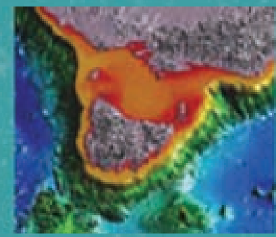
2005 National Marine Bioregionalisation *of* Australia






SUMMARY

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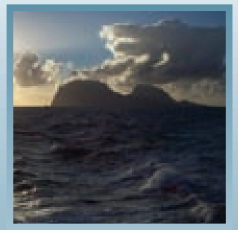

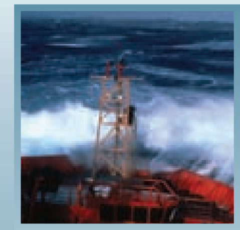
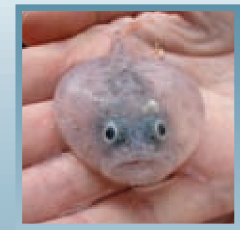

National Marine Bioregionalisation of Australia

DISCLAIMER
This document was prepared by the Department of the Environment and Heritage (National Oceans Office) to provide a spatial framework to assist with planning and management in Australiaís Marine Jurisdiction. The document synthesises information provided in reports produced by CSIRO Marine Research, Geoscience Australia and Queensland Museum. The views expressed in this report are not necessarily those of the Australian Government. The Australian Government does not accept responsibility for the contents of this report.

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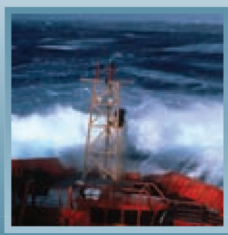

Acknowledgements

The development of the National Marine Bioregionalisation was overseen by the Bioregionalisation Working Group, whose role was to advise on scientific issues and to provide a review of the program. Members of the Bioregionalisation Working Group included Colin Creighton (Chair), Patricia von Baumgarten, Peter Bosworth, Rob Coles, Bob Creese, Ian Cresswell, Campbell Davies, Jon Day, Peter Doherty, Leanne Fernandes, Don Hough, Bryan McDonald, Paul Murphy, Sam Nelson, Paul Ryan, Chris Simpson, Neil Smit, Rob Taylor, Sally Troy, Bruce Wallner and Dennis Witt. These members' affiliations are listed in Appendix 1. Peter Harris from Geoscience Australia, Vincent Lyne from CSIRO Marine Research and Emma Campbell from the Department of the Environment and Heritage were observers in the Bioregionalisation Working Group meetings.

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Staff at the National Oceans Office who were directly involved in the production of the National Marine Bioregionalisation were Emma Campbell, Miranda Carver, Ian Cresswell, Campbell Davies, Heather Deese, Samantha Meyer, Karen Miller, Vicki Nelson, Sally Troy and Ben Waining.

Preface

Australia has one of the largest marine jurisdictions in the world, and has international obligations under the United Nations Convention on the Law of the Sea to actively manage our marine domain. Our jurisdiction encompasses a vast diversity of ocean habitats, from very shallow inshore waters, through to oceanic waters more than four kilometres deep.

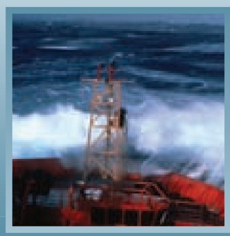
We need to understand our oceans to manage them well and use them sustainably. One of the first challenges is to create a common understanding of the physical and biological structure of the ocean and the seabed.

The National Marine Bioregionalisation project is an important step in achieving this. By collating and then using consistent and comparable datasets for Australia's vast Exclusive Economic Zone, our marine environment has been classified into bioregions that are at a scale useful for regional planning and that will provide a framework for subsequent finer levels of planning and management.

Our ocean environment is complex and varied, and the National Marine Bioregionalisation provides the most up-to-date picture of special ocean features and the variety of habitats for marine life at a national scale.

By better defining what is in our oceans, the National Marine Bioregionalisation gives us a framework to help make management decisions with a greater emphasis on spatial and ecological criteria and will assist with the implementation of ecosystem-based management.

The National Marine Bioregionalisation has drawn on existing research, incorporated new groundbreaking research methods, collated the results and made them accessible. The program is a partnership of the Department of the Environment and Heritage - National Oceans Office, Geoscience Australia and CSIRO Marine Research.



Summary

The National Marine Bioregionalisation of Australia represents a synthesis of key biological, geological and oceanographic data to provide a spatial framework for classifying Australia's marine environment into bioregions that make sense ecologically and are at a scale useful for regional planning and subsequent finer levels of planning and management. It is based on the best information currently available and represents one of the most comprehensive bioregionalisation studies ever undertaken at a national scale.

This report documents the development of the National Marine Bioregionalisation of Australia, which was developed collaboratively by the Department of the Environment and Heritage - National Oceans Office, CSIRO Marine Research and Geoscience Australia, with input from Australian museums and international and national scientific experts. A Bioregionalisation Working Group assisted its development.

The National Marine Bioregionalisation provides a picture of the spatial distribution of the broadscale physical and biological components of Australia's marine jurisdiction, including only the offshore island territories of Norfolk, Cocos (Keeling), Christmas and Macquarie Islands. It complements the existing IMCRA management framework by extending regionalisations beyond the continental shelf to cover all of Australia's Exclusive Economic Zone (EEZ).

The National Marine Bioregionalisation consists of two parts:

1. A benthic bioregionalisation for Australia's EEZ that describes three spatial scales of bioregions for the seabed beyond the shelf break. The benthic bioregionalisation:

    - uses bathymetry, data on demersal fish, sponges and sediments, and oceanographic data to define bioregions
    - consists of a suite of unique bioregions comprising 41 provinces, three depth-related biomes on the continental slope, and geomorphic units which represent clusters of geomorphic features around the EEZ.

2. A pelagic regionalisation that describes structure in the water column. The pelagic regionalisation:

    - is based on the physical properties of the water with the use of satellite imagery to provide information on primary productivity in the ocean
    - describes twenty-five different water masses in Australia's oceans within which are identified different circulation regimes and oceanographic features.

The National Marine Bioregionalisation consists of a series of bioregions that together represent an improved understanding of the structure of the seabed and ocean at a range of spatial scales. The regions described in this framework form the background and context for broad scale ecosystem-based management of Australia's oceans and will be relevant for numerous planning and management applications within Australia's Marine Jurisdiction. This includes regional marine planning, identification of candidate representative marine protected areas and environmental reporting. The National Marine Bioregionalisation is of international significance, due to the systematic process that has been undertaken within a multi-disciplinary and multi-jurisdictional context to cover the waters surrounding an entire continent.

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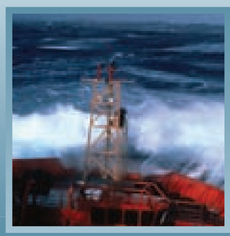


1. Introduction

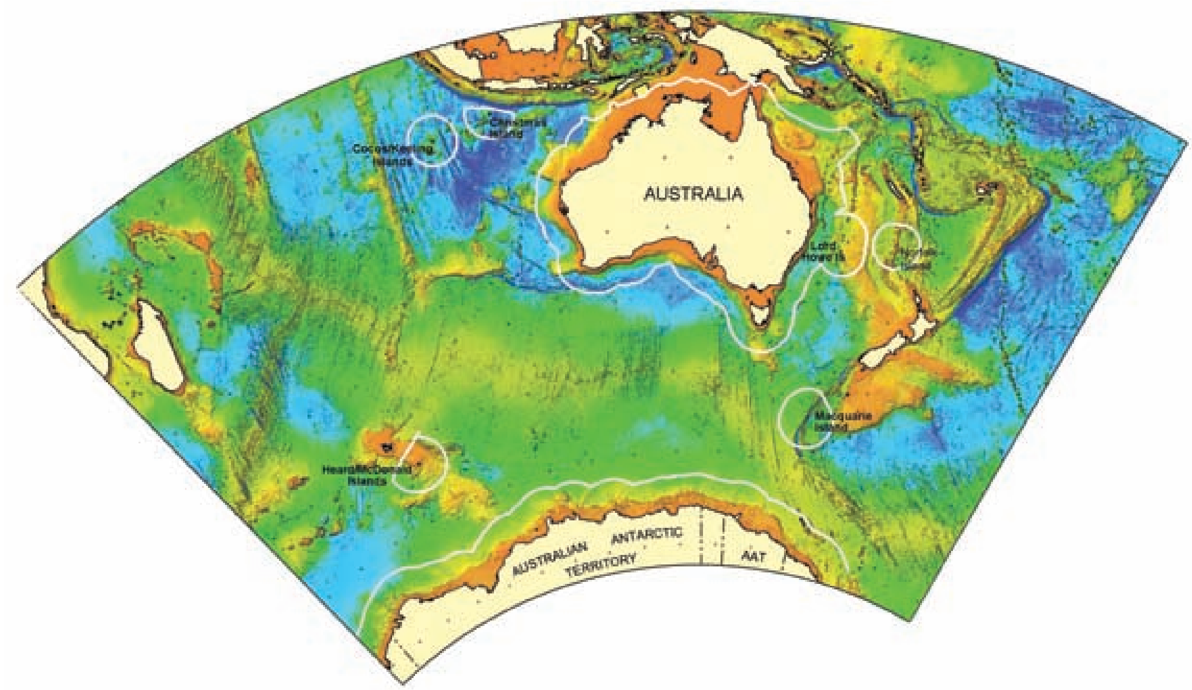
Australia's Marine Jurisdiction

Australia has one of the largest marine jurisdictions in the world. Under the United Nations Convention on the Law of the Sea, Australia has rights and responsibilities for over 10 million square kilometres of ocean – which is 30% more than the area of the Australian continent.

Australia has the right to explore and exploit the seabed and water column in Australia's Exclusive Economic Zone (EEZ). The EEZ generally extends to a maximum of 200 nautical miles from the coastline of Australia, including the external territories (Figure 1). It includes a great diversity of marine environments including tropical coral reefs, temperate rocky reefs, seagrass beds, mangroves, estuaries and bays, as well as deep ocean basins, seamounts and submarine canyons.

Australia has maritime boundaries with six other nations: East Timor, Indonesia, Papua New Guinea, the Solomon Islands, New Zealand and France through its sub-Antarctic and tropical territories. Australia's shared boundaries with neighbouring countries dictate the need for international cooperation in the management of our marine jurisdiction.

▼ **Figure 1. The boundaries of Australia's Exclusive Economic Zone (marked in white) overlying a bathymetry model of the region.** *The EEZ extends to a maximum of 200 nautical miles from the coastline of Australia including the offshore island territories. The offshore territories include Cocos (Keeling) Islands and Christmas Island, Norfolk Island, Lord Howe Island, and Macquarie Island. The Australian Antarctic Territory, Heard and McDonald Islands were not included in the National Marine Bioregionalisation project.*




Australia's Oceans Policy

The Australian Government is committed to ecologically sustainable development (ESD) in Australia's oceans. Australia's Oceans Policy (1998) sets in place the framework for ESD for all of Australia's marine jurisdictions through integrated and ecosystem-based planning and management.

The core of Oceans Policy is the development of regional marine plans (RMPs). RMPs adopt an ecosystem approach and, consequently, a key component of regional marine planning is to determine and understand ecosystem boundaries and ecological processes within marine regions. Additionally, in pursuing management that is focused on ecosystems, the Australian Government has endorsed the development of a National Representative System of Marine Protected Areas (NRSMPA).

Through its commitment to regional marine planning and the development of a NRSMPA as part of Australia's Oceans Policy, the Australian Government has supported the development of ecologically-based regionalisations. These regionalisations provide the first layer in a broad ecological planning framework within which more detailed information on ecosystems, communities and/or species distributions can be used to assist decision-making for the marine environment.

The Role of Regionalisations

Regionalisations provide spatial frameworks that have applications for many aspects of environmental management. They are based on collated data and inferred patterns across a variety of spatial scales and are an accepted tool to assist in the description of ecosystem boundaries for planning and management in the natural environment. Marine regionalisations assist with management of marine resources to ensure that marine industries are ecologically and economically sustainable.

Regionalisations also contribute to an understanding of the wide variety of marine environments and form an important input to planning and management decisions that may be made at different spatial scales. As a tool for organising spatial information, regionalisations are important for conservation, education, science, environmental inventories, delineation of biophysical distributions and the development of management policies and organisation of management activities.


Marine Regionalisations for Australia

CONCOM REGIONALISATION

A biogeographic or regional ecosystem classification was first developed by relevant Commonwealth, State and Territory management agencies in 1985, and was endorsed by the Council of Nature Conservation Ministers (CONCOM) as a basis for planning the development of a system of marine protected areas in each jurisdiction (CONCOM 1985). The regionalisation delineated and described the major coastal and marine regions at a provincial scale. The classification was generalised, broad scale and lacked sufficient details to assist detailed bioregional conservation planning.

In 1986 the Australian Committee for the World Conservation Union (ACIUCN) modified the CONCOM regionalisation in their proposal for a national representative system of marine protected areas and the regionalisation became known as the ACIUCN regionalisation.

THE INTERIM MARINE AND COASTAL REGIONALISATION OF AUSTRALIA (IMCRA)

The current version of IMCRA (Version 3.3; IMCRA Technical Group 1998) was produced in 1998 by the Australian and New Zealand Environment and Conservation Council, which is now replaced by the Natural Resource Management Ministerial Council. IMCRA was developed to provide a comprehensive, integrated and hierarchical spatial planning framework for conservation and sustainable resource use in coastal and marine environments.

IMCRAv3.3 contains two provincial-level regionalisations: demersal and pelagic. The demersal regionalisation is based on a classification of demersal fish species diversity and richness, and defines 17 continental shelf provinces and biotones that are grouped based on climate characteristics in tropical to temperate waters. The pelagic regionalisation describes four continental shelf provinces and biotones based on pelagic fish species diversity and richness, as well as nine classes of water mass types in deep water beyond the continental shelf.

The main product of IMCRA was a near-shore regionalisation that consists of sixty meso-scale regions (100s–1000s km). These are distributed around Australia in the area extending from the coast to the edge of the continental shelf (defined as the 200 m isobath). The meso-scale regions were defined using biological and physical information, including the distribution of demersal fishes and invertebrates, sea floor topography and sediments, and oceanographic data. The best available data and analyses were used to determine boundaries in inshore waters, which varied among the different jurisdictions of Australian governments.

IMCRA has been used by all governments in Australia in the development of the NRSMPA. It has also been used for State of Environment reporting and monitoring, including identifying ranges of threatened species, and has been used nationally and internationally for reporting on introduced marine species. The primary focus of IMCRA is on coastal and continental shelf waters to a depth of 200 m, with only a preliminary pelagic regionalisation in deeper water.

LARGE MARINE DOMAINS OF AUSTRALIA'S EEZ

The Large Marine Domains are a set of regional marine planning units for Australia's EEZ developed by the CSIRO Division of Marine Research (Lyne et al. 1998). These planning units are a key requirement for supporting Australia's Oceans Policy. The boundaries define areas surrounding continental Australia and the external territories including Cocos (Keeling) Islands, Christmas Island, Norfolk Island, Lord Howe Island, Macquarie Island, Heard and McDonald Islands, and the Australian Antarctic Territory.

Thirteen Large Marine Domains are described in the regionalisation, derived from the provincial demersal regionalisation in IMCRAv3.2 (based on distributional data of fish on the continental shelf), with additional analysis of oceanographic and geological data for offshore waters. The Department of the Environment and Heritage, National Oceans Office (hereafter referred to as the National Oceans Office) used the large marine domain boundaries as a major input in adopting boundaries for regional marine planning.

SOUTH-EAST INTERIM BIOREGIONALISATION

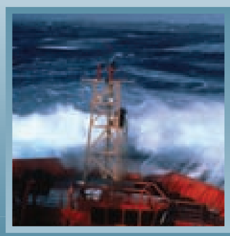
In 2001 the Australian Government undertook to develop the first regional marine plan in the South-east Marine Region of Australia as one of a number of commitments related to Australia's Oceans Policy. Through the development of the South-east Regional Marine Plan, the need to classify deepwater areas beyond the continental shelf was identified. This was considered critical in the development of operational boundaries for regional marine planning based on ecosystem characteristics, and as a significant step towards ecosystem-based management.

An interim bioregionalisation for the continental slope and deeper waters of the South-east Marine Region (Butler et al. 2001) was developed in response to this need. However, through this process it became apparent that at large scales it is inefficient to consider one region at a time without placing it in the context of neighbouring regions. It was recognised that a clearer understanding of patterns and processes in the marine environment would emerge from consideration of fish distributions, invertebrate distributions, oceanographic patterns and geological attributes around Australia as a single task. In addition, national datasets were being produced that had not been available for IMCRAv3.3. The concept for a national bioregionalisation that encompassed Australia's entire marine jurisdiction and incorporated the national datasets emerged.

OTHER AUSTRALIAN MARINE REGIONALISATIONS

Other area-specific regionalisations have been undertaken for some parts of Australian waters. A benthic regionalisation for the Great Barrier Reef was undertaken for the Great Barrier Reef Marine Park Authority (GBRMPA) as part of the representative areas program, and was a key data layer in the rezoning of the Great Barrier Reef Marine Park in 2004 (www.gbrmpa.gov.au/corp_site/management/zoning/index). This regionalisation classified the biological and physical diversity of the Great Barrier Reef World Heritage Area into 70 bioregions (30 reef bioregions and 40 non-reef bioregions) at the scale of 10s–100s of kilometres. These bioregions contain habitats, communities (e.g. areas of seagrass) and physical features (e.g. sediment type, depth) that are more similar within the bioregion than those occurring in other bioregions. The bioregions were developed with panels of experts using the best available information. More than 40 spatial datasets of biophysical variables were used, which had been compiled from years of research.

A bioregionalisation for the North West Shelf, Western Australia, has also been undertaken by CSIRO Marine Research and the Western Australian Department of Environmental Protection (North West Shelf Joint Environmental Management Study, 2002). This project provided a seven-level hierarchical characterisation of bioregions of the North West Shelf coastal and benthic habitats, and was based on all available biophysical data combined with expert knowledge. Regions identified ranged from coarse-scale biomes (at scales of >100s of km) down to finer-scale biotopes (10s – 100s of km).



2. The National Marine Bioregionalisation

What is the National Marine Bioregionalisation?

The National Marine Bioregionalisation describes spatial patterns in the benthic and pelagic environments in Australia's Marine Jurisdiction at scales appropriate to regional marine planning. It contributes to an understanding of the marine environment and provides spatial information that can be used to infer patterns in the distribution of biodiversity, ecosystem structure and ecological processes.

The National Marine Bioregionalisation complements existing national near-shore (<50 m depth) and continental shelf (<200 m depth) regionalisations completed as part of IMCRA. Other finer-scale regionalisations at sub-national levels have been developed at various times for the North West Shelf, Great Barrier Reef and in the south-east of Australia, and provide further detailed descriptions of these parts of Australia's ocean environment.

