands and a single lung that extends nearly the full length of the body.

Twenty species of true sea snakes are resident in the North-west Marine Region. Eight are restricted to Australian waters and five of these are endemic to the Region. Several other species mainly occur on intertidal mudflats and mangrove habitats in coastal areas adjacent to the Region. These species are unlikely to interact significantly with the Commonwealth waters of the Region and will not be considered further here.

Information in this Report Card is largely drawn from *Marine Snakes: Species Profile for the North-west Planning Area* (Guinea 2007), which is available at <www.environment.gov.au/coasts/mbp/north-west>.

Nationally protected species

All sea snakes of the family Hydrophiidae are listed under Section 248 of the EPBC Act and are protected as listed marine species. No species of sea snake is listed as migratory or threatened under the EPBC Act, nor are any that occur in the Region listed under international conventions.

Ecology of protected species in the North-west Marine Region

The habitat and distribution of sea snakes in the North-west Marine Region is not well understood because of the remoteness and potentially dangerous marine conditions in parts of the Region. The Region supports populations of at least 20 species of sea snake, including common species such as the elegant seasnake (*Hydrophis elegans*) and the ornate seasnake (*Hydrophis ornatus*), as well as rare species such as the fine-spined seasnake (*Hydrophis czeblukovi*), and species that are endemic to the Region, such as the Shark Bay seasnake (*Aipysurus pooleorum*), the brown-lined seasnake (*Aipysurus tenuis*) and the dusky seasnake (*Aipysurus fuscus*). Sea snakes in the Region occupy three broad habitat types: shallow water coral reef and seagrass habitats, deep water soft bottom habitats away from reefs, and surface water pelagic habitat.

Sea snakes occupy a diverse range of habitats in and around coral reefs. Some species are specialist feeders, possessing distinctive adaptations for their particular foraging strategy. For example, the turtle-headed seasnake (*Emydocephalus annulatus*) feeds exclusively on the eggs of blennies, gobies and coral fish and has evolved large scales on each side of the lip for scraping fish eggs off corals and rocks. The horned seasnake (*Acalyptophis peronii*) is also a specialist, feeding on the gobies that share the burrows of shrimps on the bottom of channels in the reef. Other species such as the olive seasnake (*Aipysurus laevis*) and the dusky seasnake are generalists, feeding on a variety of fish species that inhabit small crevices in the coral, or small gobies, eels and fish eggs gleaned from the reef flats. The olive seasnake also feeds on dead fish and has been known to take fish from baited hooks and feed on trawl discards. Species abundance and diversity can vary from reef to reef despite apparent similarities in habitat. For example, Berry (1986) notes the absence of sea snakes from the Rowley Shoals despite their abundance at Scott Reef and Ashmore Reef.

Many sea snake species live between the reefs and the mainland, over a wide range of water depths and types of seafloor. Some, such as the spine-tailed seasnake (*Aipysurus eydouxii*) and the beaked seasnake (*Enhydrina schistosa*), may enter rivers and bays, while others, such as the fine-spined seasnake, are known only from deep water. The elegant seasnake and the olive-headed seasnake (*Disteira major*) frequent the seagrass beds and sandflats in Shark Bay, but range over a variety of other

habitats, while the Shark Bay seasnake is restricted to this habitat type. Other species, such as the ornate seasnake and the spine-bellied seasnake (*Lapemis curtus*) occur in a wide range of habitats from coral reefs to turbid estuaries. Many sea snake species tend to be found in the shallower parts of the Region and species diversity appears to decrease in deeper waters. This may be because most sea snakes are benthic feeders, with foraging time decreasing as water depth increases.

The yellow-bellied seasnake (*Pelamis platurus*) is the only truly pelagic species of sea snake in the Region, as it inhabits the open ocean and rarely enters shallow water, unless washed ashore by storms. This species inhabits the slicks and drift lines of ocean convergences and is often associated with eddies down current of islands in the South Pacific Ocean. The yellow-bellied seasnake feeds by drifting motionless on the surface and catching small fish that mistake the snake for driftwood and seek shelter beneath it. The yellow-bellied seasnake is one of only two sea snake species that can capture fish in open waters. This species has an unusual ability to tie itself in knots and intricate coils, which is thought to help moulting and the removal of algae and barnacles (Pickwell 1971).

While many species are sedentary or occupy small home ranges, others may show some seasonal movements. Seasonal changes in sea snake diversity and abundance are more noticeable in the southern parts of the Region than they are in the more northern areas. Several species such as the ornate seasnake, the olive-headed seasnake and some populations of Stokes' seasnake (*Astrotia stokesii*) range further south during summer. The ornate seasnake is one of only three sea snakes that range as far south as Tasmania. In contrast, the spine-bellied seasnake moves closer to the coast during spring and occurs further offshore in autumn. Similarly, the spine-tailed seasnake moves further into estuaries during the dry season, sometimes occurring as far as 30 km upriver. Other species are more sedentary, such as the olive seasnake, which occupies small home ranges on coral reefs with females remaining resident throughout the year. Turtle-headed seasnakes also appear to occupy small home ranges throughout the year. Mark-recapture studies indicate that this species may live in groups, with the same individuals maintaining an association over several years (Shine *et al*. 2005), indicating that social organisation in sea snakes may be more complex than previously thought.

Generally, sea snakes are long-lived and slow-growing with small broods and high juvenile mortality. Little is known of the age at which sea snakes reach sexual maturity. All phases of the reproductive cycle of sea snakes takes place in the sea and reproductive seasonality varies among species with some, such as the horned seasnake, the spectacled seasnake (*Disteira kingii*) and the elegant seasnake giving birth between March and June, while others such as the dusky seasnake and the olive seasnake give birth between December and February. All members of the Hydrophiidae family bear live young, rather than lay eggs, with a gestation period of between six to seven months, indicating that females are unlikely to breed every year.

Important areas for sea snakes in the North-west Marine Region

Protected species group report cards in the North-west Bioregional Profile identify important areas for species listed under the EPBC Act as threatened or migratory, since they are considered matters of national environmental significance. No species of sea snake occurring in the Region has been listed under the Act as threatened or migratory. However the Region is considered of international significance for the diversity and abundance of its sea snake fauna, particularly the reefs of the Sahul Shelf (EA 2002a).

In the early 1990s, there was estimated to be 40 000 sea snakes from at least 13 species at Ashmore Reef National Nature Reserve, which represented the greatest number of sea snake species recorded for any locality in the world (EA 2002a). In addition, other reefs on the Sahul Shelf, particularly Hibernia, Scott and Seringapatam reefs, support important sea snake populations, with species such as the leaf-scaled seasnake (*Aipysurus foliosquama*) and the dusky seasnake occurring nowhere else. However, recent surveys at Ashmore Reef have recorded a severe reduction in the number of sea snakes recorded from the reserve. In 2007, a 10 day survey recorded only seven snakes. It appears that only generalist feeders remain in small numbers, with some species, including the short-nosed seasnake (*Aipysurus apraefrontalis*) and the leaf-scaled seasnake not being recorded at Ashmore for several years. Reasons for these declines remain speculative. There has been no similar decline in sea snake numbers at Scott Reef, Hibernia Reef or Cartier Island.

Known interactions, threats and mitigation measures

As listed marine species, sea snakes are protected in Australian waters. However, sea snakes may interact with human activities in the Region either directly, through interactions with commercial fisheries, or indirectly, through habitat degradation and climate change.

Commercial fishing

Incidental catch and death in commercial prawn trawling fisheries appears to be the biggest threat to sea snakes in the North-west Marine Region (Guinea 2007). High catch rates are exacerbated by the high death rate of snakes caught in trawl nets. Even when retained aboard to recuperate, sea snakes seldom survive (Guinea 2007). Sea snakes may be more vulnerable to overfishing than other species because of their longevity and low reproductive rates. In addition, females appear to be caught more often than males (Fry *et al*. 2001).

The Northern Prawn Fishery extends into the easternmost part of the Region to Cape Londonderry and has historically had high levels of interaction with sea snakes, particularly the large-headed seasnake (*Hydrophis pacificus*), which does not occur in the Region, and the spectacled seasnake, which is resident in the Region throughout the year. Elegant, ornate, spine-bellied and olive-headed seasnakes are also commonly caught in the Northern Prawn Fishery. Estimates from the Gulf of Carpentaria, outside the Region, indicate that in 1991 between 30 000 and 67 000 sea snakes were killed as a result of commercial trawling (Wachenfeld *et al*. 1998). However, due to the small area and shorter season of the Northern Prawn Fishery in the North-west Marine Region, the number of sea snakes caught in the Region is likely to be much lower.

In reaction to the large amounts of sea snake by-catch, by-catch reduction devices have been compulsory in the Northern Prawn Fishery since 2000 (DEH 2003). These appear to be effective at reducing sea snake by-catch (Brewer *et al*. 1998). Other prawn fisheries in the Region, such as the Pilbara Trawl Fishery, the Exmouth Gulf Prawn Fishery and the Shark Bay Prawn Fishery, also occasionally catch small numbers of sea snakes; however, their impact on sea snake populations is considered negligible (EA 2002b, c; DoF 2006).

Habitat degradation

Indirectly, human activities can interact with sea snakes through the degradation of sea snake habitat. Sea snakes may be affected by oil spills and other contamination, dredging activities and increased boat traffic causing boat strikes and disruption of feeding behaviour. In addition, while the long-term effect of climate change on sea snakes is unclear, an increase in the frequency of bleaching events, reduced rates of calcification, increased sediment loads, higher sea levels and changes in the intensity and frequency of storm activity are also likely to have a negative effect on coral reef habitats, which are used by some sea snake species (Hobday *et al*. 2006).

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D4 North-west Marine Region Protected Species Group Report Card – Marine Turtles

Current at May 2008. See <www.environment.gov.au/coasts/mbp/north-west> for updates.

General information

Marine turtles have lived in the oceans for over 100 million years and have a global distribution in tropical and temperate waters. There are seven species of marine turtles representing two families: the Cheloniidae, or hard-shelled turtles, and the Dermochelyidae, or leatherback turtles, of which there is only one species. In recognition of the global decline in marine turtle populations, six of the seven species are listed on the *IUCN Red List* as endangered or critically endangered; the remaining species, the flatback turtle (*Natator depressus*) is listed as data deficient (IUCN 2006). Six marine turtle species are found in Australia, which all have a global distribution, except for the flatback turtle, which is endemic to the Australian–New Guinea continental shelf.

Green turtle hatchling. Photo: Robert Thorn,Great Barrier Reef Marine Park Authority.

Table D4.1 Marine turtles listed as threatened or migratory under the EPBC Act that are known to occur in the North-west Marine Region

Species	Conservation Status	Conservation Plans and Policies
Loggerhead turtle (*Caretta caretta*)	Endangered, Migratory, Marine Listed under CITES (Appendix I) & CMS (Appendix I & II)	• *Action Plan for Australian Reptiles* (Cogger *et al.* 1993) • *Memorandum of Understanding on the Conservation and Management of Marine Turtles and Their Habitats of the Indian Ocean and South-East Asia* (CMS 2001) • *Recovery Plan for Marine Turtles in Australia* (EA 2003) • *Sustainable Harvest of Marine Turtles and Dugongs in Australia – A National Partnership Approach* (Australian Government 2005)
Green turtle (*Chelonia mydas*)	Vulnerable, Migratory, Marine Listed under CITES (Appendix I) & CMS (Appendix I & II)	
Hawksbill turtle (*Eretmochelys imbricata*)	Vulnerable, Migratory, Marine Listed under CITES (Appendix I) & CMS (Appendix I & II)	
Olive ridley turtle, Pacific ridley turtle (*Lepidochelys olivacea*)	Endangered, Migratory, Marine Listed under CITES (Appendix I) & CMS (Appendix I & II)	
Flatback turtle (*Natator depressus*)	Vulnerable, Migratory, Marine Listed under CITES (Appendix I) & CMS (Appendix II)	
Leatherback turtle, Leathery turtle (*Dermochelys coriacea*)	Vulnerable, Migratory, Marine Listed under CITES (Appendix I) & CMS (Appendix I & II)	

Nationally protected species

All six species of marine turtles found in Australia occur regularly in the North-west Marine Region and all are listed under the EPBC Act as threatened and/or migratory (Table D4.1). Under the EPBC Act, actions in all Australian waters that have, will have or are likely to have a significant impact on marine turtles are subject to a rigorous referral, assessment, and approval process.

As a signatory to the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS), Australia has an international obligation to protect migratory species, their habitats and their migration routes. Similarly, as a party to the *Convention on the International Trade in Endangered Species of Wild Fauna and Flora* (CITES), Australia has agreed to control the import and export of an agreed list of species that are endangered, or at risk of becoming endangered, because of inadequate controls over trade in them or their products. Further information on CITES and CMS is included in Appendix A.

Ecology of protected species in the North-west Marine Region

The life cycle of all marine turtles is broadly similar. Adults migrate from remote feeding grounds to aggregate at mating areas. After mating, males return to their foraging grounds, while females move to their natal (place of birth) beaches to nest. Unlike females, male marine turtles rarely come ashore. Females bury their eggs in nests above the tidal range on sandy beaches in tropical or subtropical regions. They generally lay between three and five clutches over a two to three month period, with an approximate two week internesting period between each clutch (Limpus 2004). Nests must have a temperature range of 25–33°C, with the hatchling's sex being determined by the temperature of the nest. After completing nesting, the females also return to their feeding grounds until their next reproductive migration, which can be up to five years later.

After leaving the nest, hatchlings leave their natal beaches and generally migrate to open ocean nursery habitat where they may spend 5–20 years. However, the flatback turtle differs in this respect, remaining within Australian coastal waters. This at-sea period for the smaller immature cheloniid turtles has been referred to in the past as the 'lost years' because little was known of their behaviour or ecology at this time, but recent research has been filling the gaps. There is some speculation that hatchling and juvenile turtles may drift over the ocean in association with rafts of *Sargassum*, a type of planktonic macroalgae, which accumulate along ocean convergences and current boundaries. It is thought that *Sargassum* rafts provide

the small turtles with food, shade and protection from predators, although this is yet to be confirmed (Collard 1990; Hasbún 2002).

Immature cheloniid turtles eventually migrate to shallow, nearshore feeding grounds where they continue growing until they reach sexual maturity at anywhere between about 15–20 and 30–50 years, depending on their location. Reproductively mature individuals then travel periodically to the general vicinity of the nesting beaches on which they were born to begin the reproductive cycle again. It is thought that hatchling turtles are imprinted to the earth's magnetic field as they emerge from the nest and that individuals also imprint on the feeding areas where they end the pelagic phase of their life cycle (Limpus et al. 1992). Therefore, feeding areas are much more widely dispersed than rookeries and may contain individuals from several nesting areas (Limpus *et al*. 1992).

The North-west Marine Region supports important nesting areas for green, hawksbill, loggerhead and flatback turtles, while leatherback turtles may occasionally nest in the Region. Olive ridley turtles are known to forage in the northern parts of the Region, but there are no records of nesting for this species in Western Australia. The Western Australian populations of the hard-shelled turtles are the only remaining populations in the south-east Indian Ocean.

Further details on the six species found in the North-west Marine Region are below:

Green turtle (*Chelonia mydas*)

Green turtles are the most common marine turtle in the North-west Marine Region and breed extensively in the Region (Limpus & Chatto 2004). Western Australia supports one of the largest green turtle populations remaining in the world, estimated to be in the tens of thousands of adult turtles. The principal near-coastal rookeries include the Lacepede Islands, some islands of the Dampier Archipelago, Barrow Island and the Montebello Islands, North West Cape and the Muiron Islands. Smaller rookeries offshore of the Kimberley region include the Maret Islands, Browse Island, Cassini Island and other islands of the Bonaparte Archipelago, and Sandy Islet on Scott Reef.

There are three distinct genetic stocks of green turtles in the Region: the North West Shelf stock, the Scott Reef stock and the Ashmore stock (Dethmers *et al*. 2006). Adults display a high level of philopatry (a tendency to return to a specific area for different parts of their lifecycle) both to their natal nesting areas and to their feeding areas throughout their lives, irrespective of the distance between them. Tagging studies by Limpus *et al*. (1992) showed that distances between nesting and feeding areas can range between 2– 2600 km.

North-west Australian breeding green turtles have ranged as far afield as the Cape York coast on the Gulf of Carpentaria, to parts of the Indonesian archipelago, and to south-western Western Australia. On Barrow Island, the green turtle nesting season begins in November, peaks in January/February and ends in April (Pendoley Environmental 2005). The re-nesting period for these female green turtles is approximately every five years. Green turtles forage for seagrass and algae within estuarine, rocky and coral reef and seagrass habitats. They occasionally feed on macroplankton including jellyfish, dead fish and small crustaceans (Limpus & Chatto 2004; Limpus 2004).

Hawksbill turtle (*Eretmochelys imbricata*)

The North-west Marine Region supports one of the largest nesting populations of hawksbill turtles in the world. This population is genetically distinct from the populations breeding in north-east Arnhem Land and the Torres Strait (Limpus 2004). The most significant breeding areas include Rosemary Island within the Dampier Archipelago, Varanus Island in the Lowendal group, and some islands in the Montebello Island group, with hundreds of females nesting every year. The nesting range extends south from North West Cape to around Coral Bay on the Ningaloo coast. The apparent scarcity of nesting in the Kimberley is in part because of the lack of suitable nesting beaches among the numerous islands. Nesting females dispersing from Pilbara beaches may disperse to the Kimberley waters, but this is yet to be confirmed (Pendoley Environmental 2005). Hawksbill turtles nest in the Region all year round with a peak between October and January. Individuals may migrate up to 2400 km between their nesting and foraging grounds. On Rosemary Island, the inter-seasonal re-nesting period for hawksbill turtles is generally every three years, but may be more than 10 years. Hawksbill turtles are generally associated with rocky and coral reef habitats, foraging on sponges and soft coral (Pendoley Environmental 2005).

Flatback turtle (*Natator depressus*)

After green turtles, flatback turtles are the second most common species in northern Australia. Flatback turtles

differ from other marine turtles in that they do not have a pelagic phase to their life cycle. Instead, hatchlings grow to maturity in shallow coastal waters thought to be close to their natal beaches. This may explain why flatback turtles are one of only two species of marine turtles not to have a global distribution (Walker & Parmenter 1990), although there is evidence that some flatback turtles undertake long-distance migrations between breeding and feeding grounds (Limpus *et al*. 1983). This species is endemic to the northern Australian-southern New Guinea continental shelf, extending south in the Region as far as the Muiron Islands (Pendoley Environmental 2005).

There are two breeding units of flatback turtles in the North-west Marine Region. Most of the flatback turtles in the Region are part of the North West Shelf breeding unit, while the population that breeds in Cape Domett in the Bonaparte Gulf is probably part of the western Northern Territory breeding unit (Limpus 2004). The North West Shelf stock nests from approximately Exmouth Gulf to the Lacepede Islands with significant rookeries on Thevenard Island, Barrow Island, the Montebello Islands, Varanus Island, the Lowendal Islands, islands of the Dampier Archipelago, coastal areas around Port Hedland, along much of the Eighty Mile Beach and inshore islands of the Kimberley region where suitable beaches occur. Nesting is also widespread along mainland beaches. On Barrow Island, flatback turtles nest annually or biennially. Nesting commences in late November/December, peaks in January and finishes by February/March. It is estimated that hundreds to thousands of individuals nest on the North West Shelf annually (Pendoley Environmental 2005). Flatback turtles that nest on the Pilbara coast disperse to feeding areas extending from Exmouth Gulf to the Tiwi Islands in the Northern Territory. Flatback turtles eat jellyfish and soft-bodied benthic invertebrates such as sea pens, sea cucumbers, crustaceans, molluscs and soft corals in habitats with unconsolidated substrates.

Loggerhead turtle (*Caretta caretta*)

In the North-west Marine Region, loggerhead turtles breed principally from Dirk Hartog Island in the south, along the Ningaloo coast to North West Cape and the Muiron Islands region in the north, although there have been occasional nesting records from Barrow, Varanus, and Rosemary islands in the Pilbara, and occasional records as far north as Ashmore Reef. The annual nesting population in the Region is thought to be several thousand females (Limpus 2004). From current knowledge, all nesting adult loggerhead turtles dispersing from Dirk Hartog Island beaches (near Shark Bay) have remained within Western Australian waters extending from southern Western Australia to the Kimberley. Turtles dispersing from the North West Cape – Muiron Islands nesting area have ranged north as far afield as the Java Sea and the north-western Gulf of Carpentaria, and to south-western Western Australia. Loggerhead turtles forage across a wide range of habitats including rocky and coral reefs, seagrass pastures, and estuaries (Limpus & Chatto 2004). In Shark Bay, loggerhead turtles feed on bivalve and gastropod molluscs and crabs (Limpus 2004).

Leatherback turtle (*Dermochelys coriacea*)

The leatherback turtle is an oceanic, pelagic species that feeds primarily on jellyfish, sea squirts and other soft-bodied invertebrates (Limpus 2004). Leatherback turtles have the greatest distribution worldwide but are uncommon throughout their range and rarely breed in Australia. There have been at least two unconfirmed reports of nesting attempts in Western Australia; however it is presumed that leatherbacks foraging in Australian waters may have migrated from the larger nesting populations in Indonesia, Papua New Guinea and the Solomon Islands, or from populations in the Americas or India (Limpus 2004).

Olive ridley turtle (*Lepidochelys olivacea*)

Olive ridley turtles are the most abundant marine turtle species globally but the least common in the North-west Marine Region. They breed at low densities on Northern Territory beaches outside the Region but no breeding records exist within the North-west Marine Region (Limpus 2004). However, olive ridley turtles forage as far south as the Dampier Archipelago–Montebello Islands area. This species is primarily carnivorous, feeding on gastropod molluscs and small crabs from soft bottom habitats ranging in depth from 6–35 m. Olive ridley turtles may also forage in pelagic waters.

Important areas for marine turtles in the North-west Marine Region

All marine turtles that occur in the Region are listed under the EPBC Act as threatened and/or migratory and as such, are considered matters of national environmental significance. (see Section 3.1 for more information). Important areas for marine turtles in the North-west Marine Region and State waters adjacent to the Region are identified below. Some of these areas

are already afforded protection through their status as Commonwealth or State marine parks or reserves.

Ashmore Reef – Ashmore Reef is a significant breeding area for green turtles and low levels of nesting activity by loggerhead turtles have also been recorded here (Limpus 2004). Ashmore possesses critical nesting and internesting habitat for green turtles (EA 2003) and supports one of three genetically distinct breeding populations of green turtles in the Region (Dethmers *et al*. 2006). Hundreds of green turtles nest at Ashmore each year, mostly on West Island (Limpus 2004). Ashmore Reef also supports large and significant feeding populations of green, hawksbill and loggerhead turtles. It is estimated that approximately 11 000 marine turtles feed in the area throughout the year (EA 2002).

Bonaparte Archipelago – The Maret Islands and other islands of the Bonaparte Archipelago including the Montalivet islands, Albert Island and Lamarck Islands support significant green and flatback turtle rookeries.

Browse Island – Browse Island is a major rookery for green turtles (Limpus 2004).

Cape Domett – Cape Domett is a major rookery for flatback turtles (Limpus 2004).

Dampier Archipelago – Rosemary Island in the Dampier Archipelago has important nesting and internesting habitat for hawksbill turtles (EA 2003). The island supports the most significant hawksbill turtle rookery in Western Australia and one of the largest in the Indian Ocean. Over 100 animals nest on the island at the peak of the season, more than at any other Western Australian rookery (Pendoley Environmental 2005). The Dampier Archipelago also supports major green turtle and flatback turtle nesting sites (Limpus 2004; Pendoley Environmental 2005).

Eighty Mile Beach – Eighty Mile Beach is a major rookery for flatback turtles (B. Prince, pers. comm. 2007).

Joseph Bonaparte Gulf – Carbonate banks in the Joseph Bonaparte Gulf are foraging areas for flatback and loggerhead turtles, while green, olive ridley, flatback and loggerhead turtles forage around pinnacles in the Bonaparte Depression (DEWHA 2008; Donovan *et al*. 2008).

Lacepede Islands – The Lacepede Islands have critical nesting and internesting habitat for green turtles (EA 2003). They support the largest green turtle rookeries in Western Australia with nightly nesting effort numbering in the thousands (Pendoley Environmental 2005).

Mangrove Islands – Aggregations of male green turtles occur on the Mangrove Islands, north east of Onslow, before the nesting season, however, the purpose of these aggregations is unknown (Pendoley Environmental 2005).

Montebello and Barrow islands – Five of the six species of marine turtles found in Western Australia have been recorded in this area. Green, hawksbill and flatback turtles regularly nest in the area, and loggerhead turtles have occasionally been recorded nesting on Barrow Island (DEC 2007). Barrow Island has critical nesting and internesting habitats for green turtles (EA 2003) and also supports an important flatback rookery (Pendoley Environmental 2005). The Montebello Islands have critical nesting and internesting habitat for flatback and hawksbill turtles (EA 2003) with low levels of nesting activity by both these species recorded on Barrow Island and the Lowendal Islands (Pendoley Environmental 2005). Varanus Island also has critical nesting and internesting habitat for hawksbill turtles (EA 2003) and supports an important flatback turtle rookery (Limpus 2004). The West Australian hawksbill turtle population is the only large population of this species remaining in the Indian Ocean (DEC 2007).

Summer mating aggregations of green turtles occur to the west of Barrow Island and within the Montebello Island group south of North-west Island and east of Trimouille Island (Pendoley Environmental 2005). A large summer aggregation of unknown purpose also occurs west of Hermite Island (Pendoley Environmental 2005).

The waters surrounding Barrow Island support year-round foraging populations of marine turtles. Possible green turtle feeding grounds occur over the Barrow Shoals off the south-east coast of Barrow Island and on the algae-covered rocky intertidal and subtidal platforms off the west coast (Pendoley Environmental 2005), with some individuals thought to be resident in the area throughout the year (DEC 2007). Hawksbill turtle feeding grounds occur in the Mary Anne and Great Sandy island groups to the south of the Barrow Shoals, while there is some evidence that juvenile flatback turtles use the Barrow Island region as developmental habitat (Pendoley Environmental 2005).

Montgomery Reef – Montgomery Reef is a feeding area for green turtles and possibly other species (Prince 1993).

Ningaloo Reef, North West Cape and Exmouth Gulf – The Muiron Islands off North West Cape have critical nesting and internesting habitat for loggerhead turtles (EA 2003) and support a major green turtle rookery (Limpus 2004). North West Cape itself is also a major green turtle nesting area, while Ningaloo Reef supports an important nesting area for loggerhead turtles (Limpus 2004). Aerial surveys in 1989 and 1994 estimated a population of between 2000 and 5000 turtles at Ningaloo Reef and between 3000 and 5000 in Exmouth Gulf (Preen *et al*. 1997).

Port Hedland – Important flatback turtle rookeries occur at Port Hedland and Cape Thouin. Critical nesting and internesting habitat for flatback turtles has also been identified at Mundabullangana Beach (EA 2003).

Quondong Point – Quondong Point is a feeding area for flatback, green, hawksbill and loggerhead turtles (DEWHA 2008; Donovan et al. 2008).

Scott Reef – Scott Reef supports a small but genetically distinct breeding population of green turtles (Limpus 2004; Dethmers *et al*. 2006).

Serrurier Island – Serrurier Island is a major nesting area for green turtles and may also be a feeding ground for this species (Pendoley Environmental 2005). Loggerhead nesting has also been recorded.

Shark Bay/Dirk Hartog Island – Shark Bay contains the largest breeding population of loggerhead turtles in Australia and the third largest in the world. Up to 1500 females may nest annually in this area (Baldwin *et al*. 2003). Dirk Hartog Island has critical nesting and internesting habitats for loggerhead turtles (EA 2003), and may accommodate up to 75 per cent of the Western Australian breeding population (Prince 1994). Shark Bay has critical feeding habitat for both loggerhead and green turtles (EA 2003). The area is probably the southern-most major foraging area for Western Australian green turtles (Limpus 2004). Aerial surveys conducted in winter in 1989 and 1994 estimated a population of between 7000 and 9000 turtles using the Shark Bay area (Preen *et al*. 1997).

Thevenard Island – Thevenard Island supports a significant flatback rookery (Limpus 2004), as well as a smaller green turtle presence. Surrounding waters also include a feeding area for green turtles (Pendoley Environmental 2005).

Known interactions, threats and mitigation measures

Marine turtles are long-lived, slow to mature and have low hatchling to maturity survival rates, making them particularly vulnerable to anthropogenic impacts. Potential interactions and threats to marine turtles in the North-west Marine Region are listed below. The *Recovery Plan for Marine Turtles in Australia* (EA 2003) aims to reduce the detrimental impacts on Australian populations of marine turtles and promote their recovery in the wild. However, as migratory species, impacts at a local level have the capacity to affect populations across the entire species' range. Some of the turtles that breed in the North-west Marine Region have feeding areas in Indonesian waters, including western Papua. Therefore, conservation efforts, even for local populations, need international coordination. In recognition of this, 27 countries, including Australia, are signatories to the *Memorandum of Understanding on the Conservation and Management of Marine Turtles and Their Habitats of the Indian Ocean and South-East Asia* (CMS 2001), an intergovernmental agreement that provides a framework for countries to work together to conserve and protect marine turtles and their habitat.

Past commercial exploitation

Commercial harvesting of green turtles occurred in the Region between the 1930s and 1973. Turtles caught from around the Montebello Islands, the Dampier Archipelago and around North West Cape were processed in turtle soup factories in Cossack and Perth. It is estimated that approximately 3000–4000 green turtles were harvested annually through the 1960s and in greater numbers leading up to cessation of the fishery in 1973. Eggs and flipper skins were also harvested for sale or export and it is thought that loggerheads as well as green turtles may have been targeted (Limpus 2004). As of 30 June 1973, there was no renewal of turtle harvesting licences in Western Australia, marking the end of commercial turtle harvest in the Region.

Commercial fishing

The incidental catch (by-catch) of marine turtles during coastal otter trawling in Australian waters north of 28°S was listed as a key threatening process under the EPBC Act in 2001. The Northern Prawn Fishery, which extends into the north-eastern part of the North-west Marine Region to Cape Londonderry, has historically had a very high level of interaction with marine turtles. In 1989 and 1990, it was estimated that over 5000

turtles were caught in the fishery, with between 550 and 950 individuals killed (DEH 2003). The use of Turtle Exclusion Devices was made compulsory in the fishery in 2000. Since then, the number of marine turtles caught has been reduced to less than five per cent of previous numbers, with approximately 120 individuals caught each year. Deaths have also been reduced from 40 per cent to 22 per cent of turtles caught (DEH 2003). Flatback turtles are the most commonly caught species in the Northern Prawn Fishery and significant numbers of olive ridley turtles are also taken, followed by smaller numbers of loggerhead, green and hawksbill turtles.

Other fisheries operating in or adjacent to the Region that are known or suspected to have an impact on marine turtles include the Western Tuna and Billfish Fishery, the Pilbara Fish Trawl Interim Managed Fishery, and Western Australian prawn and scallop fisheries (EA 2003). The Western Tuna and Billfish Fishery has reported interactions mainly with leatherback and loggerhead turtles (DEH 2004a). Interactions are reported to be at low levels in these fisheries, and the use of Turtle Exclusion Devices and other by-catch reduction devices has been compulsory since 2003. The recently established crab fisheries within the Region may also be affecting loggerhead turtles by removing prey species within Shark Bay and around the Dampier Archipelago, but this requires further investigation (DEH 2004b).

Outside the Region, turtles continue to be harvested in Indonesia, Malaysia, Papua New Guinea, Fiji, Vanuatu, New Caledonia and the Solomon Islands. The migratory nature of marine turtles means that Indonesian harvests are likely to include individuals from the Region. In addition, for a number of years there has been an illegal harvest of green turtles and/or their eggs from the more remote rookeries in the Timor Sea off north-western Western Australia and the Northern Territory by indigenous Indonesian fishers (Limpus 2004). Moreover, some eggs are taken directly from gravid (pregnant) nesting females, resulting in the death of the animals (Limpus 2004).

Traditional harvest

Turtles are of enormous cultural, spiritual and economic importance to Indigenous people. Under Section 211 of the *Native Title Act 1993*, Indigenous people with a native title right can legitimately hunt marine turtles in Australia for communal personal, domestic or non-commercial purposes. All Australian marine turtle populations are affected by Indigenous harvest of eggs. In addition, green turtle populations from the North West Shelf are also affected by harvest for meat.

In 2005, the *Sustainable Harvest of Marine Turtles and Dugongs in Australia – A National Partnership Approach* (Australian Government 2005) was endorsed by the Marine and Coastal Committee, a body of the Natural Resource Management Ministerial Council. This approach is a partnership among the Australian, Western Australian, Northern Territory and Queensland governments and relevant Aboriginal and Torres Strait Islander communities established to support management of the hunting of marine turtles and dugongs in order to contribute to the conservation of these species while maintaining traditional cultural practices. Further information is available at <www.environment.gov.au/coasts/publications/turtle-harvest-national-approach.html>.

Marine debris

The injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris is listed as a key threatening process under the EPBC Act. Entanglement in marine debris such as discarded fishing gear can lead to restricted mobility, starvation, infection, amputation, drowning and smothering. The ingestion of plastic marine debris can cause physical blockages leading to starvation, or injuries to the digestive system leading to infection or death.

Marine turtles are particularly at risk from discarded trawl and gill-nets, and plastic bags, which can be mistaken for jellyfish and ingested (Carr 1987a, b; White 2005). Outside the Region, a survey of marine debris in the Gulf of Carpentaria found that 25 per cent of white plastic bottles and 15 per cent of rubber thongs contained bite marks from fish and marine turtles (White 2005). The Australian Government is currently developing a threat abatement plan that aims to minimise the impacts of marine debris on threatened marine species. Further information is available at <www.environment.gov.au/biodiversity/threatened/publications/marine-debris.html>.

Boat strikes

Marine turtles are vulnerable to boat strikes when at the surface to breathe and rest between dives. This is particularly an issue in waters adjacent to large urban populations where there are large numbers of boats and other pleasure craft.

Light pollution

In the absence of artificial light, the horizon over the ocean is brighter than over land, owing to the reflection of stars and moonlight. Marine turtles tend to hatch at night and find their way to the ocean by cueing in to this difference in brightness. In areas of coastal development, hatchlings as well as nesting females may become disoriented by artificial light and head inland where they are vulnerable to dehydration, exhaustion, predation and collisions with traffic (Nicholas 2001). In the Region, gas flares and facility lights on petroleum production and processing plants are a significant source of artificial light near nesting beaches (EA 2003). However, some developments are working to shield light sources, establish light-free zones around nesting beaches or use types of lights that are less attractive to turtles (e.g. Chevron Australia 2005).