There are two key components of the National Marine Bioregionalisation: a benthic bioregionalisation and a pelagic regionalisation. The benthic bioregionalisation describes spatial patterns on or near the sea floor. It describes the distribution and area of four primary bathymetric units – the continental shelf, the continental slope, the continental rise and the abyssal plain – around Australia's EEZ. Smaller provincial bioregions are described based largely on patterns of fish diversity, but also on the distribution of habitats in very deep water. The continental slope is divided into biomes, which are depth-related areas derived from the distribution of fish species. Geomorphic units are also described based on clusters of identified geomorphic features of the sea floor. Additional information about sediment characteristics and mobility on parts of the continental shelf and patterns in the distribution of tropical sponges is provided to assist in the interpretation of provincial bioregions.

The pelagic regionalisation describes structure within the water column of Australia's oceans. In the pelagic regionalisation, structures including ocean zones and water masses are based on the characteristics of the water column such as oxygen content, salinity and temperature. These represent discrete water bodies that may influence patterns in the distribution of biota. Finer-scale features such as circulation regimes or oceanographic features are defined based on currents, primary productivity and energetics of the sea surface.

The National Marine Bioregionalisation extends the regionalisation of Australia's marine jurisdiction from the continental shelf to the edge of the EEZ. It focuses on waters beyond the continental shelf that were not the focus of IMCRA. Importantly, the National Marine Bioregionalisation uses consistent and comparable national data to derive bioregions. The outcome is a national set of bioregions for the Australian Marine Jurisdiction that can underpin a spatial framework for planning and management of Australia's oceans.

There a number of applications for the National Marine Bioregionalisation including:

- defining ecologically-based planning and management units, mapping their location and describing as best as possible their structure (for example, in regional marine planning)
- providing the basis for the off-shelf component of the NRSMPA by identifying (to the extent possible at any particular scale) the spatial structure and distribution of habitats and biogeographic patterns in Australia's EEZ beyond the shelf break
- providing a systematic framework for finer-scale planning and management
- providing a spatial framework for environmental assessment and reporting for the Australian Marine Jurisdiction
- providing a vehicle for communicating information about the spatial complexity of ocean ecosystems
- assisting scientists in understanding biogeographical patterns in the distribution of flora and fauna

Development of the National Marine Bioregionalisation

The National Marine Bioregionalisation was developed collaboratively by the National Oceans Office, CSIRO Marine Research and Geoscience Australia, with input from Australian museums and international and national scientific experts.

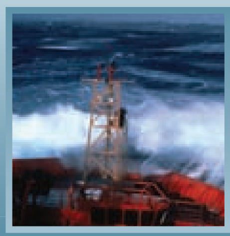
Development of the National Marine Bioregionalisation was managed by the National Oceans Office with advice from a Bioregionalisation Working Group that was established in August 2002. The purpose of the working group was to advise specifically on scientific issues, to provide a review of the program (including projects initiated under the framework of the national bioregionalisation program) and to assist in the development and preparation of this final summary report.

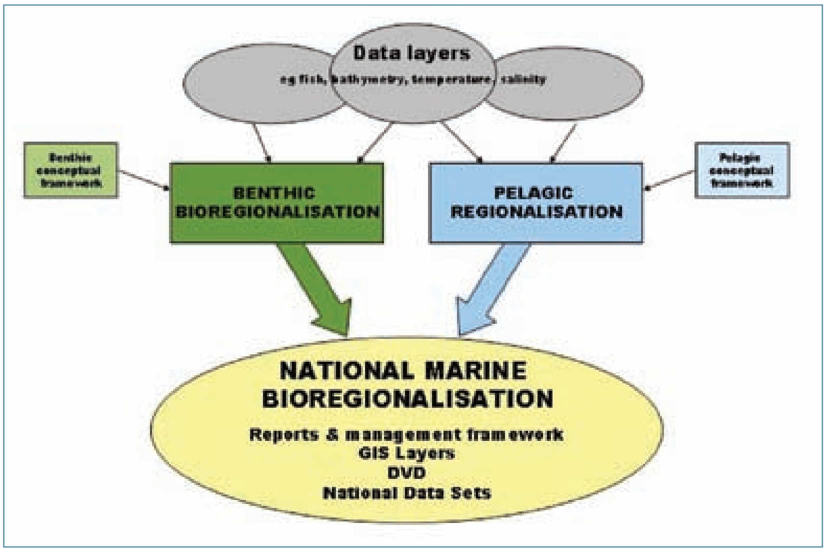
The Bioregionalisation Working Group comprised representatives from each State and Territory, and representatives from Australian Government agencies with scientific expertise or interest in the marine environment (Appendix 1). Additional scientific input was provided to the working group through workshops and reviews of the National Marine Bioregionalisation Work Program.

Following the initiation of the National Marine Bioregionalisation program, a workshop to develop a conceptual bioregional framework was held in April 2003, to which international and national experts were invited. The outcome of this workshop provided the starting point for the bioregionalisation process from which the background and context, focus and assumptions, and structure of the pelagic and benthic frameworks were developed. The participants of the workshop also agreed on the final products from the bioregionalisation, which included reports, maps, datasets, illustrations and a Geographic Information System (GIS).

The National Marine Bioregionalisation was developed through six data collation projects that involved the creation and analysis of national datasets on key marine attributes, along with two integration projects which combined the relevant data to form each of the pelagic and benthic regionalisations (Figure 2). The scope, responsible organisation, and timeframes of these projects were:

1. **National Demersal Fish**, CSIRO Marine Research, June 2002 – April 2005.
2. **National Bathymetry**, Geoscience Australia, May 2002 – July 2003
3. **National Sediments Database**, Geoscience Australia, August 2003 – September 2004
4. **Northern Sponges, Queensland Museum**, October 2003 – November 2004
5. **Oceanography Scoping Project**, CSIRO Marine Research, April – November 2003
6. **Oceanography**, CSIRO Marine Research, March 2004 – June 2005
7. **Benthic Marine Bioregionalisation Integration Project**, Geoscience Australia, July 2004 – June 2005
8. **Pelagic Bioregionalisation Integration Project**, CSIRO Marine Research, July 2004 – June 2005





◀ **Figure 2. Schematic figure illustrating the National Marine Bioregionalisation work program and the relationship and integration of the various components that were input into the final bioregionalisation products.**

Conceptual Framework of the National Marine Bioregionalisation

The basic requirements for the National Marine Bioregionalisation were that it should effectively partition known variation in biodiversity and that it should be:

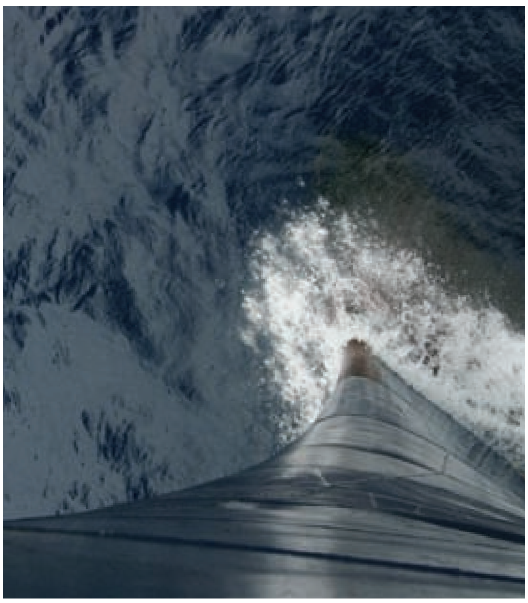
- capable of being mapped, described and easily understood and communicated
- scientifically rigorous
- objective
- transparent
- repeatable (that is, the methods used to derive the regions should be able to be repeated easily with additional data)
- relevant across a range of spatial scales
- based as far as possible on existing information (since collection of new information is expensive both in time and resources).

The purpose of regionalisation is to assist in simplifying the complex relationship between environment and species distributions, and to capture spatial patterns in the distribution of species and habitats at differing scales. To achieve this result the National Marine Bioregionalisation has a structure that incorporates information about patterns and processes which occur at progressively finer scales. It is based on two separate regionalisations, both of which encapsulate a range of spatial scales, although finer scales are not always strictly nested within the coarser scales. For example, large geomorphic features such as canyons often straddle continental shelf and slope provinces as well as crossing a number of depth-related biomes. Using an approach to regionalisation that is not strictly hierarchical acknowledges that understanding ecosystem complexity is not always collapsible in a hierarchical way, yet still allows flexibility in the use of information to suit the scale of the management issue that is being addressed.

The benthic and pelagic regionalisations have very different conceptual underpinnings. The benthic bioregionalisation is based on biology with physical surrogates, whereas the pelagic regionalisation is based exclusively on physical data with biological corroboration. Surrogates were used to represent the distribution of species in Australia's oceans because there is variable information on the abundance and distribution of biota throughout Australia's off-shelf areas. Data coverage is particularly patchy for waters of a depth greater than 1000 m, which reflects the cost and operational difficulty of survey work in the off-shelf marine environment and the historically low level of research undertaken in


this area. Where detailed information about Australia's marine species was unavailable, physical attributes (e.g. bathymetry, salinity and nutrients) were used as surrogates to infer patterns in species distributions at a variety of spatial scales, and data on a few key taxa (e.g. fish and sponges) were used as surrogates for other types of biota, or biodiversity generally.

In developing the National Marine Bioregionalisation key uncertainties have been recognised that may have implications for the application of the final regionalisation products. These include the assumption that the spatial relationship among bioregions can be inferred from biological and physical surrogates, as well as limitations associated with the coverage of data and data analysis procedures. However, as the National Marine Bioregionalisation was based on expert knowledge and the best information available, it represents the most rigorous and comprehensive marine regionalisation ever constructed at a national level.



Custodianship and Responsibilities

Products generated for and by the National Marine Bioregionalisation are accessible through the National Oceans Office website www.oceans.gov.au. These include the National Marine Bioregionalisation GIS, individual project reports and associated figures, fact sheets and large-format plot files. Additionally, the GIS and associated products, including reports and three-dimensional representations ('fly-throughs') of the final bioregionalisation, are available on DVD and can be obtained through the National Oceans Office.

The National Marine Bioregionalisation resulted in the production of a number of marine datasets and these datasets are being maintained and updated by the respective custodians. Datasets and custodians associated with the National Marine Bioregionalisation are:

- Australian Bathymetry Database (Geoscience Australia)
- National Sediments Database (MARS) (Geoscience Australia)
- Demersal Fish database (CSIRO Marine Research)
- National Sponge database (Queensland Museum, through the Online Zoological Collections of Australian Museums)
- CSIRO Atlas of Regional Seas (CARS)/Oceanographic database (CSIRO Marine Research)
- The National Marine Bioregionalisation GIS and underlying data (Geoscience Australia).

3. Benthic Bioregionalisation

The benthic component of National Marine Bioregionalisation was constructed for areas of the EEZ beyond the shelf break (i.e. the continental slope, continental rise and abyssal plain) to complement the existing Interim Marine and Coastal Regionalisation of Australia.

The principal objectives of the benthic bioregionalisation were to:

- define a national set of benthic marine bioregions for the Australian EEZ based on consistent and comparable data, in support of the management of Australia's oceans
- collate a suite of publicly accessible datasets of key geological, biological and oceanographic data
- produce information, including an interactive GIS, to make data available to managers, planners and scientists in useable formats.

Framework of the Benthic Bioregionalisation

The framework for the benthic bioregionalisation is a series of bioregions at progressively finer spatial scales. The structure of the benthic bioregionalisation is adapted from a framework developed and implemented by CSIRO Marine Research in the North West Shelf Environmental Study (2002), which was used to construct the interim benthic marine bioregionalisation of the South-east Marine Region (Butler et al. 2001). Due to the broad requirements of regional marine planning, the benthic bioregionalisation focused on defining broadscale regions (Table 1).

Table 1. Levels of the benthic bioregionalisation.

Name	Description	Data used to define each level	Indicative Area
Ocean Basins	Provide biogeographic and evolutionary context with origins dating back to the separation of Gondwana.	Literature	Greater than 100,000 km^2
Ocean Climate Zones	Contemporary modifiers of biogeographic distributions and evolutionary traits of faunal assemblages.	Literature	Greater than 100,000 km^2
Primary Bathymetric Units	Major benthic sub-divisions at a national scale consisting of continental shelf, slope, rise and abyssal plain.	Bathymetry	Greater than 100,000 km^2
Provincial bioregions	Large biogeographic regions based principally on the broad-scale distribution of fish.	Demersal fish Bathymetry Geomorphic features Oceanographic data	10,000–100,000 km^2
Biomes (continental slope only)	Biogeographic regions based on depth ranges of fish communities. These units have only been defined on the slope due to data availability. Biomes are nested within Provinces.	Demersal fish Bathymetry	Less than 1000–10,000 km^2
Geomorphic Units	Areas of similar geomorphology.	Geomorphic features	Less than 1000 – greater than 100,000 km^2

Methods

DATA

Data used to develop the benthic bioregionalisation were of three broad types: biological, geological and oceanographic. The data were supplied mostly from existing national datasets for the EEZ held at Geoscience Australia and CSIRO Marine Research, and supplemented with additional data on sponges in northern Australian waters from the Queensland Museum. In collating the national datasets, relevant new data, expert knowledge, and data obtained from literature reviews were also incorporated.

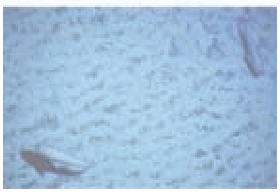
Those datasets used in the benthic bioregionalisation are referred to below and each is contained as a layer in the National Marine Bioregionalisation GIS for reference. Full details of the derivation and limitations of each of the datasets are contained in the relevant National Marine Bioregionalisation project reports which are available, along with the GIS, through the National Oceans Office either as hard copy, on DVD or online at www.oceans.gov.au.

Biological data

Demersal fish (Last et al. 2005): fishes have been used as surrogates for the rest of the marine biota as they are the most comprehensively studied group from Australian waters and importantly, are relatively well known on the continental slope. The demersal fish dataset is the only available biological dataset with adequate national spatial coverage and taxonomic resolution to provide robust analysis of broadscale biogeographic patterns.

Data on the spatial distribution (latitude and longitude) and depth distribution of 1489 demersal fish species from 494 genera (representing 121 families) were collated by CSIRO Marine Research for use in the benthic

Demersal fishes in the benthic bioregionalisation



Rattails on a seamount at 750m depth

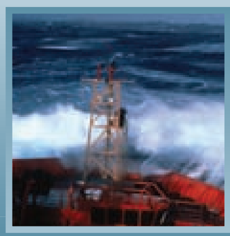
In bioregionalisations, genera containing a high number of narrow-ranging endemic species are usually more informative than genera containing only a few, wide-ranging species.

A biogeographic information index, which incorporated the number of species within a genus and the distribution of those species, was used to prioritise the potentially informative fish genera for defining provincial bioregions and biomes in the benthic bioregionalisation.

Fish of the family Macrouridae (commonly known as grenadiers, whiptails or rattails) were among the most informative groups. This is because they are a large and diverse family and are among the more common of the deep-water demersal fishes, representing up to 15% of the deep-sea fish population. The false duckbill whiptail *Caelorinchus shcherbachevi* is one of the key indicator species that defines the Northeast Province in the southern Coral Sea.

Macrorourids come in a wide variety of sizes. Some species are as small as 10cm, whereas other species, such as the Giant Rattail pictured to the left, can grow up to 1.5m in length. Rattails typically have large heads with large mouths and eyes but have slender bodies that taper to a thin rat-like tail (hence the common name rattail). They live at depths from 200 to 6000 metres and are often associated with geomorphic features such as hydrothermal vents or seamounts. They feed on smaller fish, crustaceans and cephalopods.

Little is known about the life history of rattails. They are thought to release large numbers of eggs which float up to the thermocline. Juveniles remain in shallow water where they develop, later migrating to deeper water. Most species are likely to be long-lived, and may survive for over 50 years.

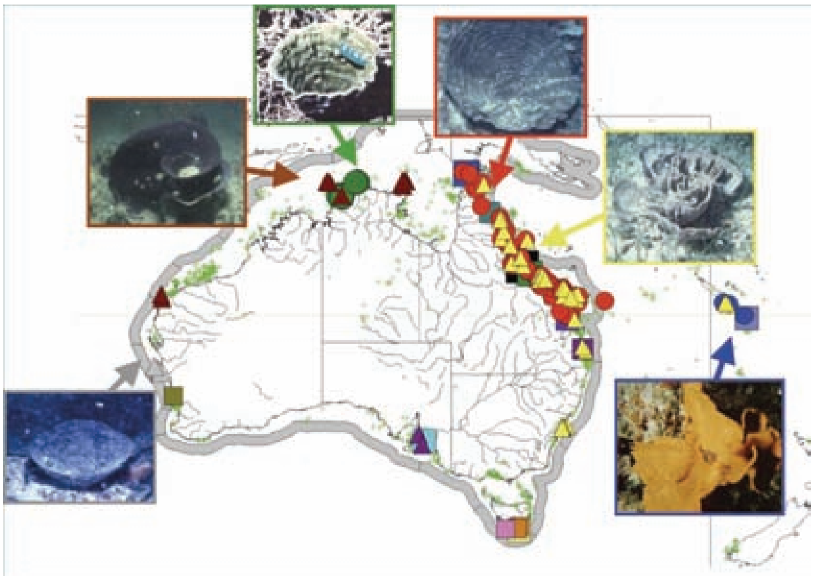


bioregionalisation. Data originated from a variety of sources including research surveys, fisheries catches, museum collection records and records in literature.

Sponges (Hooper & Ekins 2005): the sponge dataset was collated by the Queensland Museum and includes data from collections residing at the Queensland Museum, Australian Institute of Marine Science, Museum and Art Gallery of the Northern Territory and Western Australian Museum. It is limited to sponges found in the tropical waters of Australia's EEZ, ranging from Brisbane in the east to North West Cape in the west.

The sponge dataset consists of point data, including genus and species names, latitude and longitude, and water depth. The resulting database contains approximately 3800 species (where species defined as distinct operational taxonomic units) from greater than 4000 localities that represents a total of 425 genera, 120 families, 26 orders and 3 classes of sponge, of which approximately 2250 species occur in marine waters of tropical Australia. The sponge data have been used to corroborate some of the provincial boundaries in northern Australia, and will also be valuable in the future for defining finer-scale bioregions.

Sponges in the benthic bioregionalisation



Distribution of Cymbastela species in Australia where each coloured symbol represents a different species. The green "+" symbols indicate all sites for which data exists in the Australian sponge database (including marine and freshwater sponges).

Descriptive GIS analysis was used to produce spatial maps of the distribution of sponge species across northern Australia, from the central eastern to central western coasts. The maps enabled visual interpretation of species' ranges and abundance for the benthic bioregionalisation, and also provided descriptive data to help define bioregions.