Destruction of nest sites

Vehicles driving along beaches can damage marine turtle nests and nesting habitat by compacting sand, crushing nests and creating wheel ruts that impede or trap hatchlings. Unmanaged mainland nesting sites along the Pilbara coast have been identified as particularly affected by vehicle damage in the *Recovery Plan for Marine Turtles in Australia* (EA 2003).

Nest predation

Both introduced and native fauna are known to prey upon marine turtle eggs. Feral pigs, foxes, feral dogs, dingoes, bandicoots and goannas predate on marine turtle eggs in parts of mainland Australia, and goannas are thought to be a problem on some islands; however the magnitude of the problem is not known. Saltwater crocodiles may also prey on adult flatback turtles on nesting beaches where the species' distributions overlap. In the Region, the *Recovery Plan for Marine Turtles in Australia* (EA 2003) identifies the North West Shelf populations of marine turtles as being particularly affected by predation, especially by foxes. Predation by foxes is a key threatening process for green and loggerhead turtles nesting on mainland Western Australia. Predation levels appear to have been reduced since the introduction of a fox baiting program in 1980 (Limpus 2004). The *Threat Abatement Plan for Predation by the European Red Fox* was developed in 1999, and further information is available at <www.environment.gov.au/biodiversity/threatened/publications/tap/foxes>.

Climate change

The long-term consequences of climate change on marine species is still speculative, however, a warmer environment is likely to be a major threat to marine turtles globally. Sex determination is dependent on the temperature of the nest and a small increase in temperature may bias the sex ratio of hatchlings towards females, reducing or even eliminating the production of males in some areas. Marine turtles have been subject to changes in sea temperature and sea levels for thousands of years (e.g. Dethmers *et al*. 2006). However, rising sea levels in the short-term could lead to a loss of nesting habitat and inshore foraging habitats such as seagrass beds, while changes to prey availability may result in a decrease in reproductive success and affect distribution, abundance, migration patterns and community structure (Hobday *et al*. 2006).

Diseases

The fibropapilloma virus causes a disabling, life-threatening tumour disease that primarily affects sub-adult green turtles but has also been found in loggerhead turtles and olive ridley turtles. It reached plague proportions in Hawaii and Florida in the 1990s, affecting up to 92 per cent of some populations (Aguirre & Lutz 2004). It now has a world-wide, circum-tropical distribution. The disease was first identified in the North-west Marine Region in 1995 (Raidal & Prince 1996), but from observations of green turtles in Shark Bay, the prevalence of this virus appears to be low (2.6 per cent; Heithaus *et al*. 2005). Observations indicate that the disease is most prevalent in areas close to intense human activity and may be associated with heavily polluted coastal areas (Aguirre & Lutz 2004).

Habitat degradation and loss

Marine turtle habitat may be lost or degraded in many ways. In the North-west Marine Region, pollution from oil and gas production and shipping is a potential problem for marine turtles, which may ingest floating tar or be fouled by oil. Noise pollution such as that from seismic testing associated with oil and gas exploration activities may also affect marine turtles (McCauley *et al*. 2000). Increased urban and industrial development may introduce pollution and contaminants that are harmful to marine turtles, such as heavy metals or organochlorines, and potentially reduce the availability of nesting and feeding habitat. Decreased water quality and trawling operations may reduce the quality of important seagrass and benthic feeding habitat. The

identification and protection of marine turtle habitat is one objective of the *Recovery Plan for Marine Turtles in Australia*, developed by Environment Australia in 2003.

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D5 North-west Marine Region Protected Species Group Report Card – Birds

Current at May 2008. See <www.environment.gov.au/coasts/mbp/north-west> for updates.

General information

This report card deals with those bird species that are listed under the EPBC Act as marine species. A list of all the listed bird species that regularly occur or are likely to occur in the North-west Marine Region can be found at Appendix C. The marine birds of the North-west Marine Region can be divided into three categories:

- coastal or terrestrial species that inhabit the offshore islands and coastal areas of the mainland adjacent to the Region;
- migratory species that pass through the Region on their way to northern Australia from breeding grounds in the Northern Hemisphere or wintering grounds in New Guinea; and
- seabirds whose primary habitat and food source is derived from the pelagic waters of the Region.

Most of the offshore islands of northern Western Australia and their surrounding waters (up to three nautical miles from land) fall under State Government jurisdiction, and are not considered part of the North-west Marine Region. However, many of these islands support important habitat for threatened and migratory bird species and, as such, are considered important areas for matters of national environmental significance (see Section 3 for more information on matters of national environmental significance and requirements under the EPBC Act).

Some species that occur on the offshore islands adjacent to the Region are primarily terrestrial such as Australian kestrels, magpie-larks and Richard's pipits. Others, such as eastern reef egrets, silver gulls and Australian pelicans are predominantly coastal species that spend the majority of their time foraging in coastal waters close to shore. Some species, such as white-bellied sea-eagles and Caspian terns may occasionally forage further out to sea, however, many shore birds and terrestrial species that inhabit these areas are unlikely to interact significantly with the Commonwealth waters of the North-west Marine Region.

The waters of the North-west Marine Region are used by many bird species as important resting and foraging

Great frigatebird. Photo: Fusion films.

habitat on long-distance migrations. The Region is an important part of the East Asian–Australasian Flyway, a migratory pathway for millions of migratory shorebirds that travel from breeding grounds in the Northern Hemisphere to spend the Southern Hemisphere summer in northern Australia. Offshore islands adjacent to the Region are important staging or stopover sites, with some individuals remaining on the islands for the duration of the non-breeding season. A small number of species also pass through the Region on their way to overwinter in New Guinea after breeding in Australia. There are 34 bird species that regularly migrate through the Region, including 26 species of migratory shorebirds of the Scolopacidae (curlews, sandpipers etc.) and Charadriidae (plovers and lapwings) families, as well as swifts, kingfishers, cuckoos and dollarbirds.

There are 26 species of seabirds that occur in the Region including terns, noddies, petrels, shearwaters, tropicbirds, frigatebirds and boobies. These species spend the majority of their lives at sea, ranging over large distances to forage over the open ocean. Many of these species also breed in and adjacent to the North-west Marine Region and are likely to interact significantly with the Commonwealth waters of the Region.

Nationally protected species

All migratory shorebirds that occur in the Region are listed under the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS) and one or more of the *Agreement Between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and Their Environment 1986* (CAMBA), the *Agreement Between the Government of Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and Their Environment 1974* (JAMBA), and the *Agreement between the Government of Australia and the Government of the Republic of Korea on the Protection of Migratory Birds 2007* (ROKAMBA). These species are also covered by the *World Summit on Sustainable Development Type II Partnership for the Conservation of Migratory Waterbirds and the Sustainable Use of their Habitats in the East Asian – Australasian Flyway* and its implementation strategy (DEW 2007a, b) and the *Wildlife Conservation Plan for Migratory Shorebirds* (DEH 2006a).

There are a further 24 species that occur regularly in the Region that are listed under the EPBC Act as either Migratory and/or Threatened (Table D5.1). Some of these are also listed under CMS, JAMBA, CAMBA and/or ROKAMBA. In addition, some species are listed under the *Convention on the International Trade in Endangered Species of Wild Fauna and Flora* (CITES).

As a signatory to the CMS, Australia has an international obligation to protect migratory species, their habitats and their migration routes. Similarly, as a party to the CITES, Australia has agreed to control the import and export of an agreed list of species that are endangered, or at risk of becoming endangered, because of inadequate controls over trade in them or their products. Albatrosses and petrels are also covered by the *Agreement on the Conservation of Albatrosses and Petrels* (ACAP), a multilateral agreement developed under the auspices of the CMS that seeks to coordinate international activity to mitigate known threats to albatross and petrel populations. Other conservation plans and policies that relate to these species are listed in Table D5.1.

Table D5.1 Seabirds listed as threatened or migratory under the EPBC Act that are known to occur in the North-west Marine Region

Species	Conservation Status	Conservation Plans and Policies
Southern giant petrel (*Macronectes giganteus*)	Endangered, Migratory, Marine Listed under CMS (Appendix II)	• *Guidelines for Managing Visitation to Seabird Breeding Islands* (WBM Oceanics & Claridge 1997) • *Action Plan for Australian Birds* (Garnett & Crowley 2000) • *Recovery Plan for Albatrosses and Giant-petrels* (EA 2001) • *National Recovery Plan for Ten Species of Seabirds 2005–2010* (DEH 2005a) • *National Recovery Plan for Ten Species of Seabirds – Issues Paper* (DEH 2005b) • *Threat Abatement Plan for the Incidental Catch (or Bycatch) of Seabirds During Oceanic Longline Fishing Operations* (DEH 2006b)
Soft-plumaged petrel (*Pterodroma mollis*)	Vulnerable, Marine	
Streaked shearwater (*Calonectris leucomelas*)	Migratory, Marine Listed under CAMBA (as *Puffinus leucomelas*) & JAMBA	
Wedge-tailed shearwater (*Puffinus pacificus*)	Migratory, Marine Listed under JAMBA	
Indian yellow-nosed albatross (*Thalassarche carteri*)	Vulnerable, Migratory, Marine Listed under CMS (Appendix II; as *Diomedea chlororhynchos*)	

Species	Conservation Status	Conservation Plans and Policies
Wilson's storm-petrel (*Oceanites oceanicus*)	Migratory, Marine Listed under JAMBA	
White-tailed tropicbird (*Phaethon lepturus*)	Migratory, Marine Listed under CAMBA & JAMBA	
Masked booby (*Sula dactylatra*)	Migratory, Marine Listed under JAMBA	
Red-footed booby (*Sula sula*)	Migratory, Marine Listed under CAMBA & JAMBA	
Brown booby (*Sula leucogaster*)	Migratory, Marine Listed under CAMBA & JAMBA	
Great frigatebird, greater frigatebird (*Fregata minor*)	Migratory, Marine Listed under CAMBA & JAMBA	
Lesser frigatebird, least frigatebird (*Fregata ariel*)	Migratory, Marine Listed under CAMBA & JAMBA	
Eastern reef egret (*Egretta sacra*)	Migratory, Marine Listed under CAMBA	
Osprey (*Pandion haliaetus*)	Migratory, Marine Listed under CMS (Appendix II) & CITES (Appendix II)	
White-bellied sea-eagle (*Haliaeetus leucogaster*)	Migratory, Marine Listed under CAMBA & CITES (Appendix II)	
Caspian tern (*Sterna caspia*)	Migratory, Marine Listed under CAMBA as (*Hydroprogne caspia*) & JAMBA (as *Hydroprogne caspia*)	
Lesser crested tern (*Sterna bengalensis*)	Migratory, Marine Listed under CAMBA	
Roseate tern* (*Sterna dougallii*)	Migratory, Marine Listed under CAMBA & JAMBA	
Common tern (*Sterna hirundo*)	Migratory, Marine Listed under CAMBA & JAMBA	
Little tern (*Sterna albifrons*)	Migratory, Marine Listed under CAMBA, JAMBA and CMS (Appendix II)	
Bridled tern (*Sterna anaethetus*)	Migratory, Marine Listed under CAMBA & JAMBA	
White-winged black-tern (*Chlidonias leucoptera, Chlidonias leucopterus*)	Migratory, Marine (as *Chlidonias leucopterus*) Listed under CAMBA (as *Chlidonias leucoptera*) & JAMBA (as *Chlidonia leucoptera*)	
Common noddy (*Anous stolidus*)	Migratory, Marine Listed under CAMBA & JAMBA	
Australian lesser noddy (*Anous tenuirostris melanops*)	Vulnerable, Marine	

*The roseate tern has been added to the updated list of species included under CAMBA and JAMBA, however, the amendments have not yet been formally adopted.

Ecology of protected species in the North-west Marine Region

The distribution and abundance of seabirds in the North-west Marine Region is strongly influenced by the oceanography of the Region, in particular the Leeuwin Current. The Leeuwin Current is an unusual, south-flowing eastern boundary current that carries warm, low-salinity water south to south-western Western Australia and inhibits upwellings of cooler, nutrient rich waters, resulting in low biological productivity. As a consequence, seabird abundance in the Region is much lower, and tropical species occur much further south, than at equivalent latitudes off the west coasts of Africa and South America, which possess north-flowing currents and strong coastal upwellings (Wooller *et al*. 1991).

The seabird fauna of the Region consists of predominantly tropical species, such as boobies, frigatebirds and tropicbirds, as well as tropical terns and noddies, but includes many Pacific Ocean pelagic species such as streaked shearwaters, Tahiti petrels, Hutton's shearwaters and Matsudaira's storm-petrels, which migrate into the Region from the Pacific via the Indonesian Throughflow (Wooller *et al*. 1991). Others such as the Indian yellow-nosed albatross and southern giant petrel are predominantly Antarctic or sub-Antarctic species that migrate to the Region during the non-breeding season.

The offshore islands in and adjacent to the North-west Marine Region support breeding populations of many species, including significant populations of terns, shearwaters and boobies. North of 20°S, most species breed in autumn, while in the southern parts of the Region, breeding can occur in both summer and autumn. Breeding seasons, the size of breeding populations and reproductive success of some species are influenced by the annual and inter-annual variability in the strength and timing of the Leeuwin Current and Indonesian Throughflow, which affects the availability and abundance of prey (Dunlop *et al*. 2002; Nicholson 2002).

Some species such as bridled terns and wedge-tailed shearwaters migrate to the Region to breed, taking advantage of temporary abundances in food sources. Others such as lesser crested terns and boobies are resident in the Region throughout the year although they may forage long distances over the open ocean. Several species of petrel spend their non-breeding seasons foraging in the Region while other species pass through the Region only briefly as part of longer distance migrations.

Further details on the main groups of seabirds that occur in the Region are below.

Migratory shorebirds

There are 26 species of migratory shorebirds of the Scolopacidae and Charadriidae families that regularly migrate through the Region as part of the East Asian–Australasian Flyway. These species complete a round trip of up to 26 000 km every year from their breeding grounds in Alaska and Siberia to their non-breeding habitat in Australia. Migrants arrive in the Region around September, using offshore islands as staging or stopover sites before moving to freshwater wetlands, grasslands, coastal areas and intertidal mudflats on the mainland. Some individuals remain in the Region throughout the non-breeding season on the rocky platforms and intertidal sand flats of Ashmore Reef and the Montebello Islands, where they forage on worms, bivalves and other invertebrates. Others remain on the mudflats of Roebuck Bay and Eighty Mile Beach. It is thought that at least four million individual shorebirds use the flyway with at least two million of those migrating to Australia (AWSG 2007). Most migrants leave the Region to head north again in March, although some very old or very young birds may remain in Australia during the Austral winter. The Region and islands adjacent to the Region, support internationally significant populations (over one per cent of the flyway population) of at least six species.

Terns and noddies

There are 14 species of terns and noddies that regularly occur in the Region. All but two species, common and white-winged black terns, breed in or adjacent to the Region. The Region supports significant breeding populations of bridled, sooty crested and lesser crested terns and common noddies. Australian lesser noddies may breed on Ashmore Reef, however, this requires confirmation. Caspian terns, fairy terns, gull-billed terns, little terns and white-winged black terns are primarily coastal or inland feeders, interacting with the Commonwealth waters of the Region only occasionally. Other species mainly forage over the continental shelf for squid, fish, molluscs, jellyfish and insects. Terns and noddies are often observed in mixed species feeding aggregations that form when predatory fish push prey to the surface (Nicholson 2002; Surman & Wooller 2003). Bridled terns also regularly forage over floating mats of *Sargassum* in pelagic waters (Dunlop 1997).

Tropicbirds

Small breeding populations of both red-tailed and white-tailed tropicbirds occur in the Region, on the Rowley Shoals and Ashmore Reef. Tropicbirds are predominantly pelagic species, rarely coming to shore except to breed. They forage for fish and squid by plunge-diving. They are usually solitary feeders, and are rarely observed in large aggregations (Dunlop *et al*. 2001). They forage over long distances, moving up to 1500 km away from their breeding sites. Outside the Region, a banded red-tailed tropicbird has been recorded almost 6000 km from where it was first captured (Le Corre *et al*. 2003).

Boobies

The North-west Marine Region supports breeding populations of three species of booby, including large colonies of brown boobies on Ashmore Reef, Adele Island, Bedout Island and the Lacepede Islands. Smaller populations of masked boobies occur on Adele and Bedout islands and a small population of red-footed boobies breeds on Ashmore Reef. Brown, red-footed and masked boobies primarily feed on flying-fish and squid, with red-footed boobies generally eating more squid while masked boobies and brown boobies eat more fish. Brown boobies are specialised plunge divers and are thought to forage closer to land than the other species, which are considered more pelagic. A study of the marine distribution of Christmas Island seabirds found that brown boobies foraged within 250 km of their colony, however red-footed boobies foraged up to 800 km away (Dunlop *et al*. 2001).

Frigatebirds

Two species of frigatebird (greater and lesser) occur in the Region, with large breeding colonies of lesser frigatebirds occurring on several offshore islands. Frigatebirds feed mostly on fish and occasionally on cephalopods (squid and cuttlefish). They forage on the wing, scooping prey from the surface of the water or taking flying-fish from just above the surface. Frigatebirds are also kleptoparasitic, chasing and harassing other seabirds and forcing them to regurgitate their prey.

Procellariiformes

Procellariiformes include albatrosses, petrels, shearwaters and their allies. Ten species of procellariiformes occur regularly in the North-west Marine Region, including one species of albatross, one giant petrel, two storm petrels, three petrels and three shearwater species. Only the wedge-tailed shearwater is known to breed in the Region with large colonies on many offshore islands. Indian yellow-nosed albatrosses, soft-plumaged petrels and Matsudaira's storm-petrels are thought to migrate to the Region during the non-breeding season, while other species such as Wilson's storm-petrels, Hutton's shearwaters and streaked shearwaters may migrate through the Region on their way to other non-breeding areas.