For example, the map above shows the distribution of sponges belonging to the genus *Cymbastela*. These are a unique group of cyanobacterial-associated sponges which are endemic to areas in the southern Indian Ocean and west Pacific. *Cymbastela* species occupy coral reef associated habitats and they are most diverse and abundant in the tropics. Some species of *Cymbastela* are of particular interest to science as they produce bioactive compounds that have anti-malarial properties with the potential for medical applications.

Australia has the highest species diversity of *Cymbastela* with 7 described and 13 undescribed species. The genus shows highest diversity in the Great Barrier Reef (5 species) and unique bioregional associations for particular species. The disjunct distribution of many *Cymbastela* species provide support for many of the provincial bioregions in the benthic bioregionalisation.

Geophysical Data

Understanding the shape of the seabed (bathymetry), the type of seabed forms (geomorphic features) and the characteristics of the sediment of the sea floor is important for planning and management. This is because the nature of the seabed can be an important determinant of diversity and dynamics of marine biological communities. Data from Geoscience Australia were used to describe the nature of the seabed of Australia's EEZ. The datasets used included:

Bathymetry (Harris et al. 2005): this describes the topography of the ocean floor based on water depth and covers Australia's entire continental EEZ and offshore territories except Antarctica and Heard and McDonald Islands. The dataset contains water depths determined from more than 900 marine surveys representing over 280 million data points. This data was interpolated to produce a topographic grid of the sea floor for Australia's continental margins at a resolution of 250 m and with a depth resolution of 1 m.

Geomorphic features (Harris et al. 2005): this details features of the sea floor such as reefs, canyons, seamounts and abyssal plains. A total of 21 geomorphic feature types were defined using the 250 m bathymetric model of Australia's EEZ. The features were mapped at a scale of 1:5 000 000, and the smallest feature that could be resolved was approximately 10 km in length.

Ocean crust age: ocean age is assumed to be correlated with the evolutionary traits of the biota that inhabit the ocean basins. The age of the ocean crust at each of the 250 m grid points of the bathymetry map was derived from existing data held by Geoscience Australia on the spatial variability of predicted age of ocean basins around Australia.

Sedimentary basins: the extent of offshore sedimentary basins was derived from existing seismic reflection data held by Geoscience Australia. Variation among sedimentary basins results from differing geological histories and may reflect variation among benthic habitats.

Sediment parameters (Passlow et al. 2005): this characterises the composition of the sediment on the seabed and was derived from the Marine Sediment database (MARS). Data analysed included gravel content of the sediments (%gravel); mud content of the sediments (%mud); calcium carbonate content of sediments (%$CaCO_3$); and mean grain size of the sediments.

Physical hydrological processes, such as waves, tides and currents, are responsible for controlling the introduction, dispersal and deposition of sediments in the marine environment and are therefore important in defining bioregions. The hydrological processes considered as part of the benthic bioregionalisation were:

Tidal exceedance: the percentage of time that tidal currents are capable of moving the mean sediment size occurring at a given location.

Wave exceedance: the percentage of time that ocean swell waves are capable of moving the mean sediment size occurring at a given location.

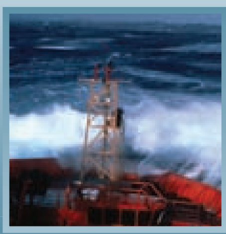
Mean wave energy: a measure of the wave energy available to mobilise sediments on the seabed and is related to wave height.

Maximum tide energy: a measure of the maximum speed that tidal currents reach at a location over a spring-neap tidal cycle.

Mobilisation of sediment on the sea floor, mean wave energy and maximum tide energy were calculated using Geoscience Australia's sediment mobility model GEOMAT (Passlow et al. 2005). GEOMAT has been developed principally to estimate the amount of sediment transported on continental shelves, as this is where surface gravity waves and tides have the most influence on the seabed. Thus the model outputs for use in the bioregionalisation are restricted to water depths of less than 300 m. This is not directly applicable to the bioregionalisation of the off-shelf areas contained in the National Marine Bioregionalisation, although it is important for subsequent levels of planning and management. For example, regional marine planning is currently underway in the Northern Planning Area which consists largely of continental shelf less than 200 m deep.

Oceanographic data

Oceanographic data (Hayes et al. 2005) describes properties of the water column and allows water bodies



which may influence patterns in distribution of biota to be defined. The annual mean temperature of the water, the salinity, concentration of nutrients (silicate, phosphate and nitrate) and dissolved oxygen at the bottom of the ocean at a 2 km resolution on the continental shelf and slope and 0.1° resolution for the rest of the EEZ, were obtained from the CSIRO Atlas of Regional Seas (CARS) database which is described in Chapter 4 of this report. Oceanographic data were used to guide the derivation of provincial boundaries in the benthic bioregionalisation.

ANALYSIS

The construction of the benthic bioregionalisation required the seabed to be partitioned into a set of coherent and ecologically meaningful bioregions that together capture the broadscale spatial patterns in distribution of fish species and habitats of Australia's EEZ beyond the shelf break. Different datasets have been used at different levels of the bioregionalisation to reflect the increasing detail and complexity at the finer levels.

Ocean basins provide the broad physical and biogeographic context for the bioregions in the benthic bioregionalisation. For the purposes of the National Marine Bioregionalisation they are defined as the regions of seabed between the continental landmasses.

Ocean climate zones capture the broad differences between tropical and subtropical, and warm and cool temperate regions, and associated habitats and biota. These zones have been defined principally on broad climate patterns reflected in the spatial distribution of the deepwater demersal fishes around the Australian continent.

Primary bathymetric units are the major morphological features of the seabed. They are described here as the continental shelf, continental slope, continental rise (where applicable), and abyssal plain. The boundary between the continental shelf and continental slope is defined by the shelf break (defined as an abrupt increase in seabed gradient at the seaward edge of the outer shelf). The boundary between the continental slope and abyssal plain and, where applicable, the continental rise and abyssal plain is defined by the foot-of-slope (defined as the point of maximum change of gradient at the base of the continental slope). The continental slope, continental rise and abyssal plain are collectively referred to in this report as the 'off-shelf' areas of the Australian EEZ.

Provincial bioregions represent areas of the seabed that capture the broad patterns in species distributions, as represented by deepwater demersal fish assemblages, and were defined for only those areas of the EEZ seaward of the shelf break and for water depths of less than 2000 m. Offshore island territories were not included in the assessment and analysis but were assumed to represent separate bioregions for the purpose of the National Marine Bioregionalisation.

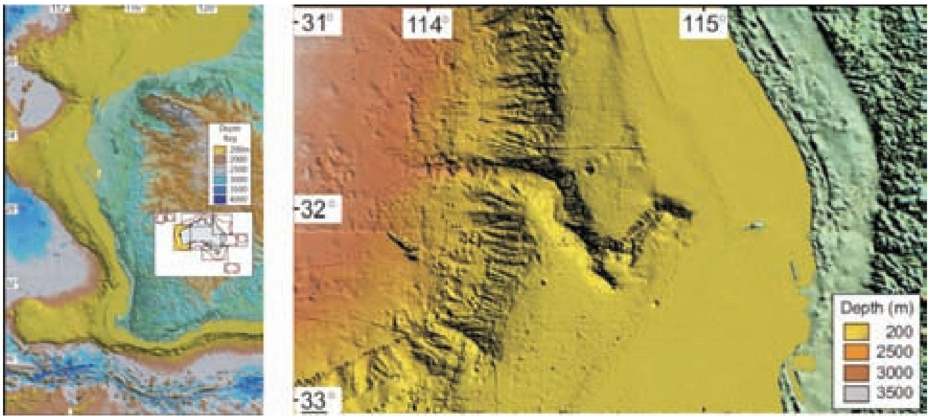
In water depths greater than 1200 m (where demersal fish data are less abundant) the boundaries of the provincial bioregions were defined using geomorphic features. Geomorphic features are considered to mark faunal changes, e.g. in the deep ocean there are likely to be significant faunal differences between the steeper slopes of seamounts compared with the gentle gradients and often sedimented slopes of the adjacent abyssal plain.

Two types of provincial bioregions were defined in the benthic bioregionalisation: provinces, which represent regions of biotic endemism; and transitions, which generally occur between the provinces, and are less well-defined mixing areas that capture the overlap of demersal fish species ranges between the provinces.

Decision rules that were applied in the determination of provincial boundaries in the benthic bioregionalisation were:

- use the boundaries defined for demersal fish on the slope
- extend demersal fish boundaries to base of slope, then along the shortest distance to the edge of the EEZ (in the absence of any other features)
- use geomorphic features where they may indicate a boundary close to the fish boundary (e.g. use the Tasman Fracture Zone for eastern boundary of Tasmania province; Naturaliste plateau for boundaries of south-west transition)
- try to keep geomorphic features whole (avoid boundaries that split features).

Geomorphic features of Australia's EEZ



False-colour bathymetric image illuminated from the north showing the western margin of Australia, and details of the Perth Canyon.

The nature of the seabed can be an important determinant of the diversity and dynamics of marine biological communities. In the benthic bioregionalisation, topographic maps of Australia's seafloor were used to identify important geomorphic features that might relate to different habitats or biological communities and that would aid in the delineation of bioregions.

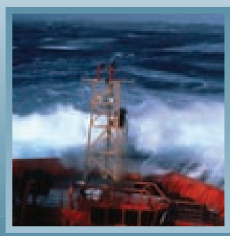
For example, the Perth Canyon is a distinctive feature on the continental shelf and slope off Perth. It is a large submarine canyon about 160km long and approximately 2000m deep which debouches on to the abyssal plain north of the Naturaliste Plateau. Along its upper course smaller feeder canyons divided by terraces enter the main canyon from the southeast.

The Perth Canyon defines the southern boundary of the Central Western Province. Studies have shown that the canyon represents a major faunal discontinuity for sponges, corals, decapods and xanthid crabs, as well as affecting the major ocean currents and associated water properties by being a conduit for significant upwelling. It is known as an area for congregating blue whales, possibly because the currents either trap planktonic animals in the canyon or bring up nutrients from deep water.

Biomes in the National Marine Bioregionalisation are biogeographic regions that capture the depth-related structuring in the distribution of demersal fish on the continental slope. Biomic structure was only defined on the continental slope where demersal fish data were the most comprehensive. Within provinces, biomes were based on community composition of demersal fish. In transitions, the upper and lower depths of each biome down the slope were arbitrarily set to the mid-point between the upper and lower depths of the corresponding biomes in the adjacent provinces. This approach was undertaken to represent the change in biomic structure between the provinces. The boundaries were projected onto the 250 m bathymetry model to create the spatial extent of the biomes over the EEZ. Biomes were not defined for the offshore island territories.

Geomorphic units represent areas of similar geomorphology over the EEZ and capture patterns in benthic marine habitat distributions. Individual geomorphic features are often too small in size and too numerous to be used effectively in management, therefore individual features were clustered into units or areas of like geomorphology to highlight regions of similar habitat type. The distribution of geomorphic units was described for all of Australia's EEZ, including the continental shelf, off-shelf areas and offshore island territories.

Not all of the datasets described in the previous section were used to derive the bioregions in the benthic bioregionalisation. Data for sponges, mean tidal and wave energy, and sediment parameters (%gravel, %mud, $\%CaCO_3$, mean grain size) are only available for the shelf, and they exhibit finer-scale patterns of variability than were required for the benthic bioregionalisation. Similarly, existing bioregionalisations, such as the regionalisation of the Great Barrier Reef Marine Park, were more detailed in spatial resolution than required for the National Marine Bioregionalisation. However, these additional datasets have been included as layers in the National Marine Bioregionalisation GIS as information that may be used to guide or assist with refinement of the benthic bioregions for subsequent planning or management purposes.



Results

OCEAN BASINS AND CLIMATE ZONES

There are three ocean basins in Australia's EEZ, namely the Indian Ocean in the west, the Southern Ocean to the south, and the Pacific Ocean/Tasman Sea in the east.

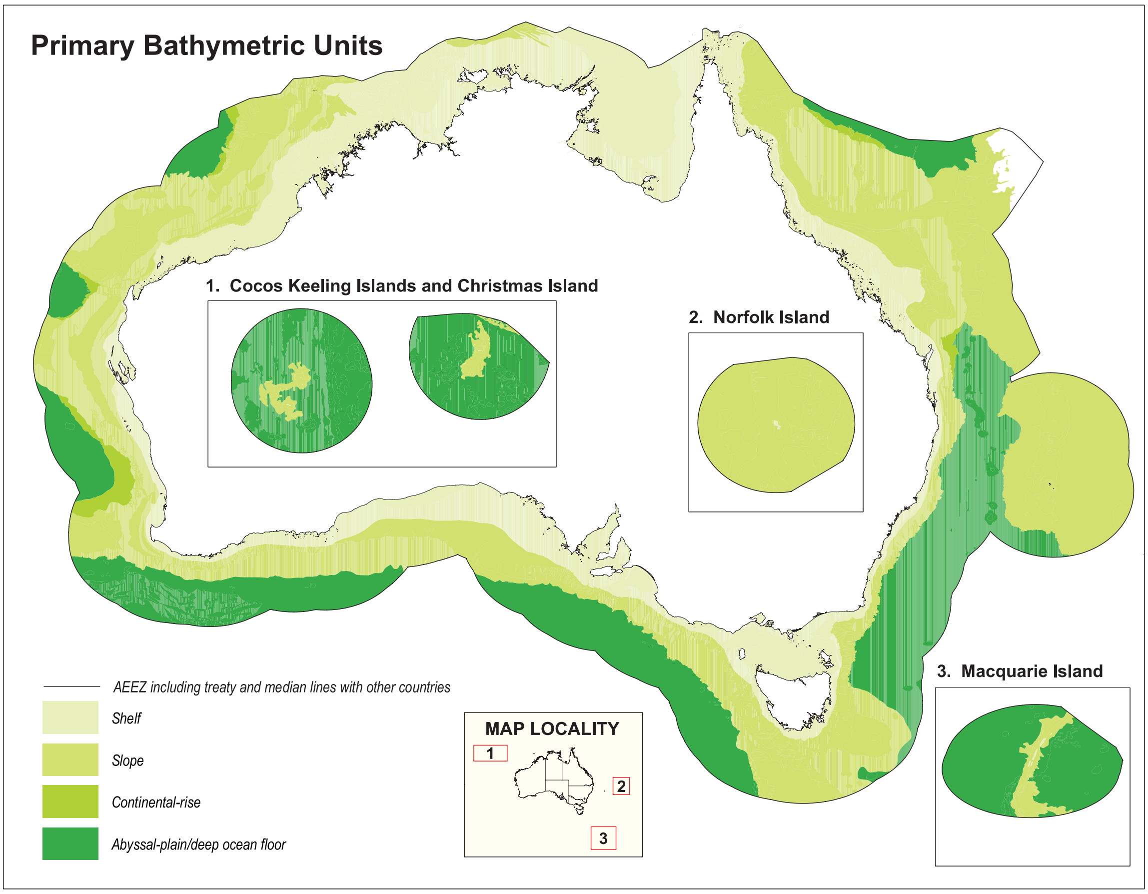
The four climate zones were used to overlay coarse climate regions on the provincial bioregions (provinces only – see Figure 4). Tropical waters are restricted to north of the Tropic of Capricorn; subtropical waters occur on the western margin and extend from Shark Bay in the north to Rottnest Island in the south; warm temperate waters extend along the southern margin from Cape Leeuwin to Kangaroo Island and on the eastern margin from Moreton Bay to Sydney Harbour; cold temperate waters are restricted to the seabed around Tasmania, extending from the vicinity of Cape Grim to the Tasman Peninsula; and sub-polar waters occur around Macquarie Island. Note the transitions were not classified into climate zones as they represent an overlap in faunal distributions.

PRIMARY BATHYMETRIC UNITS

Across the Australian EEZ, the continental shelf covers an area of more than 1.9 million km^2, the continental slope nearly 4.1 million km^2, the continental rise more than 97 000 km^2, and the abyssal plain almost 2.9 million km^2 (Table 2). Nearly half of the EEZ is slope and the abyssal plain covers nearly a third of the EEZ (Figure 3).

Table 2. *Area of each of the primary bathymetric units in the Australian EEZ.*

Primary Bathymetric Unit	Area (km^2)	Area (%)
Continental Shelf	1,976,110	21.91
Continental Slope	4,059,760	45.02
Continental Rise	97,070	1.08
Abyssal plain	2,884,590	31.99
Total	**9,017,530**	**100**



▲ **Figure 3. Map of the primary bathymetric units within Australia's EEZ consisting of continental shelf, continental slope, continental rise and abyssal plain.**

The distribution of the primary bathymetric units highlights the variation in broad depth-related morphological features around Australia's margin. For example, on the northern margin the continental shelf comprises greater than 70% of the overall area and is continuous with the shelves of Indonesia and Papua New Guinea (Figure 3). In contrast, the eastern margin is dominated by the abyssal plain, which comprises greater than 85% of that area and there is an absence of any significant continental rise in the south-east and southern margins (Figure 3). The four island margins included in this study (Macquarie Island, Norfolk Island, Cocos (Keeling) Islands and Christmas Island) differ from the continental regions in that their marine environments are mostly dominated by abyssal plains.

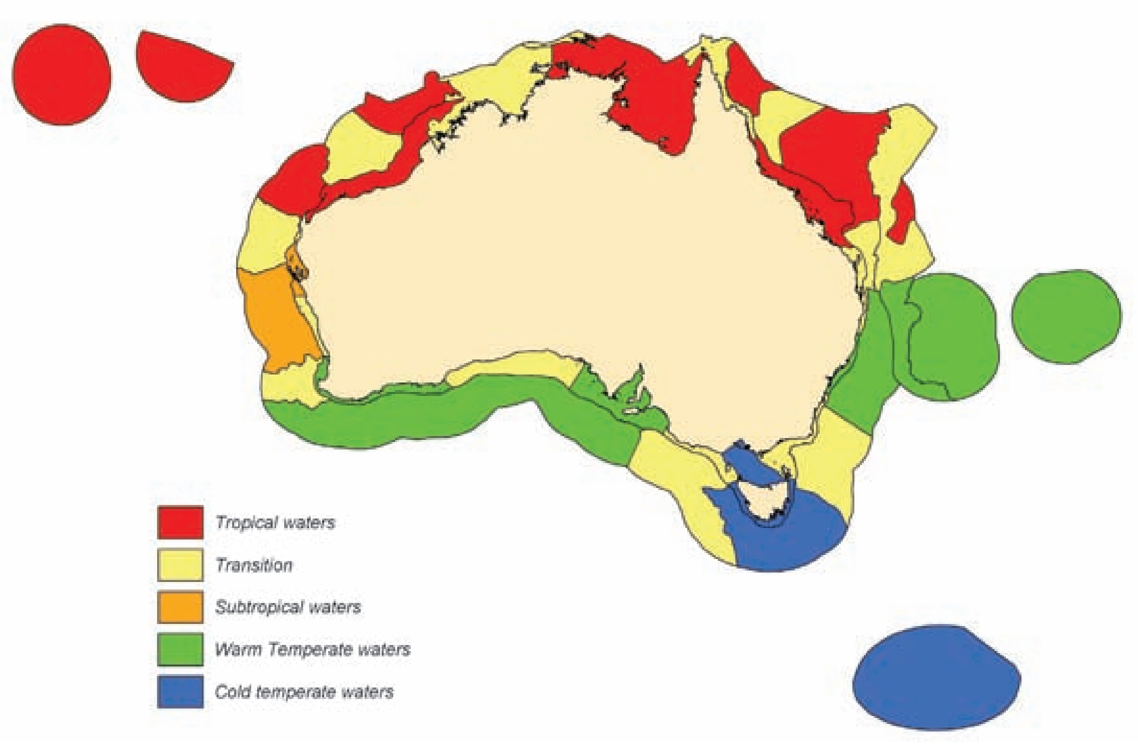
PROVINCIAL BIOREGIONS

The analysis of demersal fish data and geomorphic features produced a series of 24 provincial bioregions in the Australian EEZ seaward of the shelf break (Figure 4). Fifteen of these provincial bioregions are termed provinces (regions of biotic endemism) while the remaining nine are called transitions (less well-defined areas that capture the overlap of demersal fish species ranges between the provinces). Provincial bioregions on the shelf are the existing demersal provinces and biotones (transitions) contained in Map 2 of IMCRAv3.3. Full details of how the IMCRA provinces and bioregions were constructed are presented in the final IMCRA report (IMCRA Technical group 1998).

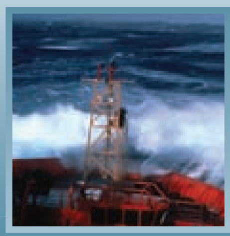
Provincial bioregions seaward of the shelf break are shown in detail in Appendix 3.

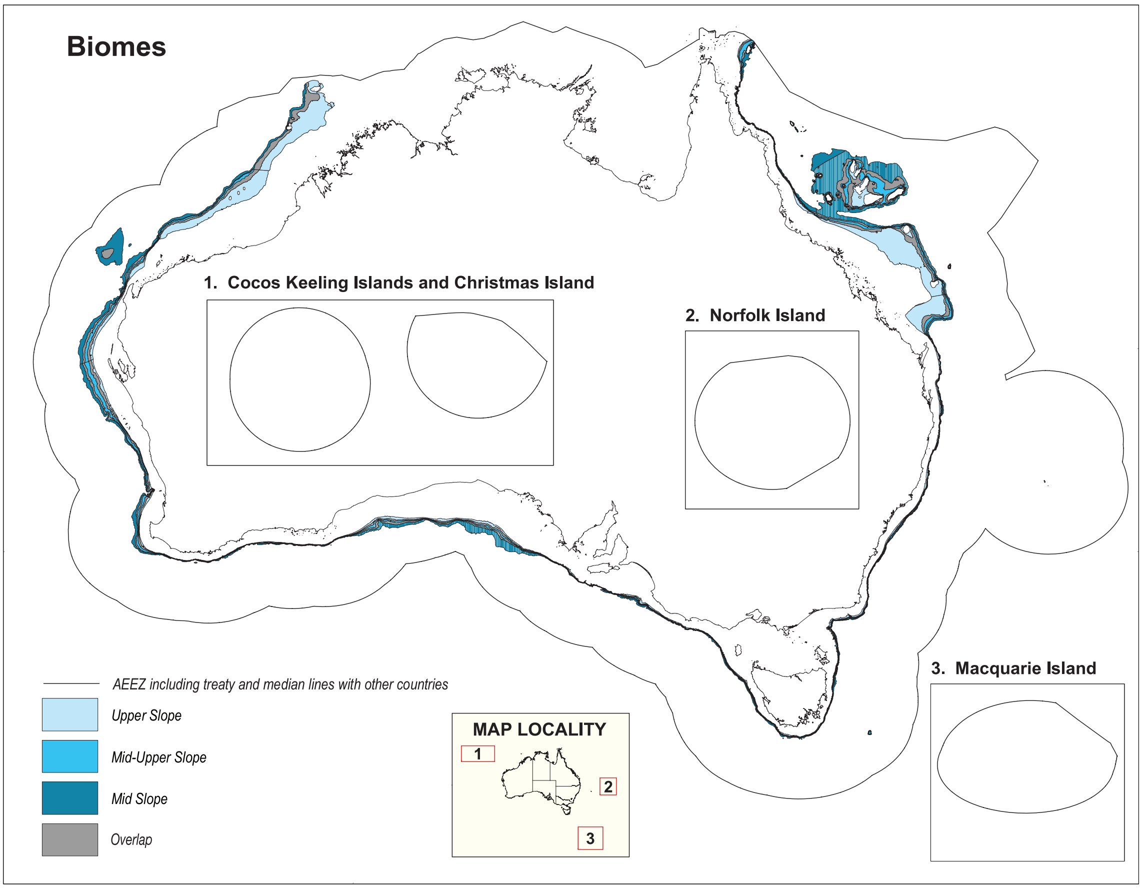
BIOMES

In the eight provinces that included areas of continental slope, three distinct biomes were defined from the demersal fish data: the upper slope, mid-upper slope and the mid-slope, with each biome separated by an area of overlap (Figure 5). The biome boundaries vary in depth around the continent and are generally deeper in the



▲ **Figure 4. Map showing each of the off-shelf provincial bioregions defined in the National Marine Bioregionalisation.** *Provinces are classified according to each of the four ocean climate zones. The shelf bioregions are those defined in IMCRAv3.3.*





▲ **Figure 5. Map of the biomes around Australia's continental slope.**

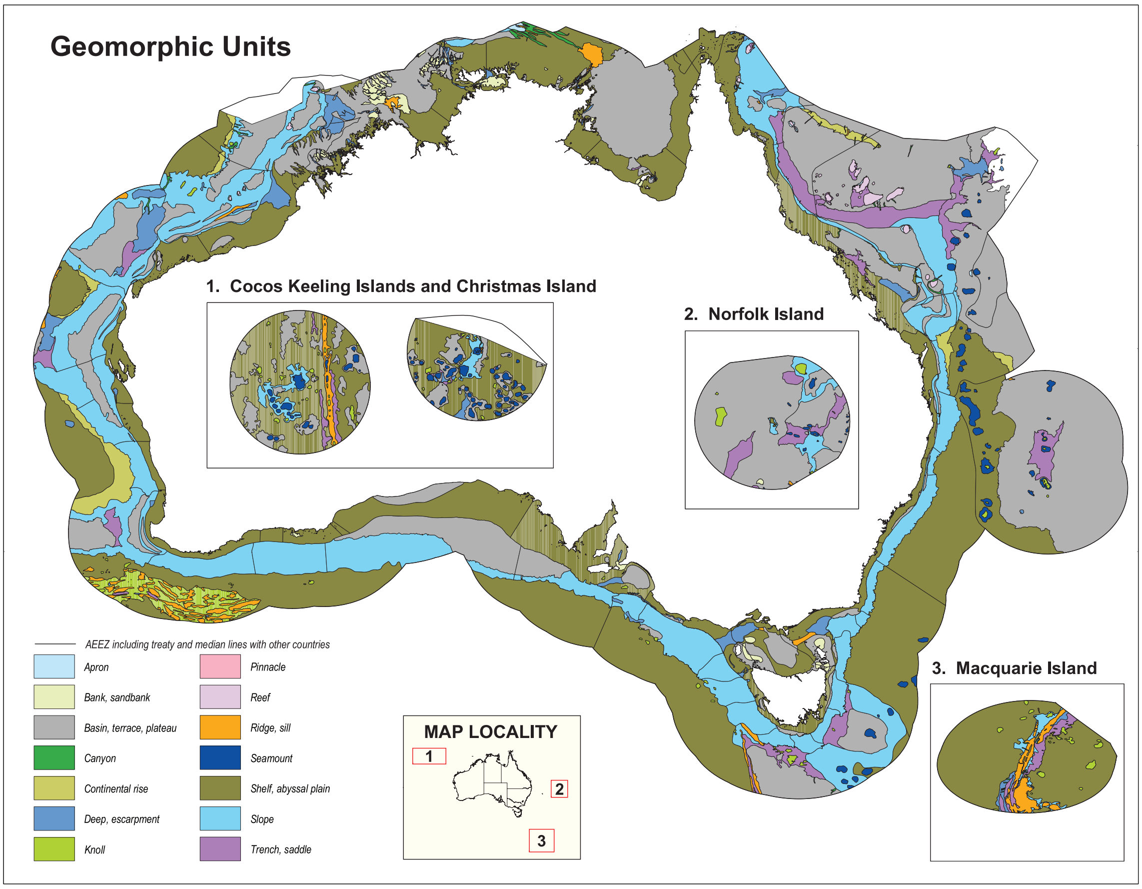
slope provinces on the southern margins. For example, the upper slope ranges from 225–500 m depth in the Timor province but from 310–520 m depth in the Tasmanian province. In general the upper slope ranges between 200–500 m depth, the mid-upper slope ranges from 600–800 m depth and the mid-slope from 900–1100 m depth. Biomes for the seven transitions that included the continental slope were based on the depth of the biome boundaries in the adjacent provinces.

Detailed maps of the biomes within each of provincial bioregions that include the continental slope are provided in Appendix 3.

GEOMORPHIC UNITS

Fourteen geomorphic units were identified in the analysis. The geomorphic units are groups of geomorphic features that represent areas of similar geomorphology. For example, basins, terraces and plateaux, which are characterised on the Australian margin by relatively expansive low-gradient surfaces, all group together into a single geomorphic unit. Other features that grouped together included banks and sandbanks, trenches and saddles, and ridges and sills.

The distribution of geomorphic units throughout the Australian EEZ was mapped. In addition the slope was subdivided based on the presence, absence and relative spacing of submarine canyons along the margin, and the shelf was subdivided based on the presence or absence of reefs, banks and sandwaves/sand banks to produce the final geomorphic unit classes (Figure 6). More detailed maps showing the distribution of the fourteen geomorphic units within each of the provincial bioregions (including IMCRA provincial bioregions) are included in Appendix 3.



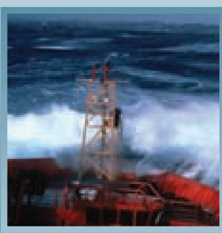
▲ **Figure 6. Distribution of geomorphic units around the Australian EEZ and island territories.**

FINE SCALE CLASSIFICATION: GEOMORPHIC FEATURES, SEABED FACIES AND SPONGES

In addition to the regions described as part of the benthic bioregionalisation, the National Marine Bioregionalisation has resulted in the collation of a number of finer-scale datasets that provide additional information and represent information and examples of how the national datasets might be used to subdivide benthic bioregions when developing management frameworks and plans. For example, the finer-scale data provide valuable information for targeting specific habitats or particular environments for management and protection.

Information on the surface area and distribution of 21 different geomorphic features in Australia's EEZ was collated. This showed that the distribution of geomorphic features on a regional basis is not uniform, although most features occur on all Australian margins as well as those of the offshore islands. Notable exceptions are ridges which are most extensive off New South Wales (i.e. the Lord Howe Rise); seamounts which are most commonly on the eastern margin; reefs which are restricted to tropical areas; escarpments which are most extensive on the Macquarie Island margin; and sills which are found on the northern and north-east margins. Full details of the extent of geomorphic features in Australia's EEZ are contained in Harris et al. (2005).

Seabed facies that represent fine-scale bioregions on the shelf have been described based on sedimentary, bathymetric and oceanographic data. This defines regions of physical complexity on the shelf, which may be used to infer areas of biological complexity. Full details of the seabed facies are contained in Heap et al. (2005).



Patterns of sponge distribution across tropical Australia, based on similarities in species richness and taxonomic distributions, have revealed finer-scale sub-structuring within the bioregions, which suggests the presence of at least 34 fine-scale localities in tropical waters. Full details of the sponge bioregions are contained in Hooper & Ekins (2005).

Additional Information

The benthic bioregionalisation has been constructed with best available data and information. Physical and biological surrogates have been used in the bioregionalisation. For example, most of the biological data in the benthic bioregionalisation are for water depths of less than 1000 m and there are few demersal fish data for any of the offshore island territories. In the deeper regions of the margin and for the offshore islands, bathymetry had the greatest coverage of all datasets, although it is important to be aware that this was also variable in many places.

As a consequence of the variable coverage of the data used to derive the benthic bioregionalisation, the bioregions contain a degree of uncertainty with regard to the location of their boundaries and the fauna they represent. This is especially so where water depths are greater than 1200 m. For example, there may be different provincial structures on the abyssal plain than on the slope, but for the purpose of this bioregionalisation they are assumed to be the same. In addition, offshore islands are assumed to contain a single distinct provincial bioregion, although it is possible that there exist multiple provinces and biomic structures within these. Variation in sampling effort among locations and depths may also have influenced the final spatial patterns and distributions used to derive the bioregions.

Interpretation of the benthic bioregionalisation is based on the assumption that the greater the number of units in each bioregion the greater the potential biodiversity of that bioregion. On this basis, it can be inferred that the more biomes and geomorphic features in each provincial bioregion the greater the complexity and number of ecosystems. Importantly, however, the presence of geomorphic or sedimentary units does not necessarily imply that specific biota exist or that the biological assemblages are necessarily the same everywhere. Application of the benthic bioregionalisation to planning and management should consider the most appropriate use of the information presented, as well as the coverage of the data that has been used to define bioregions.

4. Pelagic Regionalisation

Framework

The nature of the pelagic environment is far more dynamic than that of the benthic environment. In the pelagic environment the continual movement of water is a major influence on species composition, abundance and distribution in the water column. This is in contrast to benthic environments where physical environmental characteristics (e.g. rocky reefs or sand flats) are more stable, at least in the short-term.

The pelagic regionalisation is based on a framework that considers water properties and circulatory systems in the definition of regions (Table 3). Water properties and circulatory regimes are highly depth-structured, and can also change rapidly through time. The pelagic regionalisation considers spatial complexity in the delineation of regions and is also based on oceanographic data that is averaged through time to accommodate a component of the temporal variation. Pelagic regions have been described for Australian waters beyond the continental shelf and between 90–180°E, 0–60°S.

Table 3. Units contained in the pelagic regionalisation.

Name	Description	Data used to define each level
Oceans	Three-dimensional ecological systems discriminated by water properties and circulatory systems influenced by continental landmasses and ocean basins. For example: Pacific Ocean	Qualitative descriptions based on literature
Ocean Zones	Zones within oceans that are formed through the effects of wind, sun and the earth's rotation. These can be characterised by water properties, circulation patterns and biotic assemblages.	Temperature and salinity at the base of the mixed layer
Water Masses	Substructure within the oceans that is characterised by latitudinal bands of water extending through the water column.	Temperature, salinity and dissolved oxygen
Circulation Regimes	Different ocean circulations result in differing retention, mixing and transport of water properties and biological organisms. Circulation regimes are nested within water masses but have only been defined at the surface.	Geostrophic currents Primary productivity Sea surface height
Oceanographic features	Structure within circulation regimes that can be characterised by regions of differing energy, for example high energy areas associated with mixing due to eddy activity, frontal oscillations and boundary currents. These features have only been defined at the surface.	Demersal fish Bathymetry
Geomorphic Units	Areas of similar geomorphology.	Sea surface temperature

METHODS

Data

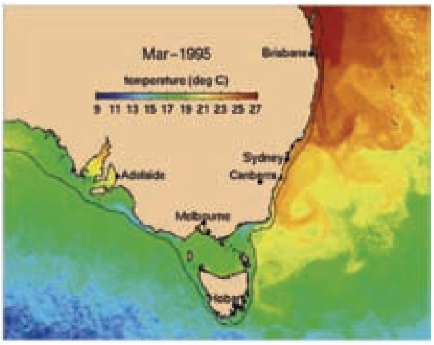
Oceanographic data used to develop the pelagic regionalisation were supplied primarily from existing national datasets for the EEZ and were collated by CSIRO Marine Research.

Each of the datasets used in the pelagic regionalisation are briefly described below and all are contained as layers in the National Marine Bioregionalisation GIS for reference. Full details of the derivation and limitations of each of the datasets are contained in Hayes et al. (2005) and Lyne & Hayes (2005). The reports and GIS are available in hard copy, on DVD or online at www.oceans.gov.au.

CSIRO Atlas of Regional Seas (CARS): is a set of seasonal maps of temperature, salinity, dissolved oxygen, nitrate, phosphate and silicate generated from all available hydrographic data in the region, mapped on a 0.5° grid at 56 standard depth levels. Data on physical attributes such as temperature and salinity provide information about factors that may affect the abundance and distribution of biota in the ocean. For example, the abundance of biota will be linked to primary productivity, which is directly affected by nutrient concentrations. In the pelagic regionalisation, mean annual temperature, salinity and dissolved oxygen from CARS were used for analyses to determine regional structure within the water column.

Sea surface temperature: was produced from remote sensing data collected by the U.S. National Oceanographic and Atmospheric Administration (NOAA) satellites. The data provide higher resolution spatial and temporal information at the sea surface (about 1 km) than is available through CARS and are important in discriminating fine-scale oceanographic features such as currents and eddies.

Sea surface temperature in the pelagic regionalisation



Data about the temperature at the ocean surface is collected by U.S. National Oceanographic and Atmospheric Administration (NOAA) meteorological satellites. Data for Australian waters is received and processed at the remote-sensing facility at CSIRO Marine Research in Hobart.

The main instrument on board the NOAA meteorological satellites is the Advanced Very High Resolution Radiometer (AVHRR). It has two thermal infra-red channels that collect data used to estimate the surface temperature of the ocean area covered by each satellite pass.

Processed images of the sea-surface temperature show the ocean structure and can be used to infer ocean currents. These images are commonly viewed in colour, with red used for the warmest areas and down through the spectrum to blue for the coolest areas.

The image top left shows sea surface temperature for the east coast of Australia during March 1995. From this image, the warm water of the East Australian Current is evident as it flows southwards from Queensland and mixes with the cooler water offshore of the southern states. Smaller features such as eddies and fields associated with the East Australian Current are also evident. Images such as this one were used to identify oceanographic features in the pelagic regionalisation.

Sea surface dynamic height: refers to the pressure associated with a water column and this can vary across the ocean with temperature and salinity. Sea surface dynamic height was calculated from temperature and salinity data derived from the CARS database. Maps of sea surface dynamic height are used to determine the direction of ocean currents.

Sea surface height variability: a measure of the difference between the actual sea surface height at any given time and place, and the height it would be if the ocean were at rest. It can be affected by eddies, currents, wind, tides and the meeting of different water masses. Changes in the ocean over months or seasons (sea surface height variability) are related to regions of high ocean variability. Thus maps of sea surface variability can be used to identify areas of high energy such as eddy fields, frontal areas and boundary currents. Monthly sea surface height variability for use in the pelagic regionalisation was derived from BLUElink Ocean Forecasting Australia (an Australian Government initiative through Commonwealth Bureau of Meteorology, Royal Australian Navy and CSIRO). Sea surface height was used to help identify circulation regimes.