Procellariiformes generally feed on squid, fish and crustaceans, either by taking prey from the surface or pursuit-diving for deeper-living prey species. Wedge-tailed shearwaters have been recorded diving to depths of up to 66 m, although most dives are to depths of less than 20 m (Burger 2001). Storm-petrels feed by scooping minute crustaceans from the ocean surface. Some species will readily follow ships and attend trawlers, foraging on fishery discards. Others may form large mixed species feeding aggregations with other seabirds and predatory fish.

Important areas in the North-west Marine Region

Threatened and migratory species are considered matters of national environmental significance under the EPBC Act. Important areas for threatened and migratory bird species, as well as other seabird species, in the North-west Marine Region are identified below. These sites include offshore islands and coastal areas that support important seabird colonies, but fall under State Government jurisdiction. Some of these areas are already afforded protection through their status as Commonwealth or State marine parks or reserves.

Adele Island – Adele Island supports large breeding colonies of brown boobies and lesser frigatebirds as well as smaller breeding populations of red-footed boobies, masked boobies, lesser crested terns and silver gulls (Serventy *et al*. 1971; DEC 2007a).

Ashmore Reef and Cartier Island – These islands support some of the most important seabird colonies on the North West Shelf, including colonies of sooty terns, crested terns, bridled terns, common noddies and brown boobies as well as smaller populations of little egrets, eastern reef egrets, black noddies, frigatebirds, tropicbirds, red-footed boobies, roseate terns and lesser crested terns (Serventy *et al*. 1971; DEC 2007a).

The reserves are also important staging points for many migratory shorebirds including large flocks of eastern curlews, ruddy turnstones, whimbrels, bar-tailed godwits, common sandpipers, Mongolian plovers, red-necked stints and grey-tailed tattlers. As such, Ashmore Reef National Nature Reserve is included on the Ramsar List of Wetlands of International Importance.

Bedout Island – Bedout Island supports one of the largest colonies of brown boobies in Western Australia, with a population estimated to be over 10 000 breeding pairs (Nicholson 2002; DEC 2007a). The island also supports smaller breeding populations of masked boobies, lesser frigatebirds, common noddies and crested, roseate and sooty terns.

Dampier Archipelago – The islands of the Dampier Archipelago are important nesting areas for wedge-tailed shearwaters, bridled, fairy, roseate and Caspian terns, eastern reef egrets, beach stone-curlews, ospreys and white-bellied sea-eagles.

Lacepede Islands – The Lacepede Islands support some of the largest colonies of brown boobies in Western Australia, with the number of breeding pairs on West Island and Middle Island estimated to be in the tens of thousands. Approximately 2500 pairs of lesser frigatebirds nest on West Lacepede Island, while smaller populations of bridled terns, roseate terns, fairy terns, sooty terns, common noddies, Australian pelicans and silver gulls also breed in the area (Serventy *et al*. 1971; DEC 2007a).

Montebello, Lowendal and Barrow islands – These islands support significant colonies (over 10 000 pairs) of wedge-tailed shearwaters, crested terns and bridled terns. The Montebello Islands support the biggest breeding population (over 6000 pairs) of roseate terns in Western Australia, while small numbers of ospreys, Brahminy kites, white-bellied sea-eagles, eastern reef egrets, Caspian terns, lesser crested terns and beach-stone curlews also breed on the Montebello and Lowendal islands. A large breeding population of silver gulls (over 1000 pairs) breeds on the Lowendal Islands between December and April (Nicholson 1998; Burbidge *et al*. 2000; Nicholson 2002; Surman & Nicholson 2006).

Barrow Island is ranked equal tenth among 147 important migratory bird sites in Australia. Along with the nearby Lowendal and Montebello Islands, Barrow Island is an internationally significant site for grey-tailed tattlers, ruddy turnstones, red-necked stints, sanderlings and greater and lesser sand plovers, supporting more than one per cent of the East Asian–Australasian Flyway population of these species. As well as an important staging post, at least some birds remain on the island throughout the summer non-breeding season and even during the winter.

Observations by Dunlop *et al*. (1988) indicate that an area to the west of the Montebello Islands may be a minor zone of upwelling in the Region, supporting large feeding aggregations of terns. More recent studies indicate that it is an important feeding area for migratory Hutton's shearwaters and soft-plumaged petrels (C. Surman pers. comm. 2007).

North West Cape and surrounds – There are records of breeding on Serrurier and Airlie islands for Caspian terns, fairy terns, little terns, wedge-tailed shearwaters, ospreys and silver gulls.

Onslow to Dampier Archipelago – Islands between Onslow and the Dampier Archipelago support important nesting sites for wedge-tailed shearwaters, roseate, crested, Caspian and bridled terns, ospreys, eastern reef egrets, beach stone-curlews and white-bellied sea-eagles.

Roebuck Bay and Eighty Mile Beach – Roebuck Bay and Eighty Mile Beach are two of the most important areas in Australia for migratory shorebirds, regularly supporting over 500 000 birds at any one time, with over 850 000 birds using the area annually. The area is an internationally significant site for 20 species, regularly supporting more than one per cent of the East Asian–Australasian Flyway population. Whistling kites, Brahminy kites and red-capped plovers also breed in the area. Both Roebuck Bay and Eighty Mile Beach are included on the Ramsar List of Wetlands of International Importance.

Rowley Shoals – The sand cays at Clerke and Imperieuse reefs and the sand areas exposed at low tides at Mermaid Reef may be important resting and feeding sites for migratory shorebirds. There are also breeding records of red-tailed tropicbirds, white-tailed tropicbirds, little terns and sooty terns on Bedwell Island and Clerke Reef (DEC 2007a).

Scott Reef – Scott Reef is an important staging post for migratory shorebirds and a foraging area for seabirds including roseate terns, lesser frigatebirds and brown boobies.

Shark Bay – Several hundred pairs of wedge-tailed shearwaters breed on the islands of Shark Bay (C.

Surman & L. Nicholson pers. comm. 2007). Bridled terns, Caspian terns, roseate terns, fairy terns, crested terns, silver gulls, Pacific gulls and Australian pelicans have also been recorded breeding in the area (Serventy *et al*. 1971; DEC 2007a).

Known interactions, threats and mitigation measures

All the bird species listed as marine, migratory and/or threatened are protected under the EPBC Act, making it an offence to kill injure, take, trade, keep or move any member of a listed bird species without a permit. However, seabirds may interact with human activities in a number of ways. Potential interactions and threats to seabirds in the North-west Marine Region are listed below.

Commercial fishing

Many seabird species such as bridled terns, common noddies and wedge-tailed shearwaters rely heavily on foraging relationships with predatory fish, such as schools of tuna that herd prey species to the surface. For some species, such as lesser noddies and sooty terns, this is a near obligate relationship. Changes in tuna stock abundance or behaviour could affect populations of these species (Shaw 2000).

Incidental catch (or by-catch) of seabirds during oceanic longline fishing operations is listed under the EPBC Act as a key threatening process. Longline fishing is a particular concern for albatrosses and petrels in higher latitudes (south of 25°S). In the North-west Marine Region, the Western Tuna and Billfish Fishery is known to interact with seabirds through the use of pelagic longlining, however, most of the effort in the fishery occurs south of the Region (DEH 2004). Data from observer programs indicate that interactions with seabirds are rare and all birds caught are released alive (Ward & Curran 2004). The Australian Government has developed a threat abatement plan for the by-catch of seabirds on longlines, which can be found at <www.environment.gov.au/biodiversity/threatened/publications/tap/longline>. This threat abatement plan was reviewed in 2006, and the provisions of the revised plan apply to all longline fisheries managed by the Commonwealth.

In the Region, seabirds also interact with the Northern Prawn Fishery through actively feeding on discards from the fishery (DEH 2003). Such an increase in food availability may affect foraging behaviour, population sizes and reproductive success. The impacts of increasing populations of some species beyond their natural capacity may have implications for the ecosystem as a whole. Studies outside the Region in the Great Barrier Reef indicate that seabirds only eat a small proportion of trawl discards (Hill & Wassenberg 2000), but Blaber *et al*. (1995) found that increased food availability may affect diet, foraging strategies and juvenile survival. Discarded by-catch in the Northern Prawn Fishery is substantial but has been reduced through reduction in effort in the fishery (DEH 2003).

Oil and gas infrastructure

The oil and gas industry is one of the most significant human activities in the North-west Marine Region. Potential effects of oil and gas infrastructure on seabirds include oil spills, the destruction or disturbance of nesting or roosting habitat, disorientation of juvenile birds by lights (Nicholson 2002; Bamford & Bamford 2005), and, rarely, death in gas flares (Bourne 1979; Nicholson 2002). Platforms and other infrastructure associated with the industry can provide new roosting areas; however, the risk of helicopter strike is associated with these structures (C. Surman & L. Nicholson, pers. comm. 2007).

Marine debris and pollution

Injury and fatality to birds and other vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris has been listed as a key threatening process under the EPBC Act. Marine debris includes garbage washed or blown from land into the sea (such as plastic), discarded commercial or recreational fishing gear, and solid non-biodegradable floating materials disposed of by ships at sea. Entanglement in marine debris can lead to restricted mobility, starvation, infection, amputation, drowning and smothering. The ingestion of plastic marine debris can cause physical blockages leading to starvation, or injuries to the digestive system leading to infection or death. The Australian Government is currently developing a threat abatement plan that aims to minimise the impacts of marine debris on threatened marine species. Further information on the impacts of marine debris on threatened species is available at <www.environment.gov.au/biodiversity/threatened/publications/marine-debris.html>.

Seabirds are also susceptible to toxic contaminants such as heavy metals, and synthetic compounds such as organochlorines, which may be absorbed after ingestion

of plastic materials. Organochlorines accumulate up the food chain and can cause reduced breeding success, increased risk of disease, altered hormone levels and death (Ryan *et al*. 1988). Similarly, heavy metals originating from agricultural and industrial run-off may be concentrated in top-level predators such as seabirds and are thought to cause decreased reproductive success, behavioural abnormalities and increased mortality (Burger & Gochfeld 2000).

Competition with introduced and other native species

Introduced species are the most significant threat to seabirds at their breeding sites. The black rat (*Rattus rattus*) is the most widely distributed introduced rodent on Australian islands and has been recorded on many islands on the Pilbara and Kimberley coasts (Morris 2002). Black rats prey on eggs and chicks and are thought to be responsible for the extermination of common noddies from Bedout Island and the Lacepede Islands. Eradication programs have been successful on several islands such as Bedout, Middle and West Lacepede islands and Barrow and Middle islands (Morris 2002). Exotic plant species can also affect seabird breeding by reducing nesting habitat, eroding burrowing substrate, giving cover to predators and reducing cover and shade for chicks (WBM Oceanics & Claridge 1997).

However, other native species may also pose a threat to seabirds, particularly at colonies. In the past 50 years, the populations of silver gulls throughout Australia have grown significantly, probably as a result of increased access to anthropogenic food sources (Smith & Carlile 1993). Silver gulls prey on the eggs and nestlings of other seabirds and displace them from preferred nesting sites (Surman & Nicholson 2006). It is estimated that approximately 40 000 silver gulls were resident in the Perth metropolitan area in 1992 (DEC 2007b). Although the species is not yet a major problem in the North-west Marine Region, substantial silver gull population increases in some parts of the Region associated with human activity and industry could have a negative impact upon other seabird breeding populations.

Disturbance at colonies

Human disturbance of seabird breeding colonies can cause breeding failure through modification or destruction of breeding habitat, displacement of breeders, nest desertion by all or part of a breeding population, destruction or predation of eggs, and exposure or crushing of young chicks, particularly in ground and burrow nesting species (WBM Oceanics & Claridge 1997).

Climate change

The long-term effect of climate change on marine species is still speculative, however, seabirds may be affected in a number of ways. An increase in temperatures is likely to lead to earlier nesting, an expansion or shift in ranges southward, the loss of nesting sites and foraging habitat through increases in sea level, and changes in availability and abundance of food resources (Hobday *et al*. 2006). Changes in prey availability will also affect distribution, abundance, migration patterns and community structure of seabird communities. There is already evidence that the ranges of a number of tropical seabird species in Western Australia are expanding south (Dunlop & Goldberg 1999; Dunlop & Mitchell 2001), although the mechanisms driving this range expansion are not clear. There is also evidence that arrival and departure dates for migratory species are changing and that this may be linked to changes in climate (Beaumont *et al*. 2006).

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D6 North-west Marine Region Protected Species Group Report Card – Dugongs

Current at May 2008. See <www.environment.gov.au/coasts/mbp/north-west> for updates.

General information

The dugong (*Dugong dugon*) belongs to the order Sirenia, and is the only remaining species in the family Dugongidae. The dugong is most closely related to the extinct Steller's sea cow (*Hydrodamalis gigas*), which was a member of the same family. Three species of manatee are the only other remaining members of the order Sirenia (Marsh *et al*. 2002).

Dugongs are also known as 'sea cows', and have been found in tropical and subtropical coastal and island waters from East Africa to Vanuatu, between about 26°N and 27°S (Marsh *et al*. 2002). Historically, the distribution was broadly coincident with the tropical Indo–Pacific distribution of its food plants, the seed-producing seagrasses (Husar 1978). Research indicates a decline in dugong numbers globally, however the degree to which their numbers have dwindled and their range has fragmented is not known. Dugong populations outside Australian waters currently consist of relict populations separated by large areas where the species is close to extinction or extinct. (Marsh *et al*. 2002).

Research indicates that a significant proportion of the world's population of dugongs is now found in northern Australian waters between Shark Bay in Western Australia and Moreton Bay in Queensland. Over 10 000 animals have been recorded in Shark Bay (14 906 km^2) alone, compared with a population estimate of 9000 animals in the Red Sea and the Arabian Gulf (72 000 km^2) (Preen 1998). The population of dugongs in Australian waters is estimated to include about 80 000 animals (Saalfeld & Marsh 2004).

Nationally protected species

The dugong is listed under the EPBC Act as a migratory and marine species, making it an offence to kill, injure, take, trade, keep or move dugongs in a Commonwealth area without a permit. Any actions in Australian waters that have, or are likely to have, a significant impact on dugongs are subject to a rigorous referral, assessment and approval process under the EPBC Act.

Currently, dugongs are classified as vulnerable to extinction under the *2006 IUCN Red List of Threatened Species* because they are considered to be at high-risk of extinction in the wild in the medium-term future. Australia supports the largest remaining dugong populations in the world, which are considered to be relatively stable across most of their range in northern Australia. As such, the dugong is currently not listed as a threatened species under the EPBC Act.

The dugong is also listed on Appendix I of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES), and on Appendix II of the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS). As a signatory to CMS, Australia has an international obligation to protect migratory species, their habitats, and their migration routes. Similarly, as a party to CITES, Australia has agreed to control the import and export of an agreed list of species that are endangered, or at risk of becoming endangered, because of inadequate controls

Dugong in Shark Bay. Photo: Kevin Crane, Department of Environment and Conservation, WA.

over the trade in specimens or their products. Further information on CITES and CMS is included in Appendix A.

On 31 October 2007, Australia signed the *Memorandum of Understanding on the Conservation and Management of Dugongs and their Habitats throughout their Range* under the CMS at a meeting in Abu Dhabi, United Arab Emirates. The memorandum of understanding is a non-legally binding arrangement that acknowledges the shared responsibility of signatory states for the conservation and management of dugongs and their habitat. The associated *Conservation Management Plan for Dugong* sets out key priority objectives and actions for the conservation and management of dugong populations across their migratory range and is consistent with plans for other species developed under CMS.

Ecology of protected species in the North-west Marine Region

Dugongs are large grey mammals that spend their entire lives in the sea. Fully grown, they are about 3 m long and weigh 400 kg. They have nostrils near the top of their snouts, and a few bristles near the mouth. Dugongs swim by moving their broad spade-like tail in an up-and-down motion, and by use of their two flippers. They surface only to breathe. For food, they rely on the seagrasses that grow on sandy seafloor regions in shallow warm water. Feeding aggregations tend to occur in some of these areas, though access to inshore feeding areas is only possible when water depth is over 1 m, and some areas may be accessible only at high tide. Where tidal amplitude is low, such as Shark Bay, or where seagrass grows subtidally, daily movements are not dictated by tides (Marsh *et al*. 2002).

It is estimated that dugongs need to eat around 40 kg of seagrass each day (QEPA & QPWS 1999). Research indicates that dugongs selectively forage for seagrass species that are lowest in fibre and highest in available nitrogen and digestibility (*Halophila* spp. and *Halodule* spp.). This allows them to maximize the level of nutrients rather than bulk. Dugongs will resort to eating marine algae when seagrass is scarce, and will delay breeding if there is insufficient food.

Dugongs have a low reproductive rate, long generation time and a high investment in each offspring (Marsh *et al*. 2002). They do not have a specific breeding season, but they do show some seasonality, with mating and calving apparently peaking in the spring and summer months. Females bear their first calf at between six and 17 years of age depending on the quality of food available. Gestation lasts for approximately 13 months and the mother gives birth underwater, usually to a single calf. Calves start eating seagrasses soon after birth but remain with their mother, suckling and following close-by for at least 18 months. The period between successive calving is very variable, ranging from around three to seven years, and is related to the quality of their food (Boyd *et al*. 1999; Kwan 2002). Three separate age classes have been defined for dugongs: newborn and unweaned calves are usually less than 1.8 m in length; juveniles that are independent but sexually immature, generally measure between 1.8–2.4 m; and adults are usually greater than 2.4 m (Husar 1978). Dugongs are believed to have a long life-span. Age determination by tusk examination has estimated a female dugong from Roebuck Bay to have been around 73 years old when she died (IUCN 2006).