Geostrophic currents: currents have major impacts on the seas and species distribution and are therefore important in understanding patterns and processes occurring in the Australian marine jurisdiction. Surface and subsurface currents were derived from sea surface dynamic height data.

Mixed layer depth: the surface layer of the ocean is usually well mixed through the effects of wind, waves and surface cooling. The depth to which the mixing process penetrates in the ocean influences primary productivity through its effect on light availability and the supply of nutrients from deepwater. Mixed layer depth may therefore be important in understanding depth stratification of biota in the oceans. Mixed layer depth was calculated from temperature and salinity data in the CARS database.

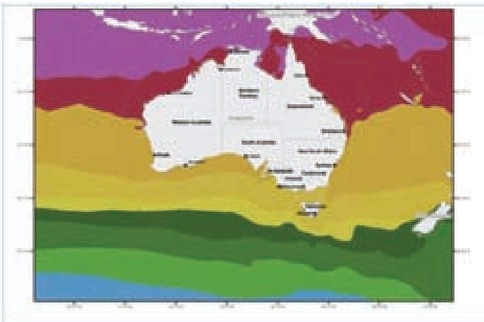
Primary production: is a measure of the amount of carbon that is fixed through the process of photosynthesis. In the oceans, primary producers are mostly planktonic diatoms. Variation in levels of primary production have consequences for nutrient cycles, the distribution of oxygen in the ocean, carbon flux and the synthesis of atmospheric carbon dioxide into biomass. Variability in ocean productivity is linked to understanding the faunal boundaries among different water masses.

For the pelagic regionalisation, primary production for surface waters was estimated from monthly mean chlorophyll-a levels for January, April, July and October and was obtained from the MODIS AQUA ocean colour satellite. Seasonal and inter-annual variations in chlorophyll from weekly composited surface chlorophyll maps covering the period September 1997 to March 2000 were derived from SeaWIFS ocean colour satellite. Surface chlorophyll data from MODIS was also used in a model to estimate the depth-integrated primary production in the ocean.

Phytoplankton: the distribution of phytoplankton species based on historical and recent data was used to corroborate the boundaries of water masses at the sea surface that were determined from physical data.

Phytoplankton distribution in the pelagic regionalisation

Phytoplankton Distribution



Water Masses (at surface)

The distribution of phytoplankton species was used as biological information to corroborate the existence and boundaries of the surface water masses that were derived from physical oceanographic data (temperature, salinity and oxygen).

Six major regions are apparent from the phytoplankton data. These are shown on the map above and are: (1) the shelf waters of North West Australia, the Gulf of Carpentaria, Arafura Sea and Timor Sea; (2) the tropical oceanic communities of the Indian Ocean and Coral Sea that are dominated by dinoflagellates; (3) the tropical communities in the shallow waters of the Great Barrier Reef Lagoon dominated by fast-growing nanoplankton diatoms; (4) the productive temperate region comprising coastal waters of New South Wales, Tasmania, Victoria, and South Australia; (5) the oceanic transition zone south of the Australian continental shelf; and (6) the Sub-Antarctic phytoplankton region. Within each of these regions, substructure (denoted by lowercase letters) is associated with subtle differences in species dominance and phytoplankton biomass.

There was broad agreement between regions based on phytoplankton distribution and the water masses determined from oceanographic data. For example, phytoplankton regions 1a and 1b reflect the different water masses located in the Gulf of Carpentaria as shown in the map of water masses above. In addition, detailed features in the phytoplankton map, such as those associated with the Leeuwin Current offshore of the shelf break in the western Great Australian Bight also appear to correspond with finer scale units in the regionalisation (circulation regimes and oceanographic features).

The areas defined qualitatively based on existing biological data do match closely those areas defined based on physical data, although there is some discrepancy between the regions defined using each approach. This discrepancy indicates that physical data will not always be a perfect surrogate for biological data, but can still closely represent spatial patterns in the distribution of biota in Australian waters.

ANALYSIS

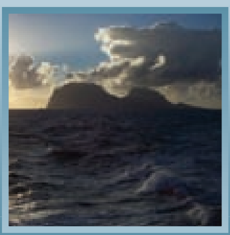
A combination of descriptive and analytical approaches was used to define the various levels of the pelagic regionalisation framework.

Oceans were the broadest oceanographic context for the pelagic regionalisation. The description of oceans relied upon literature searches and reviews, assessment from atlases and discussions with experts.

Ocean zones describe the ocean at the coarsest scale appropriate for management. They were based on temperature and salinity at the base of the mixed layer and describe latitudinal circulatory processes that result in banded structures within the oceans.

Water masses were defined based on temperature, salinity and oxygen and under the assumption that water properties influence depth structuring of organisms. Analysis of water masses examined patterns in ocean structure at 56 depth intervals from the surface to 5500 m Analysis was intentionally biased towards the surface layers as these were considered to be of more relevance to management.

Circulation regimes were examined within the 10 water masses that form part of the surface of the ocean in the Australasian study area. Analysis considered surface and subsurface currents, primary productivity, sea surface height and sea surface temperature. This process identified areas within each of the water masses that showed



fine-scale sub-structuring associated with variation in circulation patterns and air/sea moisture exchanges which will result in differing retention, mixing and transport of water properties and biological organisms.

Oceanographic features are the finest level within the pelagic regionalisation. These represent areas of varying energy within the circulation regimes and are based on sea surface temperature. This scale of regionalisation provides further insight into the processes occurring at finer scales, for example regions of higher energy within a circulation regime may be more productive and able to support a greater biomass or diversity of flora and fauna.

All the data are included as layers in the Pelagic Regionalisation GIS and may be used to guide or assist with the development of management plans or frameworks.

Results

OCEANS

Three oceans are recognised in Australia's EEZ: the Indian Ocean, the Pacific Ocean and the Southern Ocean.

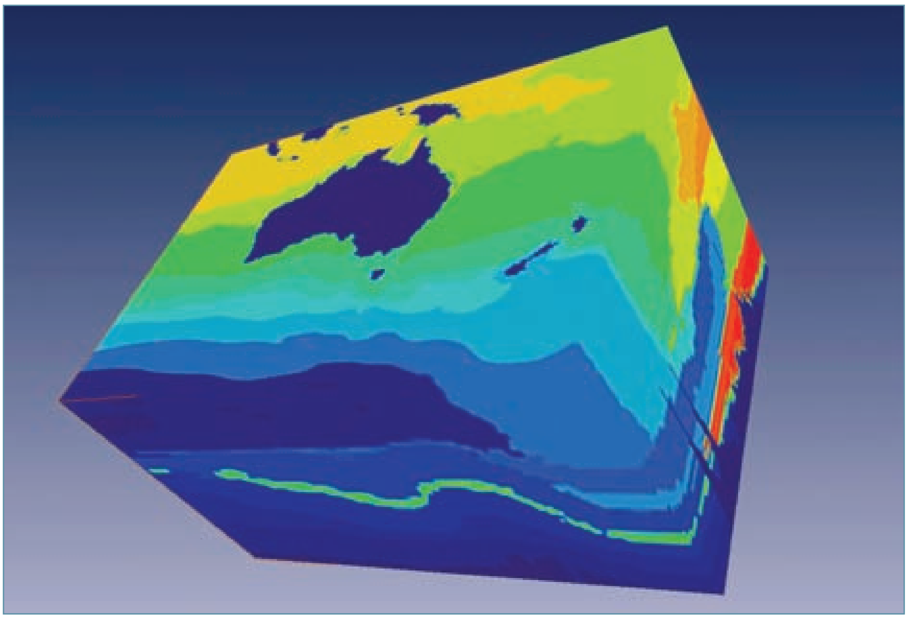
OCEAN ZONES

Ocean zones identified around Australia included the Indian Central Water, the Indonesian Throughflow Water (which has components in the Indian and Pacific Oceans) and the South Pacific Central Water. These ocean zones are influenced by winds, solar forcing and geostrophy, which combine to drive circumferentially and latitudinally-oriented water masses. They are characterised by water temperature, circulation and assemblages of biota that vary with depth and with the transition between the zones, which is generally characterised by higher plankton production.

WATER MASSES

Twenty-five different water masses were identified in off-shelf waters within Australia's marine jurisdiction. Water masses are defined by largely latitudinal oceanographic processes with exceptions in the equatorial and tropical areas. The water masses are three-dimensional in nature and occur across different latitudes and depths. For example, Water Mass 10 (the Southern Subtropical Convergence) contains 4.4 million km^3 of water and is present in part of the Southern Ocean from the surface down to around 800 m (Figure 7). Generally, the water masses with the largest volumes are those in deeper water, with a few exceptions associated with intermediate waters (Table 4).

Water masses that form part of Australia's marine jurisdiction are shown in detail in Appendix 4.



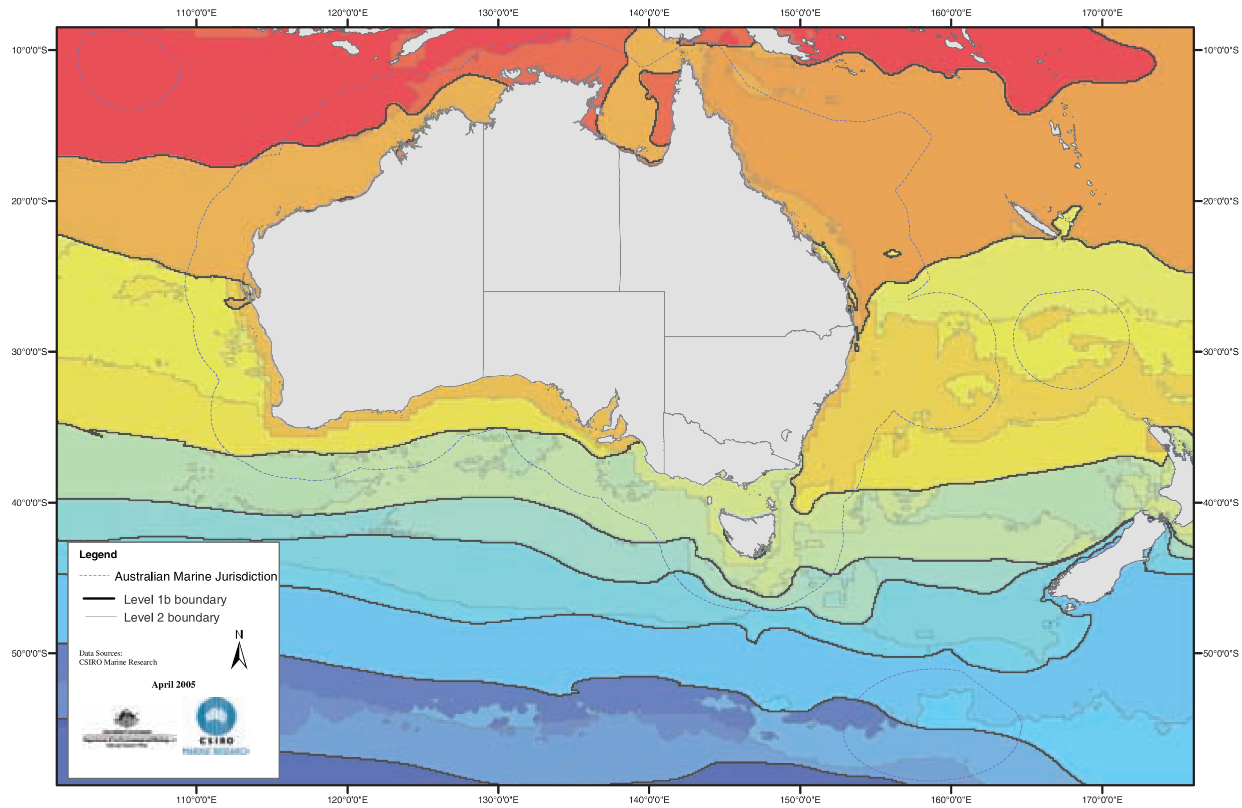
▲ **Figure 7. Image demonstrating the three-dimensional nature of water masses defined in the pelagic regionalisation.** *For example, water mass 13 in the Pacific Ocean is the Pacific Central-South subtropical water (coloured green) and extends from the surface waters to around 250 m depth. Water mass 10 (the southern Subtropical Convergence – coloured light blue) is part of the Southern Ocean, and extends from the surface to around 800 m depth. (Image produced using a demonstration version of Amira)*

Table 4. Basic descriptions of the 25 water masses defined in the pelagic regionalisation including the water mass reference number, the name of the water mass (where it is already named), and the volume of each water mass (in millions of km3). *The water masses are ordered by reference number, not according to location.*

Water Mass number	Water Mass name	Volume ($km^3/10^6$)
1	Southern Subantarctic	0.57
2	Not named	12.45
3	Not named	22.71
4	Not named	18.05
5	Not named	5.81
6	Not named	6.60
7	Not named	0.93
8	Not named	13.70
9	Subantarctic Front	2.05
10	Southern Subtropical Convergence	4.40
11	Central Subtropical Convergence	2.59
12	Northern Subtropical Convergence	1.95
13	Coral Sea Circulation: Pacific Central-south Subtropical Water Mass (in the Pacific Ocean) Indian Central (in the Indian Ocean)	1.58
14	Not named	9.08
15	Not named	18.76
16	Not named	14.54
17	Pacific North-west Tropical Warm Pool (in the Pacific Ocean) Indian Central Tropical Transition Water Mass (in the Indian Ocean)	1.00
18	Not named	2.66
19	Not named	5.44
20	Indonesian Throughflow Region: Indian North-east Equatorial Water Mass	0.62
21	Not named	1.71
22	Not named	3.70
23	Not named	0.91
24	Not named	11.06
25	Not named	14.74

CIRCULATION REGIMES

Circulation regimes were only determined for the ten water masses that were present on the ocean surface (Figure 8). In general, the structure within the water masses is associated with circulatory fields such as the East Australian Current, the Tasman Sea and to the south and east of landmass extensions or corners; for example, the south-west of Western Australia (the Naturaliste Plateau), Tasmania and its associated subsurface shelf extensions (South Tasman Rise, Cascade Plateau), and New Zealand and its surrounding subsurface plateaus (e.g. Campbell Plateau). Details of the circulation regimes within each of the surface water masses are illustrated in Appendix 4.



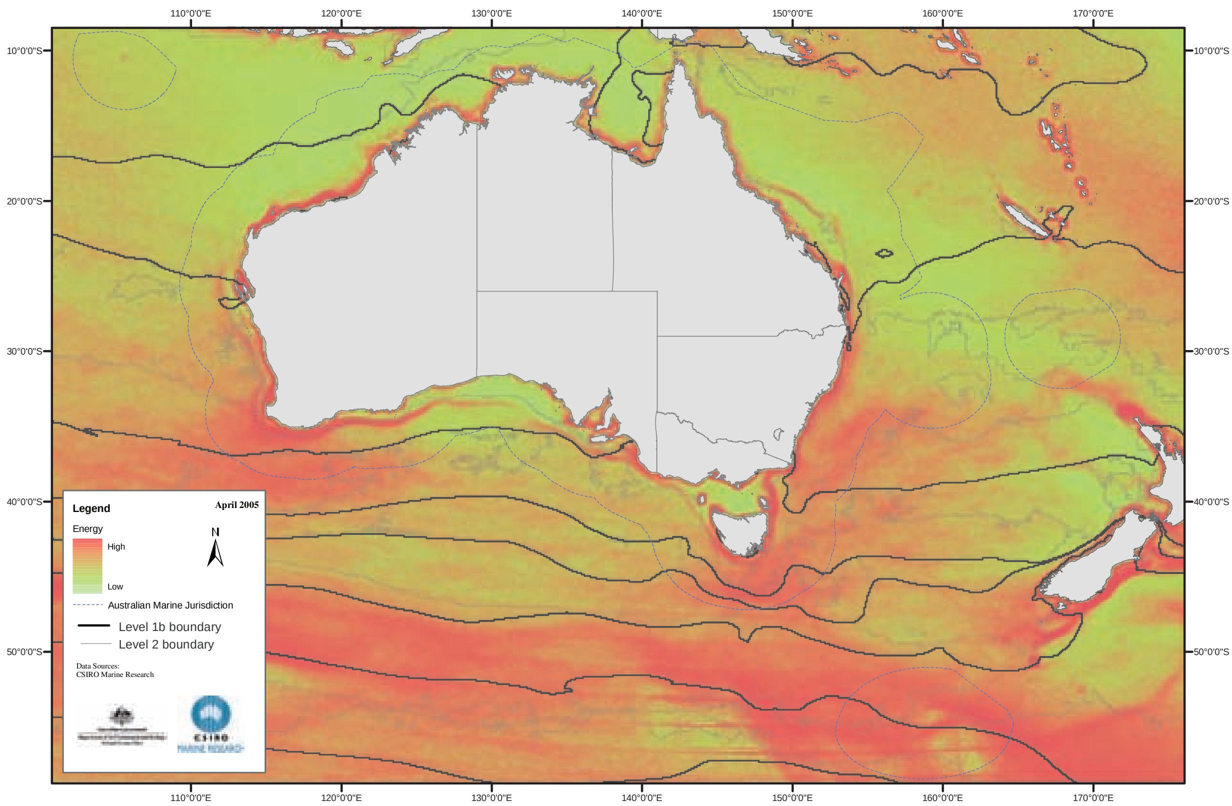
▲ Figure 8. Circulation regimes within each of the ten surface water masses. Circulation regimes are demarcated by grey lines and coloured as shades of the water mass (demarcated by black lines).

OCEANOGRAPHIC FEATURES

The finest-scale analysis of structure within oceanic surface layers, based on energetics, has been used to identify areas of varying energetics within the circulation regimes. This analysis shows a range of structures including narrow elongated features that are part of the Leeuwin Current circulation regime off south-west Western Australia, various bands and mixing regimes associated with the East Australia Current, and broadscale features such as those in the tropics (Figure 9). Within a water mass, regions of higher energetics can be expected to be more productive and hence able to support a greater biomass of flora and fauna. For example, in the East Australia Current circulation regime, areas of different energetics may consist of the core of the current, the offshore mixing boundary of the current, or the downstream region where eddies shed off and mix with surrounding waters. Some of these areas are more energetic than other areas, and these may reflect areas that are biologically variable within the circulation regime.

Oceanographic features within each of the surface water masses are illustrated in Appendix 4.

▼ **Figure 9. Oceanographic features within Australia's Marine Jurisdiction.** *This finest level of the regionalisation is used to identify areas of varying energetics within each of the circulation regimes. This is achieved by using relative brightness to correspond with areas of higher energy. For example, redder areas correspond to greater levels of energy, which may reflect higher productivity areas within a circulation regime. The surface water masses (black lines) and circulation regimes (grey lines) are also marked on the map to illustrate the relationship among all three levels of the regionalisation.*



Additional Information

As in the benthic bioregionalisation, the pelagic regionalisation has been constructed with best available data. The spatial coverage of data for the pelagic regionalisation is generally high and the primary shortcoming of the pelagic regionalisation is that quantitative biological information has not been included in the analyses.