Dugongs are highly migratory, which means Australia shares its dugong populations with other countries, including Timor and Papua New Guinea. They are also found in other parts of the Indian and Pacific oceans in warm shallow seas protected from large waves and storms. In Australia, dugongs inhabit the shallow coastal waters of northern Australia from the Queensland/New South Wales border in the east to Shark Bay on the Western Australian coast. In the North-west Marine Region, they occur in Shark Bay; Exmouth Gulf and offshore on the North West Shelf; in and adjacent to Ningaloo Reef; in coastal waters close to Broome and along the Kimberley coast; and on the edge of the continental shelf at Ashmore Reef (Marsh *et al*. 2002).

Dugongs may use certain habitats for different activities. For example, shallow waters appear to be used for calving, and deeper waters may be used in winter as a thermal refuge from cooler coastal waters (Marsh *et al*. 2002). In Shark Bay, South Cove is used for some types of mating behaviour and the Faure Sill is a major feeding ground in spring and summer (Marsh *et al*. 1994).

Dugong movements are believed to be largely related to their searches for suitable seagrass beds, however towards the high latitude limits of their range they have been observed to make seasonal movements to warmer waters (Marsh *et al*. 2002). In Shark Bay, they tend to move to the western shores of the bay in winter and the eastern shores in the summer (Marsh *et al*. 1994). Satellite tracking has enabled the observation of long-distance movements of individual animals up to 600 km. It is thought that long-distance movements are

associated with the ephemeral nature of the distribution of their preferred seagrass species (Marsh *et al*. 2002).

Important areas for dugongs in the North-west Marine Region

Dugongs prefer coastal waters; therefore, much of their distribution falls under Western Australian State jurisdiction. However, dugongs are listed as a marine and migratory species under the EPBC Act, making them a matter of national environmental significance. Important areas for dugongs in and adjacent to the North-west Marine Region are identified below. Some of these areas may already be afforded protection through their status as Commonwealth or State marine parks or reserves.

Shark Bay – A number of surveys of dugong populations have been conducted in Shark Bay. Surveys in 1989 and 1994 indicated that the dugong population was fairly stable at around 10 000 animals (Preen *et al*. 1997). A third survey in 1999 estimated that up to approximately 14 000 animals were present in the bay (Gales *et al*. 2004). Relocation of animals into Shark Bay from cyclone-affected areas to the north appeared the most likely explanation of this change (Gales *et al*. 2004).

The Gladstone/Wooramel Delta area on the eastern shore of Shark Bay is thought to be an important feeding area, particularly in the summer months when populations increase to between 3000 and 5000. During the winter months about 170 dugongs use this area (Preen *et al*. 1997). The warmer waters east of Dirk Hartog Island support seagrass banks and are thought to be a refuge frequented by dugongs during the winter months (Preen *et al*. 1997). Preen *et al*. (1997) concluded that the Shark Bay population was significant because of its large size, the low level of human predation and incidental mortality, and the presumed low level of habitat disturbance. This will provide a valuable reference point with which to compare other dugong populations.

Ningaloo Reef and Exmouth Gulf – Surveys in Exmouth Gulf in 1989 and 1994 indicated populations of around 1000 animals in this region (Marsh *et al*. 1994; Preen *et al*. 1997). A survey in 1999 indicated that the population for Ningaloo Reef and Exmouth Gulf had decreased to around 300 (Gales *et al*. 2004). A further survey in 2000 indicated that the population in Exmouth Gulf had decreased to below 100 (Prince 2001). It is thought that the numbers decreased as a result of the destruction of seagrass beds caused by the passage of tropical cyclone Vance through the Exmouth Gulf in March 1999, and relocation of previously resident dugongs responding to this loss of foraging habitat.

Pilbara coastal and offshore region (from Exmouth Gulf to the De Grey River) –Shoreline surveys of this area in the 1980s indicated reasonable concentrations of dugongs. An aerial survey in 2000 estimated the population at around 2000 animals. Knowledge of the extent of seagrass resources and their changes in response to disturbance from tropical cyclones in the area is sparse; however, potential seagrass habitat in deep water meadows and in the shallow waters around Barrow Island and the Montebello Islands has been documented. Dugong feeding trails have been observed between Middle and North Mangrove islands (Marsh *et al*. 2002).

Kimberley coast – Data from this region are sparse; however, small concentrations of dugongs have been observed in seagrass between Cape Bossut and King Sound. Reconnaissance surveys in this area in the mid-late 1980s indicated resident dugong populations at densities similar to the Pilbara (B. Prince, pers. comm. 2007). Unquantified levels of Indigenous hunting of dugongs occur in the west Kimberley region.

Ashmore Reef – Dugongs with calves have been reported at Ashmore Reef and nearby on the Sahul Shelf. The Ashmore Reef area may support a small, but possibly genetically distinct population, with a minimum population estimate of 11 animals (Whiting 1999).

Known interactions, threats and mitigation measures

As well as being listed as a marine and migratory species under the EPBC Act, dugongs are protected in Western Australian State waters under the *Western Australia Wildlife Conservation Act 1950*. The *Wildlife Conservation (closed season for Marine Mammals) Notice 1998* sets limits on human interactions with marine mammals and prevents some activities that interfere with, or result in the taking of marine mammals (Marsh *et al*. 2002).

Dugongs in the North-west Marine Region may be subject to a range of human threats including entanglement in shark-nets, mesh-nets and gill-nets, loss and degradation of critical coastal seagrass habitat, and collisions with boats (DEW 2007). Specific human activities that may pose a threat to dugongs in the region are detailed below:

Habitat loss and degradation

Dugongs are particularly vulnerable to habitat loss because of their dependence on seagrass beds containing their preferred food species (Marsh *et al*. 2002). Seagrass beds are sensitive to natural events such as cyclones and anthropogenic pressures.

Increased sedimentation and turbidity can smother seagrasses resulting in death, disease or a decrease in growth rate and, ultimately, a decline in the total area of seagrass beds. Increased sedimentation can occur from storm and cyclone activity, agriculture, coastal development, land reclamation and mining. Boat traffic and dredging practices also increase sediment suspension in the water column (Talbot & Wilkinson 2001; Hobday *et al*. 2006). Adjacent to the Region, port expansion in the Dampier Archipelago and Cape Lambert area associated with petroleum and iron ore industries also pose a potential threat to seagrass habitat as a result of increased dredging and ship movements (Marsh *et al*. 2002).

Coastal development also poses a threat to seagrass habitat. For example, in Shark Bay, the salt industry has constructed a sea wall to isolate part of Useless Inlet, and proposes to construct additional salt crystallizer ponds. The impacts of the sea wall on seagrasses are unknown, but it is expected that the crystalliser ponds will destroy approximately 40 ha of seagrass. As salt production increases, the industry will require larger vessels to export their product. This will involve dredging shipping channels in the vicinity of the seagrass banks east of Dirk Hartog Island (Marsh *et al*. 2002). This area of warmer waters is thought to be a refuge frequented by dugongs during the winter months (Preen *et al*. 1997).

Aquaculture farms being considered for parts of Shark Bay may also affect dugongs and their habitat through acoustic disturbance, eutrophication, pesticides, boat strikes, and the dragging of moorings on the seabed (Marsh *et al*. 2002).

Climate change

The long-term effects of global warming on marine species are still speculative; however, possible habitat loss and degradation of seagrass habitat in the North-west Marine Region as a result of climate change may affect dugong populations. Seagrass habitat is likely to be affected through increasing carbon dioxide levels, water temperature, UV radiation and storm activity. Changes in rainfall and coastal run-off, coastal salinity, currents and winds, and sea level rise will also have an impact on seagrass beds (Hobday *et al*. 2006).

Cyclones and storms can cause physical damage to the sea floor and seagrass beds. The passage of tropical cyclone Vance through the middle of Exmouth Gulf in 1999 is believed to have caused extensive damage to seagrass beds in that area. This may have been the reason for the decrease in dugong numbers in 2000, by an order of magnitude, from 1000 to 100 animals (Prince 2001). It is expected that climate change will change storm regimes in tropical regions across the globe. An increase in storm activity could result in an increase in turbidity and, in turn, a decrease in ultraviolet radiation levels, leading to smothering of seagrass plants (Hobday *et al*. 2006).

Rainfall and coastal salinity are also related to storm activity. Heavy rainfall during the tropical wet season (spring and summer) and associated with cyclones has the potential to increase sediment loads in coastal areas, through river flooding. In addition, while seagrasses can generally tolerate a wide range of salinity, it is thought that prolonged disturbance may affect community composition. Similarly, research indicates that increased wave exposure and wind speed may cause physical damage to seagrass beds and resuspend sentiments. This may also hinder the ability of seedlings to establish and grow, as pollination and seed dispersal depends on water movement (Hobday *et al*. 2006).

Sea level rise has the potential to increase turbidity in coastal waters through flooding and erosion. It is likely that sea level rise will result in a shift in seagrass distributions landward, with the loss of some deep water seagrass habitat (Hobday *et al*. 2006).

Commercial fishing

Interactions between dugongs and fisheries in the North-west Marine Region may include boat strikes and net entanglements. However, the Western Australian Government has introduced measures to avoid these interactions, including closures in certain areas, the use of by-catch reduction devices and observers on research vessels (Bunting 2002).

The major commercial and recreational fisheries in Shark Bay are prawn and scallop trawls, wet-lining and beach-seining. Neither of the latter two currently threaten dugongs, but there are minimal interactions with trawl nets. Shark Bay has been closed to commercial mesh

net fisheries since 1986. Recreational gill-netting is permitted but requires net attendance so is not expected to pose a threat (Marsh *et al*. 2002). Seagrass beds and other areas of sensitive habitat in Shark Bay have been closed to prawn and scallop trawling permanently (EA 2002b; Kangas *et al*. 2006).

Aquaculture operations in Shark Bay have the potential to disrupt seagrass habitat and displace dugongs, however, the conservation of seagrass habitat in Shark Bay has historically been considered a priority for the industry (DoF 2004). Aquaculture in Shark Bay is currently being reviewed by the Western Australian Department of Fisheries. The review will consider the *Shark Bay Management Paper for Fish Resources*, which includes a list of recommendations for aquaculture management to mitigate negative effects on protected species (DoF 2004).

Management of recreational and commercial fishery activities in Ningaloo Marine Park is detailed in the *Ningaloo Marine Park (Commonwealth Waters) Management Plan* (EA 2002a) and the *Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005–2015* (CALM 2005). Prawn trawling is permitted in Exmouth Gulf; however, it is excluded from shallow water areas and the Ningaloo Reef Marine Park. The Western Australian Department of Environment and Conservation frequently reviews measures to protect dugongs and their habitat in the marine park (Marsh *et al*. 2002).

Marine debris

The Australian Government is actively seeking to address threats to marine mammals, including dugongs. Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris is listed as a key threatening process under the EPBC Act. The Australian Government is currently developing a threat abatement plan that aims to minimise the impacts of marine debris on threatened marine species. Further information on the impacts of marine debris on threatened species is available at <www.environment.gov.au/biodiversity/threatened/publications/marine-debris.html>.

Indigenous use and hunting

Under Section 211 of the *Native Title Act 1993* Indigenous people with a native title right can legitimately hunt dugong to satisfy their personal, domestic or non-commercial communal needs. Limited hunting of dugongs still occurs in Shark Bay and along the Pilbara and Kimberley coasts, particularly at One Arm Point. The catch has not been quantified but is not considered to be a significant threat (Marsh *et al*. 2002). Research in the Torres Strait and Cape York areas indicate that high levels of dugong hunting in some areas may have an impact on neighbouring populations (Heinsohn *et al*. 2004). However, movements between major Western Australian populations and those in other northern Australian regions are unlikely (B. Prince pers. comm. 2007).

The Kimberley Land Council has set up a Land and Sea Management Unit to manage the land and sea country in the region. The unit has established partnerships between Traditional Owners, community organisations, governments and industry to manage projects in the Kimberley region, including marine resource management (NAILSMA 2006). The unit manages the Marine Turtle and Dugong Project, which it has established to monitor and manage turtle and dugong populations across Northern Australia.

In 2005, the *Sustainable Harvest of Marine Turtles and Dugongs in Australia – A National Partnership Approach* (DEH 2005) was established to support management of the hunting of turtles and dugongs in order to contribute to the conservation of these species while maintaining traditional cultural practices. Further information is available at <www.environment.gov.au/coasts/publications/turtle-harvest-national-approach.html>.

Boat-related impacts and ecotourism

Recreational fishing and commercial boat-based dugong-watching occurs in Shark Bay. Ecotourism and recreational fishing in these waters is controlled by licensing under the *Conservation and Land Management Act 1984* and the *Western Australia Wildlife Conservation Act 1950*, and guided by a code of conduct developed by the Department of Environment and Conservation, Western Australia. Despite the strict guidelines, tourism vessels have been found to disturb dugongs from foraging or travelling in 37 per cent of observed encounters (Gerrard 1999). There have also been prosecutions for non-compliance, including for separating a mother and her calf, and for approaching a dugong too closely (Marsh *et al*. 2002).

Similarly, in Ningaloo Marine Park there is a high level of shore-based tourist boat activity within the vicinity of seagrass beds. This has the potential to affect dugong habitat as well as increase the risk of dugong boat

strikes. The Pilbara coast has one of the highest levels of boat ownership per capita in Australia, and this is likely to increase over time (Marsh *et al*. 2002). There have been reports of boat strikes in this region and along the Kimberley coast.

The effect of boat traffic on the feeding behaviour of dugongs has been studied outside the Region in Moreton Bay, Queensland. The results indicated that dugongs are less likely to continue feeding when boats pass at a distance of 50 m or less. The observed levels of boat traffic reduced feeding time by 0.6–8 per cent, which was not considered a substantial impact. However, an increase in boat traffic may lead to an increase in disturbance to feeding dugongs (Hodgson & Marsh 2007). An increase in boat traffic in the North-west Marine Region may have a similar impact on dugong populations.

Commercial underwater and aerial filming of dugongs occurs in Shark Bay and has the potential to affect dugongs, although this has not been investigated. The impacts of filming from helicopters and light aircraft may be difficult to manage in the absence of any regulatory control over airspace (Marsh *et al*. 2002).

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D7 North-west Marine Region Protected Species Group Report Card – Cetaceans

Current at May 2008. See <www.environment.gov.au/coasts/mbp/north-west> for updates.

General information

The order Cetacea includes more than 80 species of whales, porpoises and dolphins (IWC 2007a), divided into two suborders, the Mysteceti, or baleen whales, and the Odontoceti, or toothed whales. Baleen whales include species such as blue whales, humpback whales and minke whales and are generally characterised by their large size (10–30 m) and keratinous baleen plates that hang from the upper jaw and are used to filter krill, plankton and other prey items from seawater. Toothed whales include dolphins, porpoises, killer whales and sperm whales, and are active hunters, feeding on squid, fish and sometimes other marine mammals. Cetaceans are thought to have evolved from land mammals that adapted to marine life approximately 50 million years ago. Forty-five species of cetacean occur in Australian waters. Of these, 21 occur regularly in the waters of the North-west Marine Region, including eight species of whale and 13 species of dolphin (see Appendix C, Table 1).

Nationally protected species

All whales and dolphins that occur in Australian waters are protected under the EPBC Act through the establishment of the Australian Whale Sanctuary (see below). Ten species that occur in the North-west Marine Region are also listed under the EPBC Act as threatened and/or migratory (Table D7.1). The long-snouted spinner dolphin is also considered a priority species (Bannister *et al*. 1996); however, information on this species is too scarce to assign it to a conservation category (Ross 2006).

The Australian Government has established the Australian Whale Sanctuary to protect all whales and dolphins found in Australian waters. The Australian Whale Sanctuary is in the Commonwealth marine area and includes all of Australia's EEZ including the waters around Australia's external territories such as Christmas, Cocos (Keeling), Norfolk, Heard and Macdonald islands. Within the sanctuary, it is an offence to kill, injure or interfere with a cetacean. Further information on the Australian Whale Sanctuary can be found at <www.environment.gov.au/coasts/species/cetaceans/sanctuary.html>.

In addition, as a signatory to the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS), Australia has an international obligation to protect migratory species, their habitats and their migration routes. Similarly, as a party to the *Convention on the International Trade in Endangered Species of Wild Fauna and Flora* (CITES), Australia has agreed to control the import and export of an agreed list of species that are endangered, or at risk of becoming endangered, because of inadequate controls over trade in them or their products. Further information on CITES and CMS is included in Appendix A.

Australian snubfin dolphin. Photo: Guido Parra, University of Queensland.