The pelagic regionalisation assumes that physical and chemical properties of the ocean may reflect patterns in the distribution of biota. This assumption has been corroborated qualitatively through the alignment of surface water masses with phytoplankton distributions, although it is known that many pelagic species range widely and may use different water masses during different stages of their life history. In addition, depth structure derived from the analysis of physical and chemical properties may not be entirely relevant to biological processes and organisms that rely upon surface light and the decay of light with depth. More detailed biological information is needed to guide and inform the analyses, and a better understanding of how physical and chemical data relate to biological patterns in the oceans is also required.

When interpreting and using the pelagic regionalisation, it is important to be aware that some datasets are better suited to different scales of regionalisation. For example, mixed layer depth is appropriate for regionalisation at coarser scales, but is likely to be problematic at finer scales. Some datasets are also restricted in their application due to their resolution or sampling regime. For example, sea surface dynamic height contains information about coarse-scale patterns associated with ocean currents, but it is susceptible to the effects from finer-scale dynamic features such as eddies. Similarly, estimating primary productivity or chlorophyll from ocean colour satellites is the only way to obtain chlorophyll data that spans the whole of Australia's EEZ. However, this only provides information on surface chlorophyll and models used to derive sub-surface estimates from ocean colour have varying levels of accuracy (Hayes et al. 2005). Application of the pelagic regionalisation to planning and management should consider the most appropriate use of the information presented, as well as the scope of the data that has been used to define bioregions.

5. Conclusions

The National Marine Bioregionalisation represents a synthesis of key biological, geological and oceanographic data to divide Australia's ocean and seabed habitats into bioregions that make sense ecologically, are at a useful scale for regional marine planning, and provide a systematic framework for subsequent planning and management. It is based on the best information currently available and represents the most comprehensive bioregionalisation study ever undertaken in Australia at a national scale.

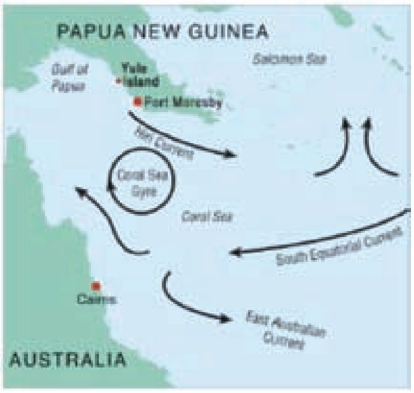
The National Marine Bioregionalisation provides a picture of the spatial distribution of the coarse-scale physical and biological components of the off-shelf component of Australia's EEZ. It consists of a series of bioregions that together represent an improved understanding of structure of the seabed and ocean at a range of spatial scales. It is the only consistent management framework for deepwater areas beyond the shelf break, and applies to approximately 80% of the total area of Australia's EEZ.

Planners and managers can use the National Marine Bioregionalisation to assist in building an understanding of broad ecosystem boundaries at several spatial scales both in the benthic and pelagic realms of Australia's Marine Jurisdiction.

The National Marine Bioregionalisation is an important tool to assist in determining ecological characteristics of the marine environment such as the spatial extent of habitat types, coarse-scale patterns in the distribution of biota, and how levels of biodiversity might vary among different regions. Classification of the pelagic environment through the integrated analysis of the whole water column assists managers to identify a rich variety of structures that may have implications for biological productivity and marine resource management.

Managers of marine resources need to consider human activities in the context of ecosystem boundaries, as well as in the context of boundaries based on governance or tenure. This is especially relevant in an international context. Australia shares maritime boundaries with six other nations and many of the habitats and structures identified in the National Marine Bioregionalisation are continuous across these maritime boundaries. Hence the National Marine Bioregionalisation has benefits beyond Australia in contributing to a better understanding of how ecosystems and ecosystem processes cross international boundaries.

Biological processes that cross international boundaries



The ornate rock lobster, which forms an important fishery in the Torres Strait, spends only part of its life in Australian waters. In spring of each year, adult lobsters travel from their homes in the Torres Strait to waters off Papua New Guinea where they mate and release larvae. The larvae are carried by the Hiri Current into the Coral Sea, and after six months the larvae eventually drift into the Torres Strait waters from where their parents originated.

The complex life cycle of the ornate rock lobster highlights how ecosystems and ecological processes rarely adhere to jurisdictional boundaries, and the importance of an ecosystem approach to ensure species such as this can complete all stages of their life cycle. Importantly, international cooperation is needed to ensure that lobster populations are managed at all stages of their life cycle and to ensure the fishery remains ecologically sustainable.

The National Marine Bioregionalisation will assist managers to identify structures and habitats that are continuous across international boundaries and that might be important for species such as the ornate rock lobster that utilise different habitats throughout their life cycle.

The National Marine Bioregionalisation program has resulted in a valuable collection of data relevant to Australia's EEZ in an accessible form. National datasets such as the bathymetry, sediment and biological datasets will be continually updated as new marine surveys are completed, and there is also scope for the development of additional national datasets from existing data. Opportunities exist for further analysis of existing data to enhance the current bioregionalisation, as well as incorporation of new data especially for areas where data coverage is variable.

The National Marine Bioregionalisation is designed to be a static snapshot of the spatial distribution of the key physical, chemical and biological components of Australia's EEZ, although it is recognised that marine ecosystems have both spatial and temporal components. Ongoing and future research into the complex interactions between the nature of the ocean, seabed and biota over a range of spatial scales and could lead to the establishment of more robust boundaries with more certainty in the bioregions. In addition, exploration and visualisation of links between the benthic and pelagic regionalisations would contribute to further understanding of ecosystem connectivity.

The temporal components of the marine environment, which can be characterised by seasonal variations and longer timescale variability such as El Niño oscillations and global climate trends, have not been captured in the present framework but will be important in consideration of possible further elaboration of the National Marine Bioregionalisation.

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Glossary of Terms (as used in this report)

Abyssal Plain. A large area of extremely flat or gently sloping ocean floor just offshore from a continent and usually at depths >2000 m. The abyssal plain begins where the continental margin ends.

Benthic. Living on or in the bottom of a body of water

Biodiversity. The variety of all life forms – the different plants, animals and micro-organisms, the genes they contain and the ecosystems of which they are a part.

Biogeographic. Relating to large regions with distinct landscapes/seascapes, flora and fauna.

Biome. A major regional ecological community of plants and animals extending over large natural areas. In the sea, these equate to units such as coastal, demersal, shelf and slope, abyssal, neritic, epipelagic, mesopelagic and bathypelagic. In the benthic bioregionalisation, biomes are biogeographic units based on primary bathymetric units and faunal communities that are nested within provinces.

Biophysical. Describes the application of physics to biological processes and phenomena.

Bioregion. Assemblages of flora, fauna and the supporting geophysical environment contained within distinct but dynamic spatial boundaries. Biogeographic regions vary in size, with larger regions found where areas have more subdued environmental gradients. These are defined and delineated at the meso-scale.

Bioregionalisation. A regionalisation that includes biological as well as physical data in analyses to define regions for administrative purposes.

Biotone. Zones of transition between core provinces (as used in IMCRA). They are equivalent to transitions in the National Marine Bioregionalisation.

Circulation regime. Areas within water masses that have differing circulations resulting in differing retention, mixing and transport of water properties and biological organisms.

Continental margin. The submerged prolongation of the landmass of Australia, which consists of seabed and subsoil of the continental shelf, slope and rise, but not the deep ocean floor.

Continental rise. The sloping part of the ocean floor at depths about 2000–4000 m, between the continental slope and the abyssal plain

Continental shelf. The shelf-like part of the ocean floor beside continents and extending from the coast to a depth of about 200 m. The shelf is divided into inner-shelf (the area closes to the coastline), outer-shelf (the area adjacent to the shelf break) and mid-shelf (the region between the inner and outer shelf).

Continental slope. The sloping, often steep, part of the ocean floor bordering the continental shelf and extending to a depth of about 200 m; divided into the upper slope (200-700 m) which is adjacent to the shelf break, mid-slope (700-1400 m) and lower slope (1400-2000 m)

Demersal. Occurring or living on or near the bottom of an aquatic environment.

Ecologically sustainable development. Using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased.

Ecosystem. A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit. In practice, ecosystems are mapped and described using biophysical data.

Ecosystem approach. A strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way

Ecosystem-based management (EBM). Management that recognises that maintaining the structure and function of ecosystems is vital, and that human uses and ecosystem health are interdependent. EBM considers ecological, social and cultural objectives for an ecosystem, but makes ecological sustainability the primary goal of management.

Endemic. Native to, or confined to, a certain region

Exclusive Economic Zone (EEZ). An area beyond and adjacent to the territorial sea, subject to the specific legal regime of Australia, under which the rights and jurisdiction of Australia and the rights and freedoms of other states are governed by the relevant positions of the United Nations Convention on the Law of the Sea. Australia's EEZ was proclaimed in August 1994, and extends 200 nautical miles from the coast.

Geomorphic feature. A distinct element of the seabed such as a seamount, canyon, basin, reef or plateau.

Geomorphic unit. A group of geomorphic features that represent areas of similar geomorphology

Habitat. A geographic area that can provide for the key activities of life – the place or type of site in which an organism naturally occurs.

Inshore. The near coastal waters extending from the coastline and estuaries out to 3 nautical miles, which is the boundary of the State and Territory waters.

Large marine domain. Area in the order of > 200 000 km² characterised by distinct bathymetry, hydrography, productivity, species composition and trophically inter-dependent populations

Meso-scale region. Large spatial unit (in terms of 100s or 1000s of kilometres in length)

Mixed layer. The layer between the ocean surface and a depth usually ranging between 25 and 200 m, where the density is about the same as at the surface.

Ocean climate zone. Regions that capture the broad differences between tropical, subtropical, warm temperate and cool temperate waters.

Ocean zone. Zones within oceans that are formed through the effects of wind, sun and the earth's rotation.

Oceanic feature. Structure within a circulation regime that can be characterised by differing energy.

Offshore. The area of the Exclusive Economic Zone extending from the border of the 3 nautical mile State and Territory waters to the limit of Australia's international marine boundary.

Off-shelf. Refers collectively to the continental slope, continental rise and abyssal plain.

Pelagic. Of, relating to, or living in open oceans or seas

Province. A large-scale biogeographic unit derived from evolutionary processes in which suites of endemics co-exist.

Provincial bioregion. A large biogeographic region based on broadscale distribution of fauna. In the benthic bioregionalisation, provincial bioregions are divided into provinces and transitions.

Primary bathymetric unit. A regional-scale bathymetric feature. In the benthic bioregionalisation these are classified as continental shelf, slope, rise and abyssal plain.

Regionalisation. The process and output of identifying and mapping broad spatial patterns based on physical and/or biological attributes for planning and management purposes.

Regional marine planning. A process designed to integrate sectoral, commercial and conservation requirements in working towards ecologically sustainable development in Australia's oceans. It is strategic, integrated planning at a broad regional scale that will result in a series of agreed long-term (10 year) objectives for sustainability, strategies for how to achieve those objectives, and a monitoring program that allows assessment of management performance.

Shelf break. The sudden change in seabed gradient (highlighted by closely spaced contours) that occurs at the boundary between the outer continental shelf and the upper continental slope

Surrogate. One that takes the place of another; a substitute. For example in the benthic bioregionalisation, physical characteristics of the seabed (e.g. geomorphic features or sediment types) were used to determine bioregions in place of biological information.

Transition. A zone of overlap between provinces. The transitions are not simply 'fuzzy' boundaries but are areas that represent unique communities and ecological processes.

Water mass. Discrete area in the ocean that is characterised by latitudinal bands of water extending through the water column.

List of Acronyms

CARS	CSIRO Atlas of Regional Seas
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EEZ	Exclusive Economic Zone
ESD	Ecologically Sustainable Development
GA	Geoscience Australia
GIS	Geographic Information System
IMCRA	Interim Marine and Coastal Regionalisation for Australia
MACC	Marine and Coastal Committee
MARS	National Marine Sediments database
NBMB	National Benthic Marine Bioregionalisation
NMB	National Marine Bioregionalisation
NRSMPA	National representative system of marine protected areas
OZCAM	Online Zoological Collections of Australian Museums

Appendix 1 – Bioregionalisation Working Group: membership and terms of reference

Bioregionalisation Working Group members and their affiliations

Name	Affiliation
Mr Colin Creighton (Chair)	Water for a Healthy Country, CSIRO Flagship (Australian Government)
Mr Peter Bosworth Mr Dennis Witt	Department of Primary Industry, Water and Environment (TAS)
Ms Patricia von Baumgarten Mr Bryan McDonald	Department of Environment and Heritage (SA)
Dr Rob Coles	Department of Primary Industries and Fisheries (QLD)
Dr Bob Creese	Department of Primary Industries – Fisheries (NSW)
Mr Ian Cresswell	Department of the Environment and Heritage (Australian Government)
Dr Campbell Davies Dr Sally Troy Mr Ian Cresswell Ms Emma Campbell	Department of the Environment and Heritage, National Oceans Office (Australian Government)
Mr Jon Day Dr Leanne Fernandes	Great Barrier Reef Marine Park Authority (Australian Government)
Dr Peter Doherty	Australian Institute of Marine Science
Mr Don Hough	Marine Strategy Section Dept of Sustainability and Environment (VIC)
Dr Sam Nelson Mr Paul Ryan Mr Bruce Wallner Mr Paul Murphy	Australian Fisheries Management Authority (Australian Government)
Dr Chris Simpson	Marine Conservation Branch Department of Conservation and Land Management (WA)
Dr Rob Taylor Mr Neil Smit	Parks and Wildlife Service Department of Infrastructure, Planning and Environment (NT)

National Bioregionalisation Working Group Terms of Reference:

1. Contribute to and advise on the development and implementation of a work program for the national bioregionalisation for Australia's EEZ.

2. Contribute to and advise on the development and implementation of a work program for bioregionalisation within individual regional marine plan areas, initially Northern Australia.

3. Provide technical expert advice and peer review on component data, analysis and integration projects, including:

   - methods for identifying and expressing uncertainties in the component data and the resulting bioregions

   - capturing and linking the differences in pelagic and benthic/demersal environments

   - expressing the connections between ecosystem structure and ecosystem function/dynamics/processes

   - protocols for data management and coordination with National Marine Data Group.

4. Provide advice on communication products and strategies.

5. Participate in technical workshops and meetings to incorporate input from a broad range of experts, policy makers and stakeholders

6. Liaise with other technical working groups and advise the Science Advisory Group, as necessary.

Members were invited on the basis of their expertise and experience in using regionalisations in planning and management of the terrestrial or marine environment or expertise in marine ecology more generally. The group includes individuals involved in the IMCRA process, the Interim Biogeographic Regionalisation of Australia process, the GBRMPA regionalisation, the North West Shelf Joint Environmental Management Study project, the National Ocean Office's South East Marine Region Interim Bioregionalisation, State/Territory marine mapping projects, other planning and management programs (e.g. Task Force on Marine Protected Areas) and relevant scientific research. Member's views are not taken to represent the views of their agency or respective governments.

Secretariat support for the Working Group was provided by the National Oceans Office.

Appendix 2 – Data contained in the GIS layers of the National Marine Bioregionalisation

Benthic Bioregionalisation

GIS Layer	Description
Primary Bathymetric Units	Outlines of the major geomorphic features (i.e. shelf, slope, rise, abyssal plain/deep ocean floor).
Provincial Bioregions	Draft national benthic marine bioregionalisation provincial bioregions and their boundaries as defined from demersal fish provincial structure and geomorphology. For the shelf, the provincial bioregions are the existing IMCRA provincial bioregions.
Biomes	Draft national benthic marine bioregionalisation biomes and their boundaries as defined from demersal fish depth structure.
Geomorphic Units	Draft national benthic marine bioregionalisation geomorphic units and their boundaries as defined from a cluster analysis of the geomorphic features.
Seabed Facies	Draft national benthic marine bioregionalisation seabed facies and their boundaries for water depths of less than 300 m as defined from a cluster analysis of sediment, geomorphic and oceanographic data.
Coastline (250k)	Australian coastline (including islands) shown at a scale of 1:250 000.
Australian EEZ	Australian Exclusive Economic Zone boundary.
Bathymetry (contours)	Bathymetric contours derived from the 250 m spatial resolution bathymetry model.
Bathymetry (image)	Tagged Image File format (TIFF) colour-ramped image of the 250 m spatial resolution bathymetry model.
Sedimentary Basins	Outlines of offshore sedimentary basins.
Geomorphic Features	Outlines of 21 types of geomorphic features.
Ocean Crustal Age	Outlines of regions showing oceanic crustal rocks of equal age.
Percent Carbonate	Calcium carbonate ($CaCO_3$) concentrations over the seabed for water depths of less than 300 m interpolated to a 0.01° (~1 km) grid.
Percent Gravel	Gravel concentrations over the seabed for water depths of less than 300 m interpolated to a 0.01° (~1 km) grid.
Percent Sand	Sand concentrations over the seabed for water depths of less than 300 m interpolated to a 0.01° (~1 km) grid.
Percent Mud	Mud concentrations over the seabed for water depths of less than 300 m interpolated to a 0.01° (~1 km) grid.
Mean Grain Size	Mean grain size in mm of seabed sediment for water depths of less than 300 m interpolated to a 0.01° (~1 km) grid.
Sediment Mobility Regime	Outlines showing the relative influence of waves and tides in mobilising sediment on an annual basis for water depths of less than 300 m.
Australian Sponge Distribution	Points showing the distribution of sponges.
Demersal Fish Provinces (slope)	Outlines of the major provincial structure of deep-water demersal fishes for water depths of 40–2000 m.
Demersal Fish Provinces (shelf)	Outlines of the provincial structure of demersal fishes on the shelf (less than 200 m).
IMCRA (shelf)	Outlines showing the boundaries of the shelf provincial bioregions and biotones contained in the Interim Marine and Coastal Regionalisation of Australia.
GBRMP Reef Bioregions	Outlines showing the boundaries of the reef bioregions in the Great Barrier Reef Marine Park.

GIS Layer	Description
GBRMP Non-reef Bioregions	Outlines showing the boundaries of the non-reef bioregions in the Great Barrier Reef Marine Park.
Tide energy	Mean tidal current speed (m s^{-1}) for water depths less than 300 m, generated by GEOMAT model.
Tide exceedance	Tide-induced exceedance for water depths less than 300 m calculated using GEOMAT.
Seabed Temperature	Average annual seabed temperature in °C generated from the CSIRO Atlas of Regional Seas (CARS) database interpolated to a 0.01° (~1 km) grid.
Wave energy	Mean wave energy (J m^{-2}) for water depths less than 300 m, generated by GEOMAT model.
Wave exceedance	Wave-induced exceedance for water depths less than 300 m calculated using GEOMAT.

Pelagic Regionalisation

GIS Layer	Description
Nitrate	The annual mean concentration of nitrate (based on data from 1970–2000) at different depths (surface, 150 m, 500 m, 1000 m and 2000 m). Derived from CARS.
Oxygen	The annual mean concentration of oxygen (based on data from 1970–2000) at different depths (surface, 150 m, 500 m, 1000 m and 2000 m). Derived from CARS.
Phosphate	The annual mean concentration of phosphate (based on data from 1970–2000) at different depths (surface, 150 m, 500 m, 1000 m and 2000 m). Derived from CARS.
Salinity	The annual mean salinity (based on data from 1970–2000) at different depths (surface, 150 m, 500 m, 1000 m and 2000 m). Derived from CARS.
Silicate	The annual mean concentration of silicate (based on data from 1970–2000) at different depths (surface, 150 m, 500 m, 1000 m and 2000 m). Derived from CARS.
Temperature	The annual mean water temperature (based on data from 1970–2000) at different depths (surface, 150 m, 500 m, 1000 m and 2000 m). Derived from CARS.
Sea Surface Dynamic Height	Average monthly sea surface height (over years 1970–2000) for January, April, July and October.
Sea Surface Height Variability	Sea surface height monthly variability (over years 1993–2001) calculated from altimeter data (Topex/Poseidon, Jason-1, ERS-a and ERS-2) for January, April, July and October.
Surface Currents	Geostrophic surface currents calculated from dynamic height fields derived from CARS (monthly means calculated from years 1970–2000) for January, April, July and October.
Sea Surface Temperature Heterogeneity	Areas of low, medium and high heterogeneity (showing eddies and fields) based on sea surface temperature from NOAA satellite imagery for January, April, July and October.
Chlorophyll	Monthly means for chlorophyll for January, April, July and October (based on MODIS Aqua data from 2002–2004).
Primary Production	Monthly means for primary production for January, April, July and October (based on MODIS data from 1997–2004).

Appendix 3 – Description of the Provincial Bioregions (benthic bioregionalisation)

The descriptions contained within this appendix have been sourced from the following report to the National Oceans Office on the development of the National Benthic Marine Bioregionalisation.

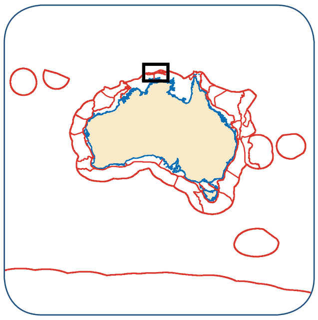
Heap, AD, Harris, PT, Last, P, Lyne, V, Hinde, A & Woods, M 2005, *Draft Benthic Marine Bioregionalisation of Australiaís Exclusive Economic Zone*. Geoscience Australia Report to the National Oceans Office. Geoscience Australia, Canberra.

The information provided details the location and principal features of each of the 41 Provincial Bioregions and Transitions described in the report. Further detail on the derivation of the regions can be found in Heap et al (2005).

PB1 – Timor Transition

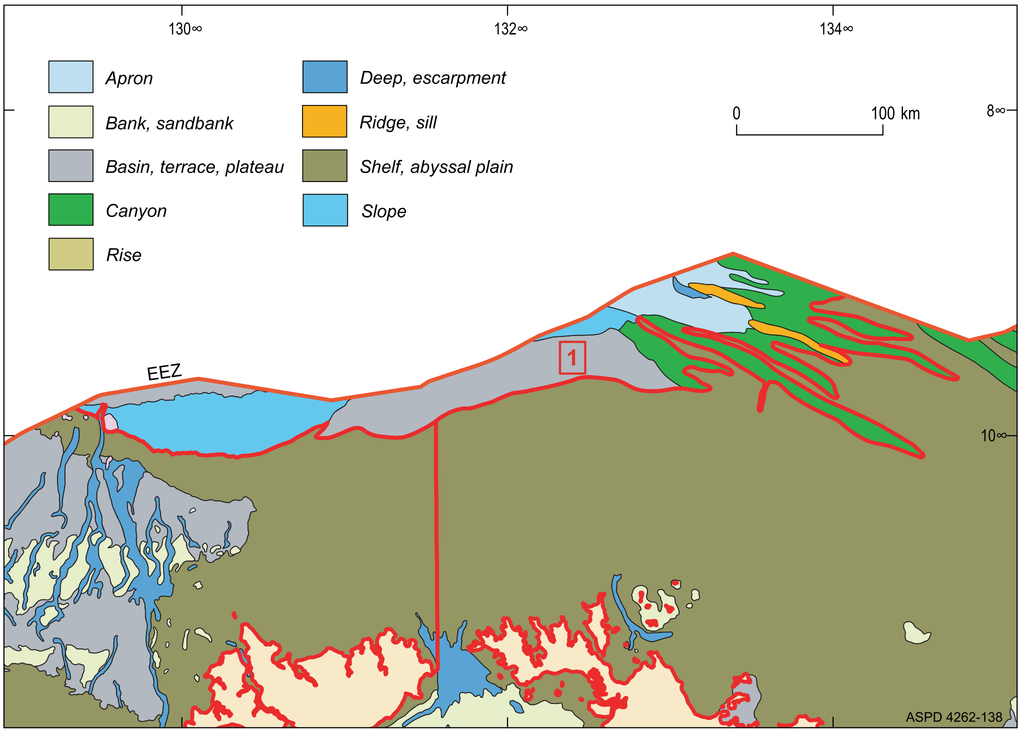
This bioregion is located on the northern margin of Australia

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
24,040	-15	-357	-161	53



Primary Bathymetric Units (km²)			Biomes (km²) *N* = 0		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
24,040	–	–	–	–	–

No. of Demersal Fish Species:	284 (>2 string nodes)
Key Indicator Demersal Fish Species:	N/A
No. of Endemics:	N/A
Strength:	N/A



Geomorphic Units in PB1 – Timor Transition.

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Geomorphic Units (km²) *N* = 13													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	3	5,720	–	–	2	680	–	–	–	–	2	7,490
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	4	7,330	–	–	–	–	–	130	1	2,590	1	100

Notes:

- This bioregion is the shallowest on average of all the NBMB bioregions due to its location on the upper slope of the north margin.
- This bioregion is one of six NBMB bioregions to cover only one Primary Bathymetric Unit, and one of five to occur only on the slope.
- This bioregion contains the second smallest area of slope of all the NBMB bioregions.
- The demersal fish data indicate that this bioregion has a strong boundary with Indonesian and Papua New Guinea fauna, although the similarity of the demersal fishes in this bioregion to Timor and Indonesian fauna has not been fully established (Last et al., 2005).
- This bioregion is the only NBMB bioregion adjacent to the mainland not to contain any Biomes.
- This bioregion is one of four NBMB bioregions to contain seven classes of geomorphic units.

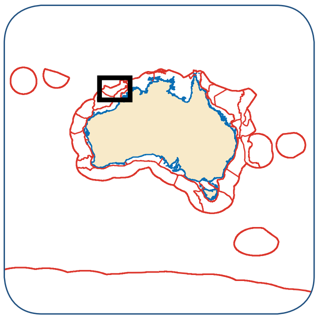
Reference

Last, P., Lyne, V., Yearsley, G., Gledhill, D., Gomon, M., Rees, T. and White, W., 2005. Validation of National Demersal Fish Datasets for the Regionalisation of the Australian Continental Slope and Outer Shelf. Draft CSIRO Report to the National Oceans Office, Sept, 2004. CSIRO Marine Research, Hobart.

PB2 – Timor Province

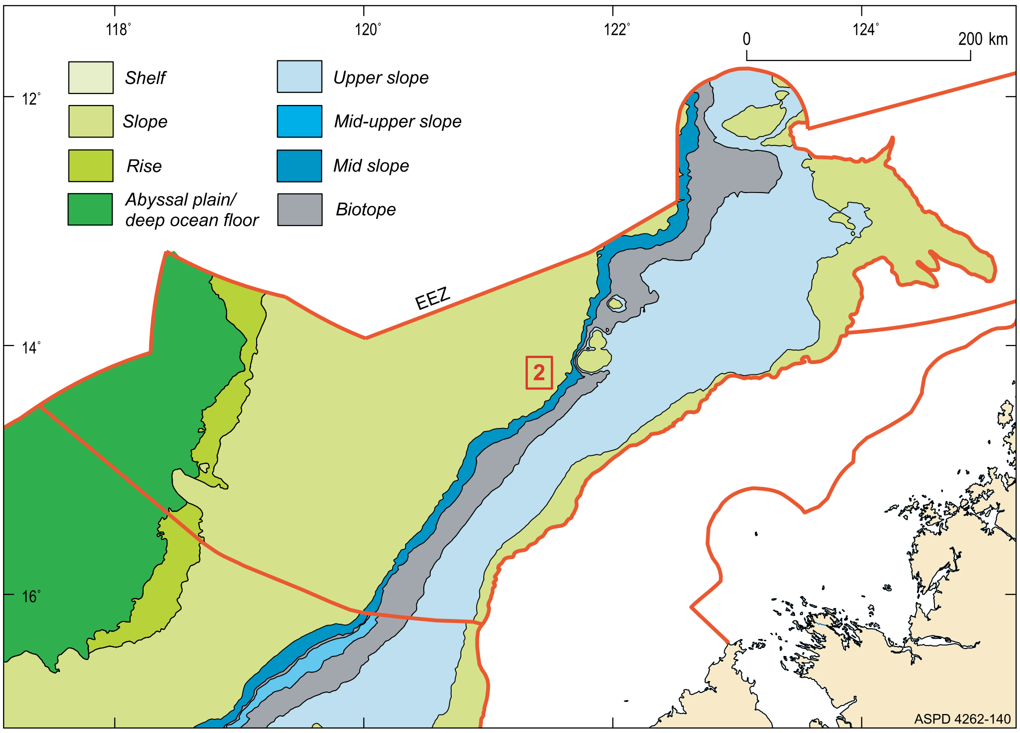
This bioregion is located on the northwest margin of Australia

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
160,690	0	-5,819	-2,022	1,864



Primary Bathymetric Units (km²)			Biomes (km²) $N = 4$		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
138,150	4,530	18,020	40,940	–	5,290

No. of Demersal Fish Species:	418 (34 string nodes)
Key Indicator Demersal Fish Species:	*Bembrops nelsoni*, *Bythaelurus* sp., *Halicmetus* sp., *Malthopsis* spp, *Neobythites australiensis*, *Nobythites bimaculatus*, *Neobythites macrops*, *Neobythites soelae*, *Parapterygotrigla* sp., *Physiculus roseus*
No. of Endemics:	64
Strength:	7.7 (strongly defined)



Biomes in PB2 – Timor Province.

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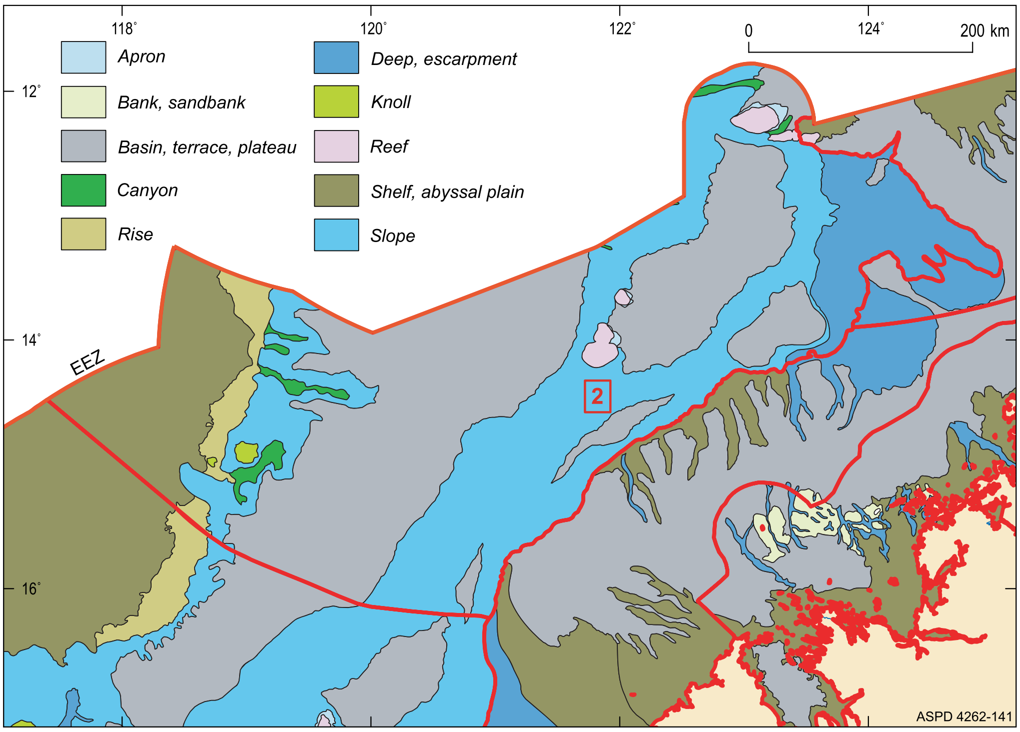
Geomorphic Units (km²) *N* = 30													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
1	18,020	4	54,030	2	4,850	–	–	–	–	–	–	8	66,400
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
2	350	8	2,180	–	–	–	–	1	13,200	3	380	4	1,830

Notes:

- This bioregion is one of seven NBMB bioregions to cover all three Primary Bathymetric Units.
- This bioregion contains the 5th largest area of rise of all the NBMB bioregions.
- This bioregion is the only NBMB bioregion to contain two biome types.
- The ratio of endemics to total species is the second highest for all the NBMB bioregions.
- The demersal fish fauna in this bioregion are linked to the Indonesian slope demersal fish fauna.
- Biomes defined by the demersal fish depth structure in this bioregion are the second largest in terms of area and cover the third largest area as a percentage of the area of the bioregion.
- This bioregion is the only NBMB bioregion to contain nine classes of geomorphic units.

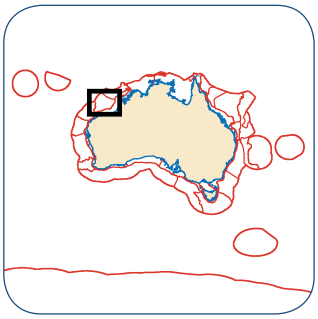


Geomorphic Units in PB2 – Timor Province.

PB3 – Northwest Transition

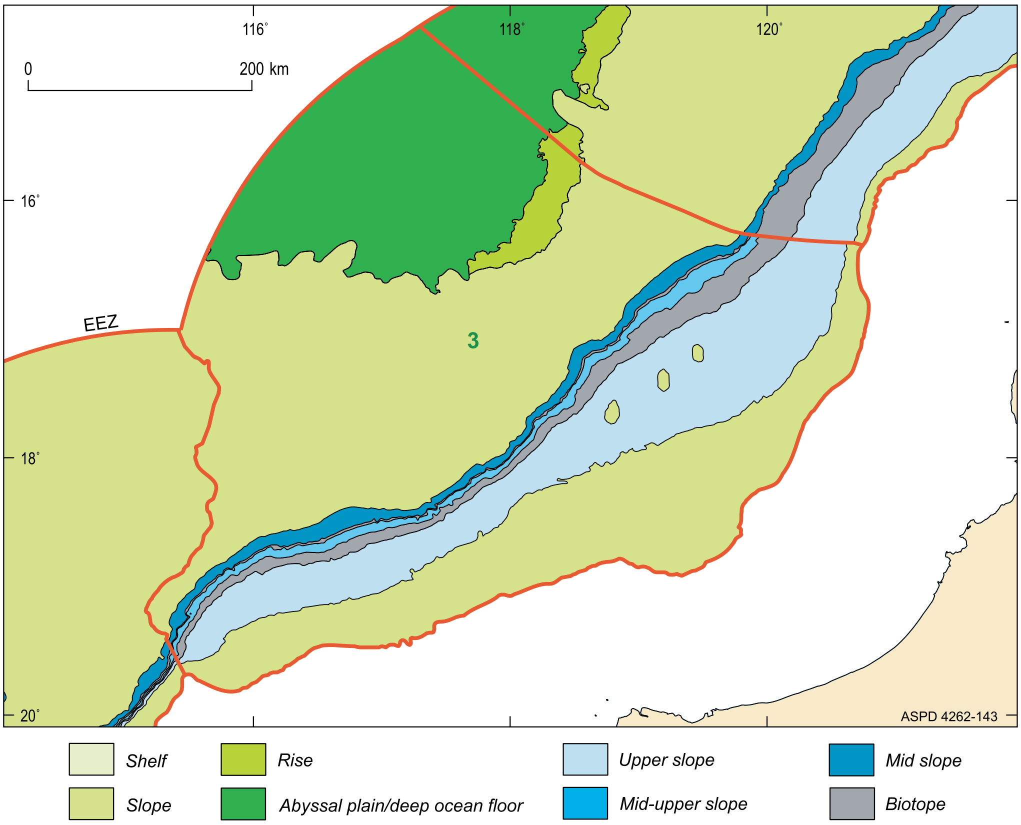
This bioregion is located on the northwest margin of Australia

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
217,230	0	-5,895	-2,144	2,086



Primary Bathymetric Units (km²)			Biomes (km²) N = 3		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
172,810	3,800	40,630	34,110	4,530	5,880

No. of Demersal Fish Species:	505 (10 string nodes)
Key Indicator Demersal Fish Species:	N/A
No. of Endemics:	N/A
Strength:	N/A



Biomes in PB3 – Northwest Transition.