Table D7.1 Cetaceans listed as threatened or migratory under the EPBC Act that are known to occur in the North-west Marine Region

Species	Conservation Status	Conservation Plans and Policies
Humpback whale (*Megaptera novaeangliae*)	Vulnerable, Migratory Listed under CITES (Appendix I) & CMS (Appendix I)	• *Interaction Between Offshore Seismic Exploration and Whales – EPBC Act Policy Statement 2.1* (DEW 2007) • *Review of the Conservation Status of Australia's Smaller Whales and Dolphins* (Ross 2006) • *Recovery Plans for Australia's Threatened Whales 2005–2010: Humpback; Southern Right; Blue, Fin and Sei* (DEH 2005) • *Australian National Guidelines for Whale and Dolphin Watching* (Australian Government 2005) • *The Action Plan for Australian Cetaceans* (Bannister *et al*. 1996)
Antarctic minke whale (*Balaenoptera bonaerensis*	Migratory Listed under CITES (Appendix I) & CMS (Appendix II)	
Bryde's whale (*Balaenoptera edeni*)	Migratory Listed under CITES (Appendix I) & CMS (Appendix II)	
Fin whale (*Balaenoptera physalus*)	Vulnerable, Migratory Listed under CITES (Appendix I) & CMS (Appendix I & II)	
Blue whale (*Balaenoptera musculus*)	Endangered, Migratory Listed under CITES (Appendix I) & CMS (Appendix I)	
Sperm whale (*Physeter macrocephalus*)	Migratory Listed under CITES (Appendix I) & CMS (Appendix I & II)	
Indo-Pacific humpback dolphin (*Sousa chinensis*)	Migratory Listed under CITES (Appendix I) & CMS (Appendix II)	
Spotted bottlenose dolphin (*Tursiops aduncus*)	Migratory Listed under CITES (Appendix II) & CMS (Appendix II) – Arafura/ Timor Sea population only	
Killer whale (*Orcinus orca*)	Migratory Listed under CITES (Appendix II) & CMS (Appendix II)	
Australian snubfin dolphin (*Orcaella heinsohni*)	Migratory Listed under CITES (Appendix I as *Orcaella brevirostris*) & CMS (Appendix II as *Orcaella brevirostris*)	

Ecology of protected species in the North-west Marine Region

Cetaceans found in the North-west Marine Region include truly pelagic species such as Antarctic minke whales, and spinner and striped dolphins that spend the majority of their time in the Commonwealth waters of the Region, as well as species such as Australian snubfin dolphins and Indo-Pacific humpback dolphins that are predominantly found in Western Australia State waters close to the coast. Sperm whales, false killer whales and short-finned pilot whales may be found around areas of upwelling and canyons on the continental shelf.

Many species are thought to be resident in the Region throughout the year. Resident populations of bottlenose and Indo-Pacific humpback dolphins are known from the Montebello Islands and the population of bottlenose dolphins in Shark Bay is a popular tourist attraction, as well as the subject of long-term behavioural studies (Mann *et al*. 2000; Watson-Capps & Mann 2005; Bejder *et al*. 2006). Family pods of female and juvenile sperm whales are likely to reside in the warm tropical waters of the Region throughout the year, while male sperm whales migrate south to feed in the waters of the Antarctic. While specific areas for sperm whales have not been identified in the Region, historical whaling records show they were commonly encountered offshore

in the southern parts of the Region (Townsend 1935; WCS 2006). The Australian snubfin dolphin (formerly known in Australian waters as the Irrawaddy dolphin) is also thought to be resident in shallow seagrass habitats in and adjacent to the Region. This species is newly described and may be endemic to Australian waters (Beasley *et al*. 2005).

The Region is an important migratory pathway between feeding grounds in the Southern Ocean and breeding grounds in tropical waters for several cetacean species. Blue whales, fin whales, dwarf and Antarctic minke whales may travel through the Region on their way to breeding grounds, which are thought to be in deep oceanic waters around the Indonesian archipelago, but have yet to be discovered. The North-west Marine Region is particularly important for the Western Australian population of humpback whales whose known breeding and calving grounds are between Broome and the northern end of Camden Sound (Jenner *et al*. 2001; DEH 2005).

Humpbacks migrate north from their Antarctic feeding grounds around May each year, reaching the waters of the North-west Marine Region in early June. Immature individuals and lactating females arrive first, followed by non-pregnant mature females and adult males, with pregnant females arriving last. Breeding and calving takes place between mid-August and early September when the southern migration starts. Females with calves are the last to leave the breeding grounds, stopping to rest in Exmouth Gulf and Shark Bay. The western Australian population of humpbacks (known as the Group IV population) is genetically distinct from the eastern Australian population, with very little exchange between the two, even in their Antarctic feeding grounds (Baker *et al*. 1993).

Humpbacks are thought not to feed while visiting the Region, however, other baleen whales may feed on tropical krill species, such as *Pseudeuphausia latifrons*, while in the Region. Toothed whales and dolphins are significant predators of cephalopods (squid, octopus and cuttlefish), fish and crustaceans (krill, amphipods and copepods) with some species diving to take deep water prey at depths of more than 1500 m. Others move to feed offshore at night when deep-living organisms, usually schools of fish, migrate to the surface. Killer whales have been known to attack humpback whales, particularly calves, and may be attracted to the Region during the humpback breeding migration, although records of killer whale attacks on humpbacks are rare (Flórez-González *et al*. 1994).

Mixed species feeding aggregations are known to occur among common, bottlenose, Risso's and rough-toothed dolphins as well as melon-headed and pilot whales. Groups of spinner and spotted dolphins also commonly associate with tuna and seabirds. To the south of the Region, blue, fin and possibly sei whales aggregate to feed in the Perth Canyon. Similarly, Australian snubfin and Indo-Pacific humpback dolphins share similar habitat preferences in inshore waters (Parra 2006).

Important areas for cetaceans in the North-west Marine Region

Threatened and migratory species are considered matters of national environmental significance. Important areas in the North-west Marine Region are identified for species listed as threatened or migratory under the EPBC Act. A number of areas in or adjacent to the Region are of particular importance for cetacean species listed as threatened or migratory, including:

Shark Bay – An important resting area for migrating humpbacks, particularly for females and calves on their southward migration. Resident populations of bottlenose dolphins.

Exmouth Gulf – An important resting area for migrating humpbacks.

Wallaby Saddle – Possible aggregation area for sperm whales (DEWHA 2008).

Montebello and Barrow islands – Resting area for migrating humpbacks. Resident populations of common bottlenose and Indo-Pacific humpback dolphins.

Roebuck Bay – Important feeding area for Australian snubfin dolphins and other inshore dolphin species (Thiele 2008).

Quondong Point – Appears to be a migratory waypoint and high density area for northbound humpback whales as well as false killer whales, pygmy blue whales and a number of dolphin species (DEWHA 2008).

Kimberley coast north of Broome – The Kimberly coast from Broome to north of Camden Sound is the main calving area for the west Australian population of humpback whales. High concentrations of humpbacks are observed in Camden Sound and Pender Bay between

June and September each year. Shallow coastal waters and estuaries along the Kimberley coast, particularly Beagle and Pender bays on the Dampier Peninsula and tidal creeks around Yampi Sound and between Kuri Bay and Cambridge Bay are important areas for Australian snubfin dolphins and Indo-Pacific humpback dolphins.

Browse Island – Offshore waters surrounding Browse Island support a larger number of cetacean species than any other area on the Western Australian coast, including large pods of oceanic dolphins, pygmy killer whales, false killer whales, melon-headed whales, minke whales and pilot whales (Jenner & Jenner 2007). Upwellings around Browse Island are likely to be a feeding area for blue whales migrating to Indonesia. Unconfirmed sightings of humpback whales feeding have also been reported from waters around Browse Island. This observation is significant as humpbacks are currently known to feed only in Antarctic waters, but further investigation is necessary (DEWHA 2008).

Scott Plateau – Historically a sperm whale aggregation area. Possible breeding and feeding area for beaked whales (DEWHA 2008).

Known interactions, threats and mitigation measures

All cetaceans in the North-west Marine Region are protected within the Australian Whale Sanctuary under the EPBC Act, making it an offence to kill, injure, take or interfere with (defined as 'harass, chase, herd, tag, mark or brand') a whale or dolphin in Commonwealth waters. However, cetaceans in the Region may interact with human activities in a number of ways. Specific human activities that may pose a threat to cetaceans in the Region are detailed below:

Whaling

Commercial whaling had a significant impact on the western Australian population of humpback whales in the early 20th century. Two whaling stations operated intermittently in the North-west Marine Region between 1912 and 1955. Norwegian whalers operated the Norwegian Bay whaling station on Point Cloates between 1912 and 1916 and again between the early 1930s and World War II. In 1949, the station was reopened by the Nor' West Whaling Company and operated until 1955. The Australian Government operated a whaling station at Babbage Island near Carnarvon between 1950 and 1955. It is estimated that between the whaling stations at Carnarvon, Point Cloates and the Cheyne's Beach Whaling Company at Albany, 18 000 whales were killed and processed between 1949 and 1963 (Egan 1995).

When the International Whaling Commission banned humpback whaling in 1963, it is estimated that the western Australian population of humpbacks had been reduced to about 800. However, recent information on illegal Soviet whaling up until the 1970s (Clapham *et al*. 2005) could mean that the figure was probably much lower by 1985 when the commission imposed an international moratorium on all commercial whaling. In 1999, the western Australian humpback population was estimated at between 8000 and 14 000 and increasing at a rate close to the biological maximum of just above 10 per cent annually (DEH 2005).

Whaling is not currently a threat to most species; however, Antarctic minke whales and fin whales, which are thought to migrate through the Region, are still targeted by the Japanese scientific whaling program with 856 minke whales and 10 fin whales killed during the 2005/06 season. Fifty fin whales, 50 humpback whales and 935 minke whales are proposed to be taken annually in the JARPA II scientific whaling program starting in the summer of 2007/2008. However the humpback take has since been suspended. No fin whales and only 551 minke whales were taken during the first season. Humpback whales are expected to be included in the program in the future and it is likely that western Australian animals will be among those targeted. As populations recover, pressure may increase for the moratorium on commercial whaling to be lifted.

Outside the Region, sperm whales, short-finned pilot whales and some dolphin species (e.g. spinner, spotted, striped, rough-toothed) are hunted in Japan, Indonesia and Sri Lanka. The large-scale movements of these species mean that the Australian populations may be killed outside of Australian waters.

Commercial fishing

Interactions between cetaceans and fisheries in the North-west Marine Region may include depredation of catch (i.e. the removal of hooked fish or bait from longlines), feeding on discarded by-catch, entanglement in gear, or injury or death through incidental capture or boat strikes.

The Western Tuna and Billfish Fishery (DEH 2004), which encompasses the whole of the North-west Marine Region, reports that depredation, or the removal of

hooked fish or bait from longlines, is a growing problem in the fishery. Killer whales, false killer whales, short-finned pilot whales and rough-toothed dolphins are all known to depredate longlines, increasing the risk of injury or capture. In addition, there are anecdotal reports of instances where animals robbing longlines have been shot by fishers. Research into possible mitigation measures, such as avoiding areas of high biological productivity, retaining offal, acoustic deterrents and the use of quieter engines is underway (AFMA 2005).

Dolphins actively feed on discards from the Northern Prawn Fishery (DEH 2003), part of which extends into the north-eastern part of the Region. Floating discards are scavenged by species including dolphins. Discarding in areas of regular trawling may affect dolphin and shark populations as discards concentrate in smaller areas within the foraging range of the scavengers. Provisioning of animals is an issue of concern and the impacts of increasing populations of some species beyond their natural capacity may have implications for the ecosystem as a whole. However, as a result of a reduction in effort to protect prawn stocks, discards have also been reduced (DEH 2003).

Interactions with dolphins are a serious issue for the Pilbara Fish Trawl Interim Managed Fishery, which operates almost entirely in the Region (DoF 2006). In 2005, before the implementation of mitigation measures, 56 interactions with dolphins were reported, 52 of which were deaths. In the first half of 2006, a further 23 dolphin interactions were reported in the fishery, 21 of which were deaths (DEW 2007). A by-catch action plan for the fishery is currently being developed (DoF 2006) and mitigation measures such as 'pingers' and by-catch reduction grids are being trialled. In 2006, by-catch reduction grids became mandatory for all trawl operators in the Pilbara Fish Trawl Managed Fishery. Further information on dolphin interactions with the fishery is being collected through an observer program and the use of underwater cameras.

Australian snubfin and Indo-Pacific humpback dolphins are vulnerable to gill-nets targeting barramundi and other fish species in the river and estuarine parts of their range. The overfishing of their prey species is also expected to be an increasing problem for these species (Ross 2006).

Rough-toothed, spinner and spotted dolphins are known to form feeding associations with yellowfin tuna (*Thunnus albacares*). As such, purse seine netting by tuna fleets, particularly in the eastern tropical Pacific Ocean, has been a major threatening process for these species. However, purse seine fishing is not currently a significant problem in the North-west Marine Region, as no fisheries in the Region currently use this fishing method.

Aquaculture and pearling

Aquaculture activities and equipment may be a source of interaction with cetaceans, particularly smaller species of whales and dolphins, often with negative impacts. Some types of aquaculture may negatively affect the marine environment through the introduction of exotic species, diseases, antibiotics and medicines, increased deposition of organic and faecal matter, and disruption of benthic communities. Cetaceans may also become entangled in aquaculture installations (Watson-Capps & Mann 2005). Outside of the Region, 29 dolphins died between 1990 and 1999 after becoming entangled in tuna feedlots at Port Lincoln, South Australia (Kemper & Gibbs 2001). In a study of the impact of aquaculture on cetaceans in Shark Bay, adjacent to the Region, Watson-Capps & Mann (2005) showed that dolphins may avoid aquaculture installations resulting in displacement from preferred habitat.

Tourism

Whale-watching is a growing industry in Australia and around the world. In Australia between 1994 and 1998, the industry grew by an average of 15.9 per cent per year (Hoyt 2001). In 1998, there were 89 commercial whale-watching operations in Western Australia, including two 'swim-with-dolphins' operations. The population of bottlenose dolphins at Monkey Mia in Shark Bay, adjacent to the North-west Marine Region, has been habituated to human interactions through food provisioning since the 1960s and attracts visitors from all over the world. Almost 90 per cent of Shark Bay's 100 000 annual visitors come to see the dolphins (Mann & Kemps 2003).

Interactions with the dolphins have been managed by the West Australian Government since 1986 and feeding has been restricted to 2 kg of fish per dolphin per day since 1989 (Mann & Kemps 2003). Feeding was further restricted in 1995 after several negative effects of provisioning were observed. Some calves became dependent on human provisioning and failed to learn to forage effectively for themselves. Some mothers were distracted from defending their calves from predators, and habituation to humans and human activities increased the chance of entanglements or

injuries. In addition, death of calves whose mothers were provisioned was almost twice as high as calves whose mothers were not provisioned (Mann *et al*. 2000). Changes to the feeding policy have reduced death rates among provisioned calves, however further research has shown that provisioning may still affect maternal care (Mann & Kemps 2003).

More generally, repeated disruption to breeding, social, feeding or resting behaviour can have deleterious effects on reproductive success, health, distribution and ranging patterns, or access to preferred habitat (Bejder & Samuels 2003). Bejder *et al*. (2006) showed a decline in dolphin abundance in Shark Bay during a period of increased exposure to tourist vessels. They suggested that the dolphins were shifting habitat to avoid vessel disturbance. Similarly, Van Parijs & Corkeron (2001) found that noise from boat traffic affected group cohesion among Indo-Pacific humpback dolphins and that mother-calf pairs were particularly sensitive to disturbance. With increasing numbers of humpback whales migrating through the Region, there is likely to be increasing interest in this species from commercial and recreational whale-watching operations.

In response to concerns regarding the impact of the growing cetacean-watching industry, the Australian Government and all State and Territory governments jointly developed the *Australian National Guidelines for Whale and Dolphin Watching 2005*, which can be found at <www.environment.gov.au/coasts/publications/whale-watching-guidelines-2005.html>. These guidelines apply equally to commercial and recreational whale-watching and have the dual aims of:

- minimising harmful impacts on whales, dolphins and porpoises; and
- ensuring that people have the best opportunity to enjoy and learn about the whales, dolphins and porpoises found in Australian waters.

Additional management measures such as regulations, permits, licenses and management plans may apply to areas that are particularly important to the survival of cetacean species or areas that support a substantial whale or dolphin-watching industry. Authorisation from the relevant State, Territory or Australian government is also required to approach cetaceans closer than outlined in the guidelines, for scientific or educational purposes, or for commercial filming.

Oil and gas industry

The oil and gas industry is one of the most significant human activities in the North-west Marine Region. Several aspects of oil and gas exploration and development have, or are likely to have, impacts on cetaceans in the Region. In particular, the use of seismic survey techniques has raised concern over the potential negative effects on whales. Seismic hydrocarbon surveys involve the use of high-energy noise sources operated in the water column to determine the composition of rock strata beneath the seafloor. Research has shown that migrating humpback whales exhibit a startle response to seismic survey sounds and will move to avoid a seismic vessel at a distance of around 3 km. Resting mothers with calves are particularly sensitive and will show an avoidance response at approximately 7–12 km from the seismic source (McCauley *et al*. 2000). Such avoidance behaviour could result in displacement from resting areas, migration routes or feeding or breeding areas. Baleen whales such as humpback, blue and fin whales may be especially vulnerable to negative effects from seismic surveys because their acoustic range operates in the same low frequency. Studies on the relationship between military sonar operations and whale strandings indicate that beaked whales may also be particularly sensitive to acoustic trauma (Frantzis 1998). It is possible that extremely close encounters may cause damage to ears.

Seismic operations are regulated by the Australian Government's *Interaction Between Offshore Seismic Exploration and Whales, EPBC Act Policy Statement 2.1* (see <www.environment.gov.au/epbc/publications/seismic.html>). The guidelines outline standard management procedures for conducting seismic surveys in areas and at times when the likelihood of encountering cetaceans is low, as well as procedures that aim to reduce interference with cetaceans when the likelihood of encounters are moderate to high. Other actions that are likely to interfere with whales may also require permits under the EPBC Act.

Shipping

Shipping in the North-west Marine Region is dominated by traffic from the ports of Dampier, Port Hedland and, to a lesser extent, Broome. Dampier and Port Hedland are the largest tonnage ports in Australia and are being expanded to accommodate an anticipated increase in iron ore and oil and gas exports (DPI 2006). Ship strikes are likely to affect the larger cetaceans in the Region, in particular, humpback whales whose migratory path

intersects major shipping routes from both Dampier and Port Hedland ports (Western Australian Government 2006). In 2005, the International Whaling Commission established a Ship Strike Working Group to examine the extent of ship strikes and possible mitigation measures. Since then, one ship strike of a sub-adult humpback whale has been reported from the Region (IWC 2007b). Worldwide, fin whales are killed by ship strike more than any other species (Laist *et al*. 2001), probably because of their surface-feeding behaviour. The coastal nearshore distribution of Australian snubfin dolphins and Indo-Pacific humpback dolphins also makes these species extremely vulnerable to interactions with vessel traffic.

Marine debris

The injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris is listed as a key threatening process under the EPBC Act. Entanglement in marine debris such as discarded fishing gear can lead to restricted mobility, starvation, infection, amputation, drowning and smothering. The ingestion of plastic and other marine debris can cause physical blockages leading to starvation, or injuries to the digestive systems of cetaceans leading to infection or death. Cuvier's beaked whales are thought to be particularly susceptible to ingestion of anthropogenic marine debris because of their suction foraging technique. Outside of the Region, an autopsy on a stranded Bryde's whale found almost 6 m^2 of plastic in the whale's stomach (more information is at <www.environment.gov.au/coasts/publications/cetacean-poster.html>).

The Australian Government is currently developing a threat abatement plan that aims to minimise the impacts of marine debris on threatened marine species. Further information on the impacts of marine debris on threatened species is available at <www.environment.gov.au/biodiversity/threatened/publications/marine-debris.html>.

Water pollution

Toxic contaminants such as heavy metals and synthetic compounds (e.g. organochlorines) may enter the marine environment through soil erosion and agricultural and industrial run-off. Organochlorines are commonly used in insecticides and, while usually only found at very low concentrations in seawater, they can accumulate up the food chain to toxic levels (EA 2002). Organochlorines are soluble in fat and heavy doses may be passed to offspring through mothers' milk. Concentrations of organochlorines and other toxic contaminants have been found in marine mammals throughout the world, including sperm whales off Tasmania and dolphins off South Australia (Evans *et al*. 2004; Correll *et al*. 2004). It is thought that organochlorines and other toxins may have deleterious effects on the immune, endocrine and nervous systems of cetaceans and may contribute to mass mortality events and strandings. Species with an inshore distribution such as Australian snubfin dolphins and Indo-Pacific humpback dolphins may be particularly vulnerable to changes in water quality.

Climate change

The long-term effects of global warming on marine species are still speculative, however it is predicted that both habitat and food availability will be affected by increasing ocean temperatures, changing ocean currents, rising sea levels and reductions in sea ice. Such changes may affect current migration routes, feeding areas and calving grounds, rendering current habitat unsuitable. Similarly, changes to climate and oceanographic processes may lead to decreased biological productivity and different patterns of prey distribution and availability (DEH 2005).

Threats to cetaceans listed as endangered or vulnerable are addressed in the objectives of the *Recovery Plans for Australia's Threatened Whales* (DEH 2005). The objectives of the recovery plans are:

- the recovery of populations of whales utilising Australian waters so that each of the five species can be considered secure in the wild;
- a distribution of each species of whale in Australian waters that is similar to the pre-exploitation distribution; and
- to maintain the protection of each species of whale from human threats.

To achieve these objectives, the recovery plans recommend the implementation of programs to measure population abundance and trends; to better define the characteristics of calving, feeding and migratory areas; to manage and monitor threats to important habitat and prey availability; and to monitor climate and oceanographic change. More information on the recovery plans for humpback, blue, fin and sei whales can be found at <www.environment.gov.au/coasts/species/cetaceans/protecting.html#plans>.

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Abbreviations and Acronyms

ABS Australian Bureau of Statistics

ACAP The Agreement on the Conservation of Albatross and Petrels

ACMA Australian Communications and Media Authority

AFMA Australian Fisheries Management Authority

AMSA Australian Maritime Safety Authority

ANZECC Australian and New Zealand Environment and Conservation Council

ANZECC TFMPA Australian and New Zealand Environment and Conservation Council, Task Force on Marine Protected Areas

APEC Asia-Pacific Economic Cooperation

APPEA Australian Petroleum Production and Exploration Association

ATO Australian Taxation Office

AWSG Australasian Wader Studies Group

BPA Broome Port Authority

BPC Border Protection Command

CALM Department of Conservation and Land Management – Western Australia

CAMBA *Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986*

CCSBT Commission for the Conservation of Southern Bluefin Tuna

CITES Convention on International Trade in Endangered Species of Wild Fauna and Flora

CMS Convention on Migratory Species (also known as the *Convention on the Conservation of Migratory Species of Wild Animals* or the Bonn Convention)

COP Conference of the Parties

CSIRO Commonwealth Scientific and Industrial Research Organisation

DAFF Australian Government Department of Agriculture, Fisheries and Forestry

DEC Department of Environment and Conservation – Western Australia

DEH Department of the Environment and Heritage

DEW Department of the Environment and Water Resources

DEWHA Department of the Environment, Water, Heritage and the Arts

DIA	Department of Indigenous Affairs,
DoF	Department of Fisheries - Western Australia
DoIR	Department of Industry and Resources – Western Australia
DPA	Dampier Port Authority
DPI	Department of Planning and Infrastructure – Western Australia
DITR	Department of Industry, Tourism and Resources
EA	Environment Australia
EEZ	Exclusive Economic Zone
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FAO	United Nations Food and Agriculture Organisation
FPSO	Floating Production, Storage and Offloading vessel
FSO	Floating Storage and Offloading vessel
GA	Geoscience Australia
GBRMPA	Great Barrier Reef Marine Park Authority
GVP	Gross Value of Production
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
IOSEA	Marine Turtle MoU Indian Ocean - South-East Asian Marine Turtle Memorandum of Understanding
IOTC	Indian Ocean Tuna Commission
IRC	International Risk Consultants Pty Ltd
IUCN	International Union for the Conservation of Nature and Natural Resources (World Conservation Union)
IWC	International Whaling Commission
JAMBA	*Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment 1974*
KLC	Kimberley Land Council
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MARPOL	*International Convention for the Prevention of Marine Pollution from Ships, 1973*, as modified by the Protocol of 1978 relating thereto
MoU	Memorandum of Understanding

MPA Marine Protected Area

Mtpa Million tonnes per annum

NAILSMA North Australian Indigenous Land and Sea Management Alliance

NWMR North-west Marine Region

NWSV North West Shelf Venture

NT Northern Territory

ONT Office of Native Title

PHPA Port Hedland Port Authority

PPAA Pearl Producers Association Australia

QPWS Queensland Parks and Wildlife Service

QEPA Queensland Environmental Protection Agency

Ramsar *Convention on Wetlands of International Importance* (Ramsar Convention 1971)

ROKAMBA *Agreement between the Government of Australia and the Government of the Republic of Korea- on the Protection of Migratory Birds, 2007*

SEA_ME_WE3 South East Asia, Middle East and Western Europe submarine cable 3.

TACC Total Allowable Commercial Catch

Tcf Trillion cubic feet

UNCLOS United Nations Convention on the Law of the Sea

WA Western Australia

WCS Wildlife Conservation Society

Glossary

abyssal plain

The flat, relatively featureless bottom of the deep ocean at a depth greater than 2000 m. The average depth of the abyssal floor is about 4000 m.

amphipod

A small crustacean belonging to the order Amphipoda.

anthropogenic

Of human origin or resulting from human activity.

ascidians

Members of the class Ascidiacea (sea squirts).

bathymetry

The measurement of ocean depths to determine the sea floor topography.

bêche-de-mer

See trepang/sea cucumber.

benthic/benthos

Refers to all marine organisms living on or within the seafloor.

biodiversity

The totality of genes, species, and ecosystems in a region or the world. The variability among living organisms from all sources (including terrestrial, marine and other ecosystems), which includes diversity within species and between species and diversity of ecosystems.

biofouling

Biofouling (biological fouling) is the accumulation of plants, animals and micro-organisms on submerged structures such as ships' hulls, wharves, oil rigs, and even on other organisms.

biogeographic

Relating to large regions with distinct fauna and flora.

biological or ecological productivity

The ability of an ecosystem to produce, grow or yield products such as food.

biomass

The quantity of organic matter within an ecosystem (usually expressed as dry weight for unit area or volume).

biome

Community type e.g. biomes of demersal fish species.

bioregion (see also province/provincial bioregion)

A large area of the ocean that is classified as having similar types of plants, animals and ocean conditions, compared to other similarly-sized areas. For the purpose of this document, 'bioregion' means provincial bioregion as defined in the Integrated Marine and Coastal Regionalisation of Australia (IMCRA) Version 4.0.

biota

All of the organisms at a particular locality.

bioturbation

The disturbance and mixing of sediment layers by biological activity (plants or animals).

by-catch

Species taken incidentally in a fishery where other species are the target.

bryozoans

Sessile, filter-feeding marine animals. The majority are encrusting, forming flat sheets that spread out over the substrate, but others grow upwards into the water column.

carbonate reefs/banks

Reefs or banks whose structure primarily consists of calcium carbonate.

cetaceans

Members of the mammalian group Cetacea, including whales, dolphins and porpoises.

Commonwealth waters

The Commonwealth marine area, which includes 'Commonwealth waters' is defined in the EPBC Act as 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 three nautical miles from the territorial sea baseline to the outer limit of the Exclusive Economic Zone, 200 nautical miles from the baseline. The territorial sea baseline is normally the low water mark along the coast.

connectivity corridors

Corridors connecting habitat patches that enable organisms to disperse. Connectivity corridors increase the amount of habitat that is available for species and effectively reverse habitat fragmentation. They are necessary because they maintain biodiversity, allow populations to interbreed, and provide access to larger habitats. In the Australian marine bioregional planning context, the size and shape of Marine Protected Area boundaries should be orientated to account for inclusion of connectivity corridors and biological dispersal patterns within and across MPAs.

conservation dependent (see also: threatened species)

The definition of a conservation dependent species in the EPBC Act (Section 179) is: "A native species is eligible to be included in the conservation dependent category at a particular time if, at that time:

(a) the species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered; or

(b) the following subparagraphs are satisfied:

(i) the species is a species of fish;

(ii) the species is the focus of a plan of management that provides for management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long term survival in nature are maximised;

(iii) the plan of management is in force under a law of the Commonwealth or of a State or Territory;

(iv) cessation of the plan of management would adversely affect the conservation status of the species."

conservation values (see marine conservation values)

continental rise

The gently sloping surface located at the base of a continental slope.

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.

convergence front

An interface or zone of transition between two dissimilar water masses.

copepod

Any small, aquatic crustacean belonging to the subclass Copepoda.

coralline algae

Coralline algae are red algae characterized by a body that is hard as a result of calcareous deposits contained within the cell walls. Many are typically encrusting and rock-like, found in tropical marine waters all over the world. They play an important role in the ecology of coral reefs. Sea urchins, parrot fish, limpets (molluscs) and chitons molluscs feed on coralline algae.

critically endangered (see also: threatened species)

The definition of a critically endangered species in the EPBC Act (Section 179) is:

"A native species is eligible to be included in the critically endangered category at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria."

crustacea/crustaceans

A class of arthropods that have gills and bodies covered by a hard shell (e.g. crabs, lobsters, shrimps).

demersal

Living on or near the bottom of the sea.

deposit feeders

Animals such as worms, molluscs, echinoderms and crabs that feed on particles of living or dead organic matter found in or on the sediments.

detritivores

Animals or plants that consume decomposing organic matter and in doing so contribute to decomposition and recycling of nutrients.

detritus

Any loose, unconsolidated debris that is either finely divided rock or the finely divided remains of animal or plant tissue, or both.

East Asian-Australasian Flyway

A migratory pathway for wader and shorebirds stretching from Russia and Alaska in the northern

hemisphere to Australia and New Zealand in the southern hemisphere. The Flyway covers much of eastern Asia, including China, Japan, Korea, South-East Asia and the western Pacific. It is especially important for the millions of migratory waders or shorebirds that breed in northern Asia and Alaska and spend the non-breeding season in South-East Asia and Australasia. In total, the flyway passes through 22 countries with approximately 55 migratory species travelling along it, equating to about 5 million birds.

echinoderms/echinoids

Echinoderms include starfishes, sea cucumbers, sand dollars, brittle-stars, basket stars, sea lilies, feather stars, and sea urchins. Echinoids are a group (class) of echinoderms including sea urchins, heart urchins and sand dollars. They are spiny and globular to disc-like in shape.

eddies

Circular movements of water formed on the side of a main current.

elasmobranch

A cartilaginous fish of the subclass Elasmobranchii, which includes skates, rays and sharks.

El Niño Southern Oscillation (see also: La Niña)

The El Niño phenomenon is an unpredictable warming of surface ocean waters in the eastern tropical Pacific (off Peru) and cooling of western tropical Pacific waters that is caused by a sustained drop in air pressures over the south-eastern Pacific Ocean due to the Southern Oscilllation: a pattern of reversing surface air pressure between the eastern and Asian Pacific regions. When the surface pressure is high in the eastern tropical Pacific it is low in the western tropical Pacific and vice versa. El Niño is often associated with drier than normal conditions in northern and eastern Australia.

endangered species (see also: threatened species)

The definition of an endangered species in the EPBC Act (Section 179) is:

"A native species is eligible to be included in the endangered category at a particular time if, at that time:

(a) it is not critically endangered; and

(b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria."

endemic/endemism

Native to a particular area and found nowhere else. Uniqueness.

epibenthic

Living on top of the sea floor. Epibenthic organisms may be freely moving (motile) or permanently attached to a surface (sessile).

epifauna

Animals living attached to rocky reefs or on the seafloor. They include hydroids, sea-pens, small bryozoans and sponges. (Compare to infauna).

euphotic

The euphotic zone (also known as the photic zone or epipelagic zone) is the depth of the water in a lake or an ocean that is exposed to sufficient sunlight for photosynthesis to occur. It extends from the surface down to a depth where light intensity falls to one per cent of that at the surface (also called euphotic depth). The depth of the euphotic zone is greatly affected by turbidity; euphotic depths vary from only a few centimetres in highly turbid lakes and estuaries, to about 200 m in the open ocean.

eutrophic

Refers to any environment with high levels of nutrients, usually in the form of compounds containing nitrogen or phosphorus. This may lead to an increase in the ecosystem's primary productivity. (Compare to oligotrophic).

Exclusive Economic Zone

The sovereign waters of a nation, recognized internationally under the United Nations Convention on the Law of the Sea as extending out 200 nautical miles from shore.

fauna

The entire group of animals found in an area.

filter-feeder

Animals that feed by straining suspended particles from water (also known as suspension feeders). Some animals that use this method of feeding are corals, krill, sponges and whale sharks.

finning

The practice of removing the fins from shark species and discarding the bodies into the sea.

flagship species

Species that have a strong association with the Region and its habitats. The concept of flagship species is not legislative, and does not change the conservation status the species may have, nor does it change associated provisions under the EPBC Act. Identifying flagship species for a Region is useful for education purposes and to raise awareness about marine conservation among the public. Flagship species of the North-west Marine Region are the humpback whale (Western Australian population), whale shark, flatback turtle, olive sea snake, lesser frigatebird, manta ray and trochus shell.

flora

The entire group of plants found in an area.

Foraminifer/foram

Members of the order Foraminifera, a large group of mainly marine single-celled organisms with calcareous shells (called tests) perforated by small holes.

genus

The scientific grouping of plants and animals immediately above the species level; when combined with the species name this provides a unique identifier for a plant or animal in scientific nomenclature (plural: genera).

geomorphology

The study of landforms and the processes which shape them.

gobiid fish

Any species of fish from the family Gobiidae, one of the largest families of fish. Gobies are carnivorous, usually small in size, and found throughout the world.

gorgonians

A gorgonian, also known as sea whip or sea fan, is a marine invertebrate animal, belonging to the phylum Cnidaria. Gorgonians are found throughout the oceans of the world, especially in the tropics and subtropics, and form colonies that are normally erect, flattened, branching, and reminiscent of a fan. Others may be whiplike, bushy, or even encrusting. A colony can be several feet high and across but only a few inches thick.

Holocene

The geological period of time between the present and 10 000 years before the present.

hotspot

Biodiversity hotspots are areas that support an unusually diverse array of organisms.

hydrocarbon seep

The seeping of gaseous or liquid hydrocarbons (including oil and methane) to the surface of the seabed from fractures and fissures in the underlying rock.

Indonesian Throughflow

An oceanographic current that brings warm water of low salinity from the tropical western Pacific Ocean between the Indonesian islands to the Indo–Australian basin.

infauna

Animals that inhabit the sandy or muddy surface layers of the ocean bottom, i.e., those that live buried or dig into the substrate. (Compare to epifauna).

internal tides (also known as barotropic tides)

Internal tides occur at the delineation between water bodies with marked differences in density. They are large in scale, frequently occurring across an ocean basin and, in common with normal tides, forced by the gravitational pull of the moon and sun. The internal tide can rise and fall at a different rate to the surface tide, but they most commonly have a semi-diurnal (twice daily) frequency and may travel either towards the shore, or away from the shore across the shelf and out into deeper water

internal waves

Internal waves are dynamic, episodic events, which are strongly influenced by topography and generated by internal tides. For internal waves to form, the seafloor topography must have a significant change in water depth over a relatively short distance, such as over the continental slope or shelf break. Internal waves can be tens of kilometres long, with a crest of up to 75 m.

invertebrates

An animal without a backbone composed of vertebrae (e.g. insects, worms, snails, mussels, prawns and cuttlefish).

isobath

A mapping line connecting points of equal depth below the sea's surface.

key ecological features

Conservation values identified within Commonwealth waters to help inform decisions affecting the marine environment in each Marine Region. Key ecological features are not specifically protected under the EPBC Act, although the Commonwealth marine environment as a whole is a matter of national environmental significance under the Act.

krill

Shrimp-like marine euphausiid crustaceans, dense swarms of which occur in ocean waters. They feed on diatoms and themselves comprise the main food of filter-feeding whales. Krill are up to 5 cm in length and are found in both surface and bottom waters.

La Niña (see also: El Niño)

La Niña is the normal pattern of surface ocean water circulation in the tropical Pacific Ocean that occurs whenever El Niño is not taking place. During La Niña, the waters of the western tropical Pacific (off northern Australia and Papua New Guinea) are 3–8°C warmer than those of the eastern tropical Pacific. La Niña is often associated with above average rainfall in eastern Australia.

macro-algae

The algae are a major group of 'plants'; they are plants without a vascular or 'vein' system, living in fresh or marine waters. Macro-algae are the large, visible algae, such as kelps, as opposed to micro-algae, the microscopic algae that form phytoplankton.

macroplankton

The component of plankton that consists of large organisms (plant or animal) 2-20 cm in size.

macrophytes

Large water plants.

marine conservation values

Marine conservation values are defined for the purpose of marine bioregional planning as including:

(a) Protected species and communities, including: (i) species and communities listed as threatened under the EPBC Act; (ii) species listed as migratory under the EPBC Act; (iii) cetaceans (including all whales, dolphins and porpoises) under the EPBC Act; and (iv) species listed as marine species under the EPBC Act;

(b) Key ecological features of the marine environment, including: (i) species and communities considered to play an important ecological role in the Region; and (ii) habitats or areas considered to be ecologically important at a regional scale; and

(c) Protected places, including: (i) heritage places (including World Heritage, National Heritage and Commonwealth Heritage); (ii) historic shipwrecks; (iii) Commonwealth marine reserves; and (iv) listed critical habitats.

Marine Protected Area

Any area of intertidal or subtidal terrain, together with its overlying water and associated plants, animals, historical, or cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment.

marine reserve

A marine protected area that is highly protected, and is effective as a complete sanctuary; no extractive uses are permitted, and very few (or no) other human uses (including scientific research) are permitted.

marine species (listed)

A marine species included in the list referred to in Section 248 of the EPBC Act.

The list contains the following:

(a) all species in the family Hydrophiidae (sea-snakes);

(b) all species in the family Laticaudidae (sea-snakes);

(c) all species in the family Otariidae (eared seals);

(d) all species in the family Phocidae ("true" seals);

(e) all species in the genus Crocodylus (crocodiles);

(f) all species in the genus Dugong (dugong);

(g) all species in the family Cheloniidae (marine turtles);

(h) the species Dermochelys coriacea (leatherback turtles);

(i) all species in the family Syngnathidae (seahorses, sea-dragons and pipefish);

(j) all species in the family Solenostomidae (ghost pipefish); and

(k) all species in the class Aves (birds) that occur naturally in Commonwealth marine areas.

megabenthic/megabenthos

Large invertebrates living upon or in the bottom of the sea, such as clams, sea stars, sea cucumbers, crabs and lobsters.

meiofauna

Meiofauna are small benthic invertebrates that live in both marine and fresh water environments. The term Meiofauna loosely defines a group of organisms by their size, larger than microfauna but smaller than macrofauna, rather than a taxonomic grouping.

meso-scale

Of intermediate size (e.g. hundreds of kilometres).

micro-algae

Microscopic algae and diatoms which form the base of the ocean food chain; sometimes called microphytes.

micro-organism

A microscopic organism (animal or vegetable).

migratory species (listed)

A migratory species included in the list referred to in Section 209 of the EPBC Act. Under the Act, migratory species has the meaning given by Article 1 of the Bonn Convention: "the entire population, or any geographically separate part of the population, of any species or lower taxon of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries".

MoU Box

A Memorandum of Understanding (MoU) exists between Indonesia and Australia which provides for continued Indonesian traditional fishing activities in an area known as the MoU Box. The MoU Box is an area 50 000 km^2 within the Australian Exclusive Economic Zone (EEZ). Six coral reef systems exist within the MoU Box, including Ashmore and Cartier Reefs (in the north of the area) and the Scott and Seringapatam reefs.

myctophids

Lanternfish: large family of marine, mainly deep-water, fish, which have a slender and compressed body, a single dorsal and adipose fin, and a distinct anal fin. The mouth and eyes are large. Generally small fish, they are probably the most abundant deep-sea fish, occurring in schools at depths exceeding 500 m during the day, but sometimes found near the surface at night.

national environmental significance (matters of)

The matters of national environmental significance listed under the EPBC Act include: listed threatened species and communities; listed migratory species; Ramsar wetlands of international importance; the Commonwealth marine environment; World Heritage properties, National Heritage places, and nuclear actions

nanoplankton

Planktonic organisms that are 2–20 micrometres in size.

oligotrophic

Refers to any environment that offers little to sustain life. This term is usually used to describe bodies of water or soils with very low nutrient levels (compare to eutrophic).

pelagic

Associated with the surface or middle depths of the water column, e.g. fish swimming freely in the open sea.

petroglyph

A carving or line drawing on rock, especially one made by prehistoric people.

phytoplankton

Small plants, mostly microscopic, which are suspended in water and free-drifting.

planktivores

Organisms that eat plankton. Large planktivores include whale sharks and manta rays.

plankton

Any small or microscopic drifting organism (plant or animal) that inhabits the water column of oceans, seas, and fresh water.

photic/photic zone

See euphotic zone.

Pleistocene

The epoch forming the earlier half of the Quaternary Period, beginning about two million years ago and ending 10 000 years ago, characterized by widespread glacial ice and the advent of modern humans.

Pliocene

The geological epoch from 5.2–1.64 million years ago. The Pliocene was a period of gradual cooling leading up to the Pleistocene ice ages.

polychaetes

Members of the class Polychaetae, a group of mainly marine annelid worms, also known as bristle worms.

There are more than 10 000 known species in this class.

province

A large-scale biogeographic unit. See bioregion/provincial bioregion.

provincial bioregion (used interchangeably with bioregion; also refer to province)

There are eight provincial bioregions in the North-west Marine Region: Central Western Shelf Province, Central Western Shelf Transition, Central Western Transition, Northwest Province, Northwest Shelf Province, Northwest Shelf Transition, Northwest Transition, and the Timor Province.

prospective

Referring to the likelihood of finding commercial mineral deposits/petroleum products.

Ramsar-listed wetlands

The Convention on Wetlands of International Importance, known as the Ramsar Convention, was signed in 1971 in Ramsar, Iran, and is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

recruit/recruitment

The influx of new members into a population by reproduction or immigration.

scleractinian

Scleractinian corals are hard corals. Ashmore Reef is characterised as a scleractinian coral reef.

sedimentology

The study of sediments and the processes that deposit them.

sea mount

A mountain on the floor of the ocean.

sea cucumber (see also trepang and bêche-de-mer)

An echinoderm of the class Holothuroidea with an elongated body and leathery skin. Sea cucumbers are edible and have been harvested and traded in northern Australia and South-East Asia for hundreds of years. When processed for eating, the sea cucumber is known as bêche-de-mer or trepang.

seismic

Relating to earthquakes or other vibrations of the Earth and its crust. Also relates to geological surveying and mineral and petroleum exploration methods that involve artificially induced shock waves. A seismic source (such as dynamite or air guns) provides a pulse of energy that generates seismic waves, which travel through a medium such as water or layers of rocks. Some of the waves then reflect and refract off subsurface features to receivers, such as geophones or hydrophones, providing information on structures and stratigraphy. This information can be used to locate potential mineral deposits or petroleum sources.

semidiurnal

Half daily.

sessile

Sessile animals are fixed and immobile. They are usually permanently attached to a solid substrate of some kind, such as a rock or the hull of a ship in the case of barnacles. Other sessile animals such as corals lay down their own substrate. Sessile animals typically have a free-moving (motile) phase in their development.

shelf break

The area of the seabed where the continental shelf meets the steeper slope; commonly around depths of 200 m.

socio-economic

Of or relating to both social and economic considerations.

South Equatorial Current

A major ocean current that flows west across the Pacific and Indian oceans just south of the equator, forming part of the large-scale anti-clockwise movement of water in the oceans of the Southern Hemisphere.

spawning

The release of gametes (eggs and sperm) into water when marine organisms (e.g. corals and fish) reproduce.

spring/neap tide cycle

The spring/neap tide cycle has an approximately seven day interval between spring tides. During spring tides, high tides are higher than average and low tides are lower than average. At neap tides the tidal range is

at its minimum, with relatively high low tides, and relatively low high tides.

State/Territory waters

State or Territory waters are a belt of water that extends from the territorial sea baseline for three nautical miles 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.

stock

A group of individuals of a species, usually occupying a particular spatial range. Stocks are used as a unit for managing and assessing fisheries.

substrate

A surface on which organisms live.

sub-tropical

Relating to or occurring in a region intermediate between tropical and temperate.

supratidal

Pertaining to the shore area above the high-tide level.

temperate

The regions in which the climate undergoes seasonal changes in temperature and moisture. Temperate regions of the earth lie primarily between 30 and 60 degrees latitude in both hemispheres.

terrigenous

Sediments derived from the erosion of rocks on land; consisting of sand, mud, and silt carried out to sea by rivers. Deposition of these sediments is largely limited to the continental shelf.

threatened species

Threatened species are listed under the EPBC Act (Section 178) in six categories:

(a) extinct;

(b) extinct in the wild;

(c) critically endangered;

(d) endangered;

(e) vulnerable; and

(f) conservation dependent.

The definitions for these categories of listing are detailed in Section 179 of the EPBC Act.

thermocline

A steep temperature gradient in the ocean where the layer above is a different temperature from the layer below.

Timor Trough

A geomorphic feature located to the north of the Region.

trepang (see also sea cucumber, or bêche-de-mer)

The Indonesian word for sea cucumber or holothurian. Trepangers were originally Moluccan fishermen who visited the north coast of Australia to collect and process sea cucumbers for eating.

trophic level

The position an organism occupies in a food chain; levels include primary producers, herbivores, primary, secondary and tertiary carnivores, and decomposers.

turbidity

The cloudiness in water that is caused by particles, usually of fine sediment or microscopic particles of biological material.

upwelling

The phenomenon of deep ocean water rising to the surface, usually bringing nutrients that can increase biological productivity.

vulnerable species (see also: threatened species)

The definition of a vulnerable species in the EPBC Act (Section 179) is:

"A native species is eligible to be included in the vulnerable category at a particular time if, at that time:

(a) it is not critically endangered or endangered; and

(b) it is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria."

zooplankton

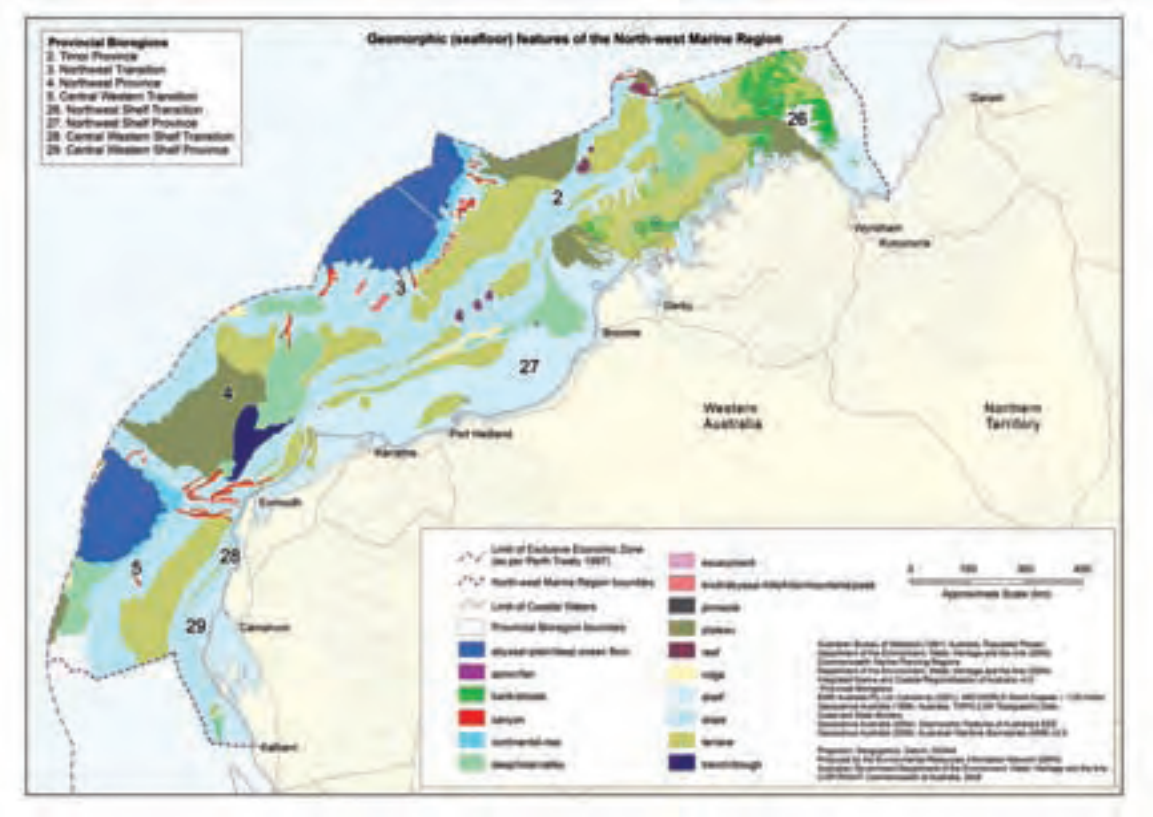
Animal component of the plankton community.

zooxanthellae

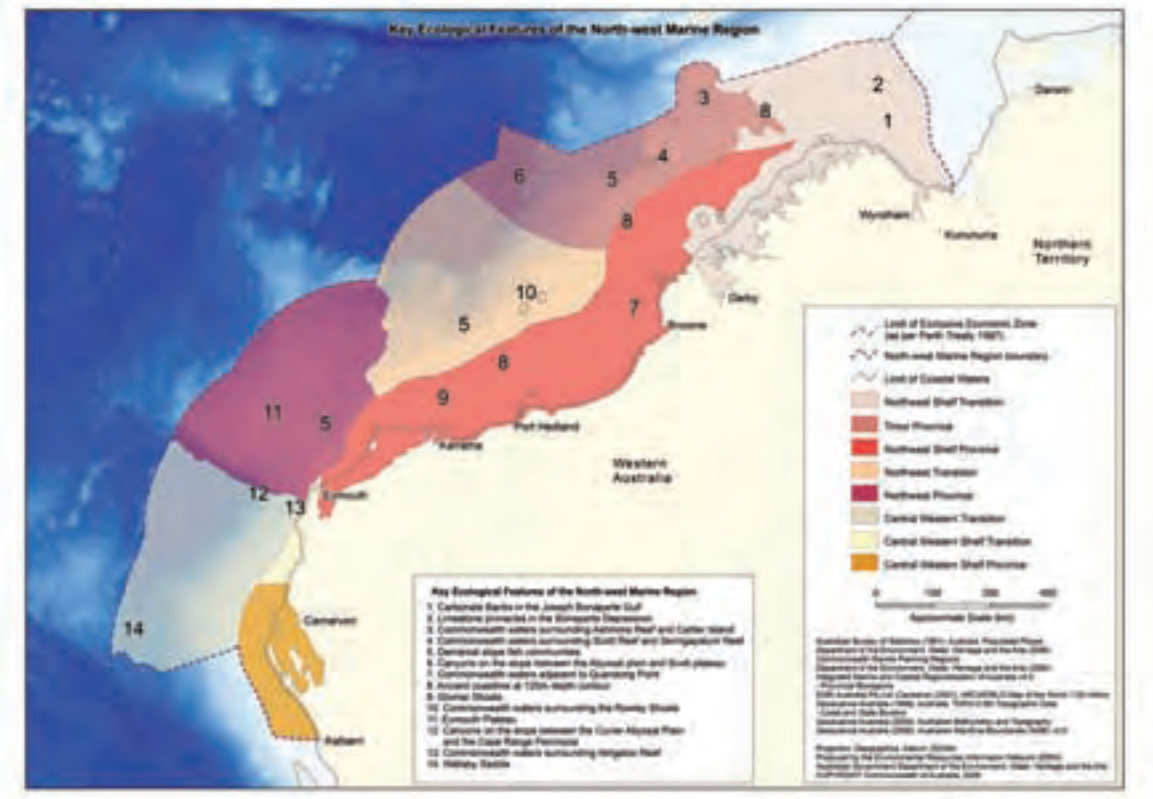
Single-celled yellow-brown algae that live symbiotically within the cells of reef-building corals and supply them with nutrients. When corals are subjected to high environmental stress the zooxanthellae can die, resulting in coral bleaching.

Maps

Geomorphic (seafloor) features of the North-west Marine Region



Key ecological features of the North-west Marine Region



Australian Government

Department of the Environment, Water, Heritage and the Arts