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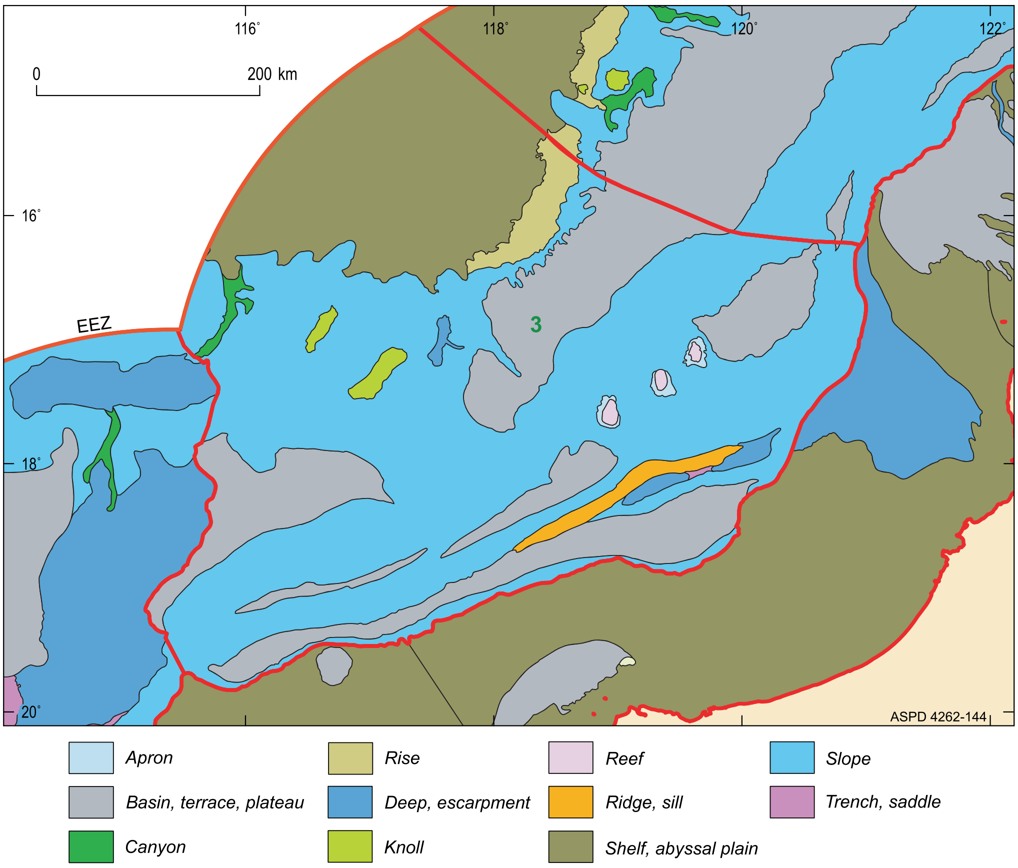
Geomorphic Units (km²) *N* = 25													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
1	40,630	2	114,050	1	3,800	1	2,570	–	–	1	110	7	50,700
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
2	1,370	1	880	–	–	–	–	3	1,910	3	690	3	520

Notes:

- Class 2 in this bioregion is the 3rd largest in area for all of the NBMB bioregions.
- This bioregion is one of seven NBMB bioregions to cover all three Primary Bathymetric Units.
- The demersal fish fauna in this bioregion are mixed and could be related to the bight in the Exmouth Plateau.
- This is one of 14 NBMB bioregions to contain three biome types.
- Biomes defined by the demersal fish depth structure in this bioregion are the fourth largest in terms of their total area and cover the fourth largest area as a percentage of the bioregion area.
- This bioregion is one of two NBMB bioregions to contain 11 classes of geomorphic units. This bioregion along with PB18 contains the most classes of geomorphic units of all the NBMB bioregions.

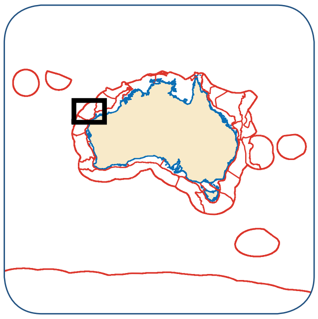


Geomorphic Units in PB3 – Northwest Transition.

PB4 – Northwest Province

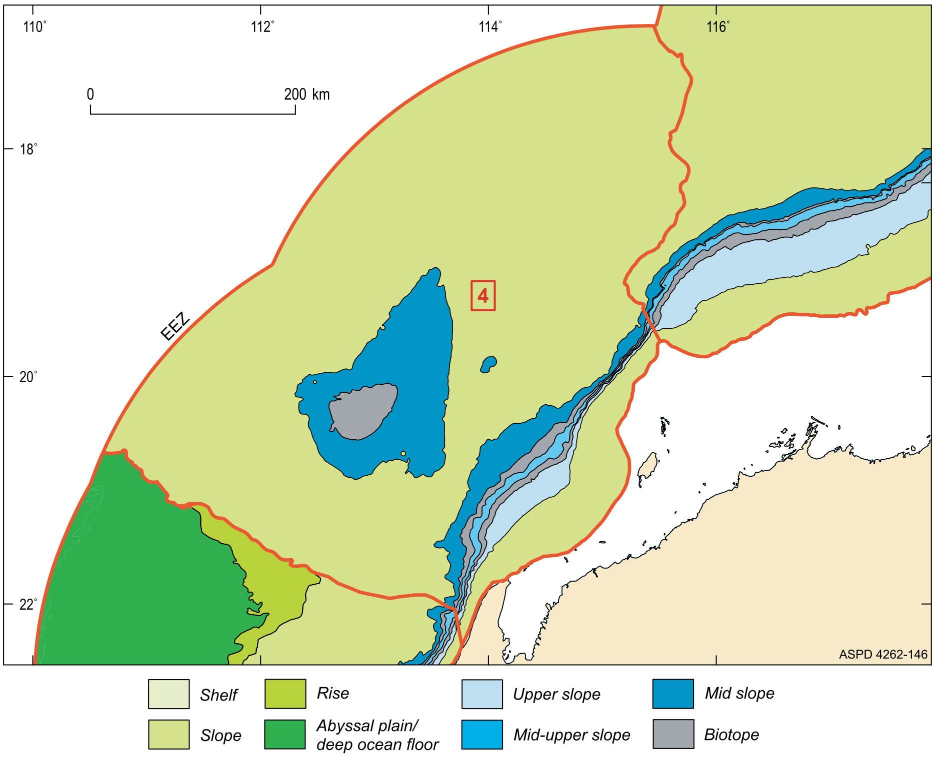
This bioregion is located on the northwest margin of Australia

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
188,730	-20	-5,133	-1,597	804



Primary Bathymetric Units (km²)			Biomes (km²) *N* = 5		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
188,180	420	–	2,980	1,590	20,550

No. of Demersal Fish Species:	508 (8 string nodes)
Key Indicator Demersal Fish Species:	*Chaunax* sp., *Dibranchus* sp., *Diplacanthopoma* sp., *Hime* sp., *Leptochilichthys microlepis*, *Parapercis cf. macrophthalma*, *Uranoscopus* sp.
No. of Endemics:	76
Strength:	2.2 (weakly defined)



Biomes in PB4 – Northwest Province.

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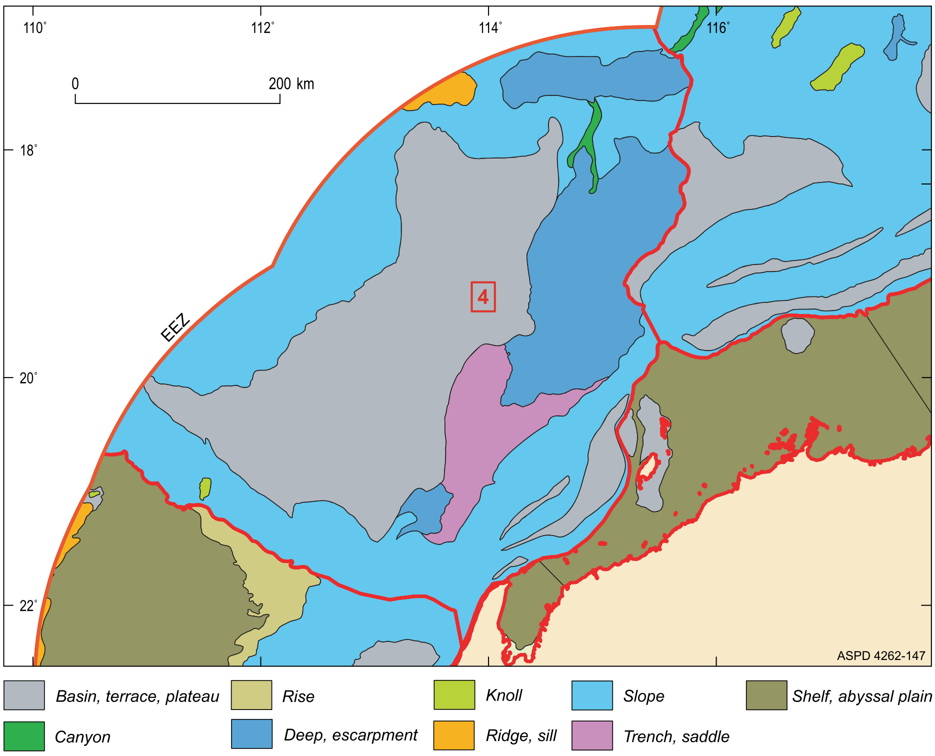
Geomorphic Units (km²) *N* = 16													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	3	75,200	–	–	1	1,340	–	–	1	10,120	6	67,720
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
1	170	1	700	–	–	–	–	3	33,090	–	–	–	–

Notes:

- This bioregion is one of 11 NBMB bioregions to cover two Primary Bathymetric Units, and one of only two to occur on the slope and rise.
- This bioregion contains the 2nd smallest area of rise of all the NBMB bioregions.
- This bioregion is one of 14 NBMB bioregions to contain all of the biome types.
- The ratio of endemic species to total species is the highest for all the NBMB bioregions.
- Biomes defined by the demersal fish depth structure are the 11th largest in terms of their total area and cover the 10th largest area as a percentage of the bioregion area.
- This bioregion is one of four NBMB bioregions to contain seven classes of geomorphic units.
- Class 12 in this bioregion is the largest in area for all of the NBMB bioregions.
- Class 2 includes units defined by the spacing of submarine canyons on the slope.



Geomorphic Units in PB4 – Northwest Province.

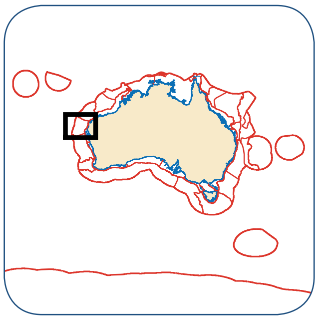
PB5 – Central Western Transition

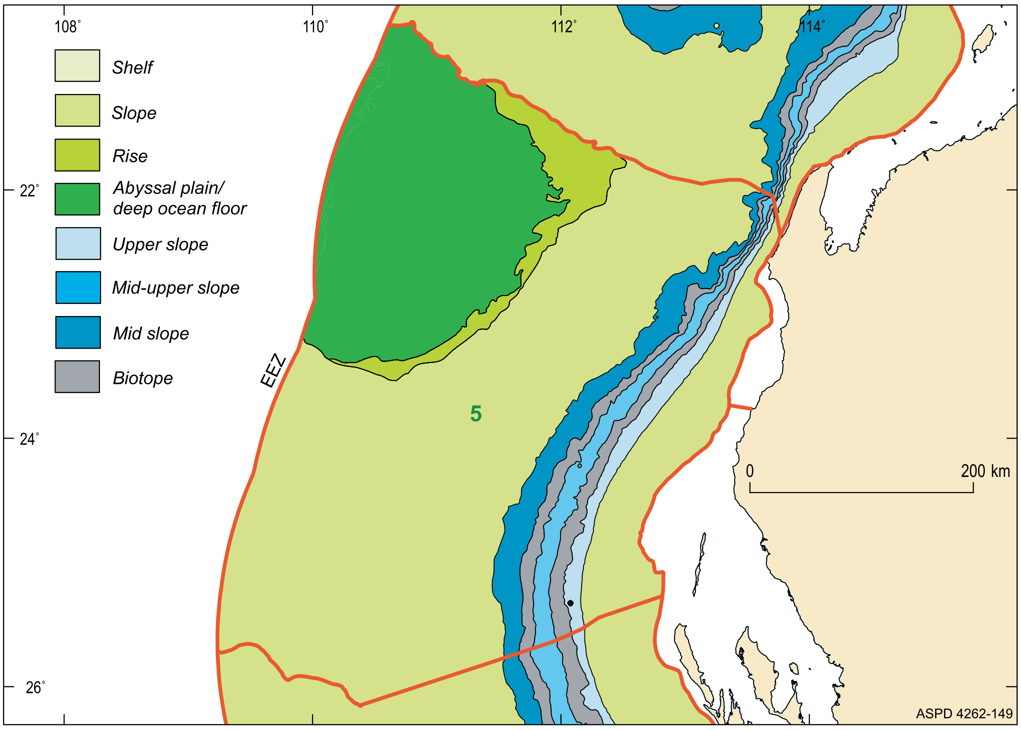
This bioregion is located on the western margin of Australia

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
173,660	0	-5,325	-3,036	1,784

Primary Bathymetric Units (km²)			Biomes (km²) *N* = 4		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
125,230	7,060	41,330	4,250	4,800	8,130

No. of Demersal Fish Species:	462 (10 string nodes)
Key Indicator Demersal Fish Species:	N/A
No. of Endemics:	N/A
Strength:	N/A





Biomes PB5 – Central Western Transition.

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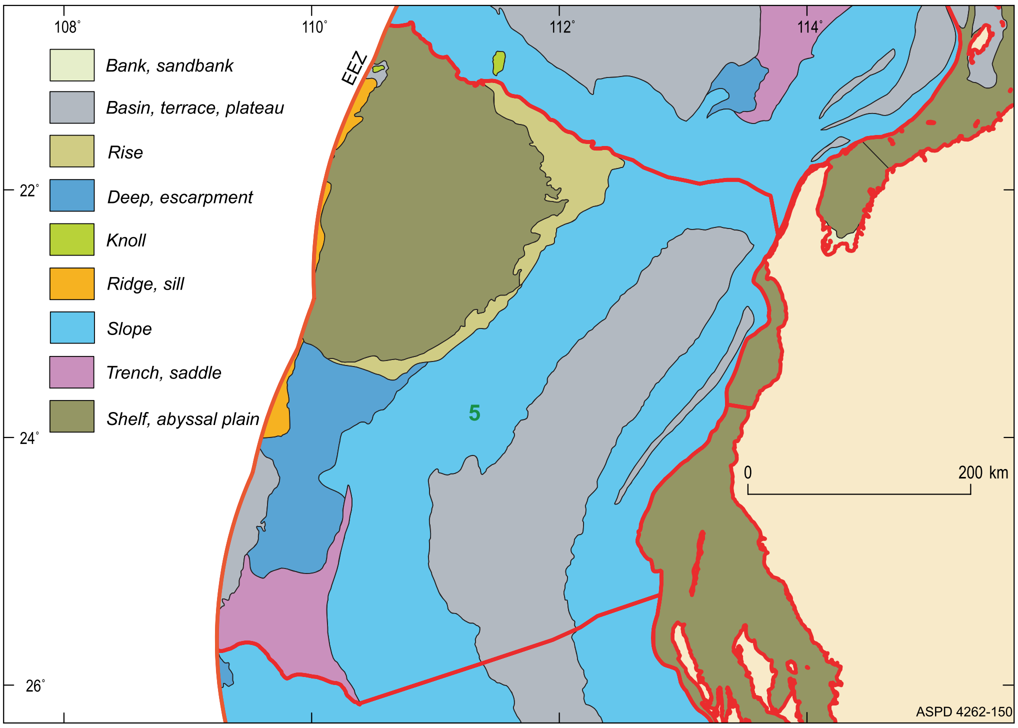
Geomorphic Units (km²) *N* = 17													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
1	40,140	2	64,170	3	7,520	3	1,880	–	–	1	7,880	4	40,490
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
2	50	–	–	–	–	–	–	1	12,180	–	–	–	–

Notes:

- This bioregion is one of seven NBMB bioregions to cover all three Primary Bathymetric Units.
- This bioregion contains the 4th largest area of rise of all the NBMB bioregions.
- This bioregion is one of 14 NBMB bioregions to contain all of the biome types.
- Biomes defined by the demersal fish depth structure are the 7th largest in terms of their total area and cover the 5th largest area as a percentage of the bioregion area for all the NBMB bioregions.
- This bioregion is one of five NBMB bioregions to contain eight classes of geomorphic units.
- Class 2 includes units defined by the spacing of submarine canyons on the slope.

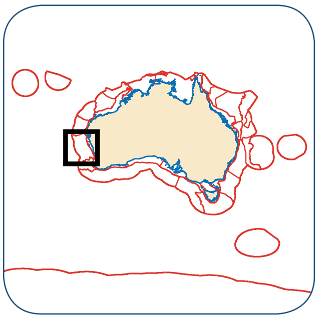


Geomorphic Units in PB5 – Central Western Transition.

PB6 – Central Western Province

This bioregion is located on the western margin of Australia.

Total Area	Water Depth (m)			
(km^2)	Minimum	Maximum	Mean	Std Dev.
286,730	-33	-6,001	-3,815	1,866



Primary Bathymetric Units (km^2)			Biomes (km^2) *N* = 7		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
129,120	52,090	105,170	4,320	8,590	7,610

No. of Demersal Fish Species:	480 (15 string nodes)
Key Indicator Demersal Fish Species:	*Dicrolene* sp., *Epigonus macrops*, *Monomitopus* sp., *Neomerinthe cf nielseni*, *Parascyllium sparsimaculatum*, *Dipturus* sp.
No. of Endemics:	31
Strength:	1.7 (weakly defined)

Geomorphic Units (km^2) *N* = 11													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
1	103,910	6	107,630	1	52,240	–	–	–	–	–	–	2	21,110
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
–	–	–	–	–	–	–	–	2	1,500	–	–	–	–

Notes:

- This bioregion is one of seven NBMB bioregions to cover all three Primary Bathymetric Units.
- This bioregion contains the largest area of rise of all the NBMB bioregions.
- This bioregion is one of 14 NBMB bioregions to contain all of the biome types
- The southern boundary of this bioregion is well-defined by Perth Canyon. This large submarine canyon is a significant geomorphic feature on the margin. Studies have shown that it represents a major faunal discontinuity for sponges, corals, decapods and xanthid crabs, as well as affecting the major ocean currents and associated water properties by being a conduit for significant upwelling.
- Biomes defined by the demersal fish depth structure are the 6th largest in terms of their total area and cover the 7th largest area as a percentage of the bioregion area for all the NBMB bioregions.

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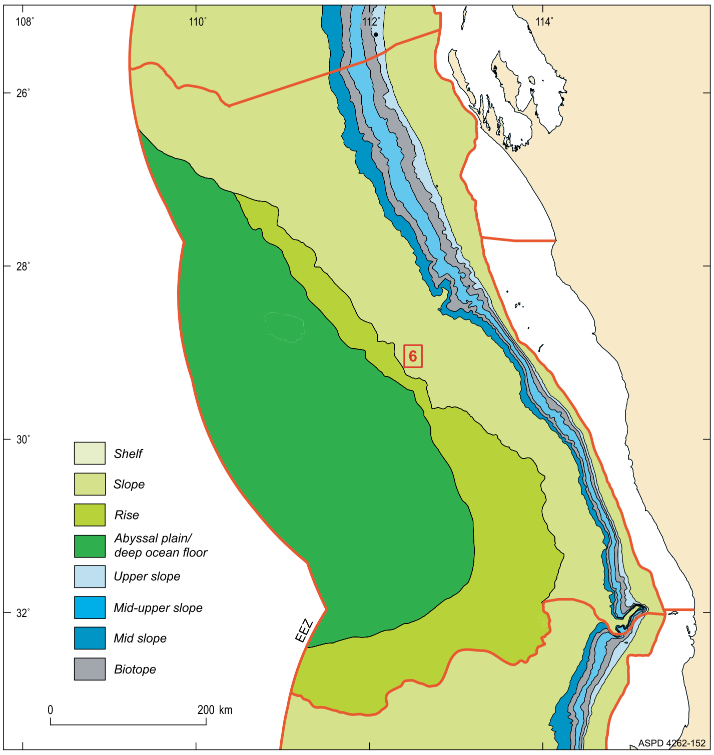
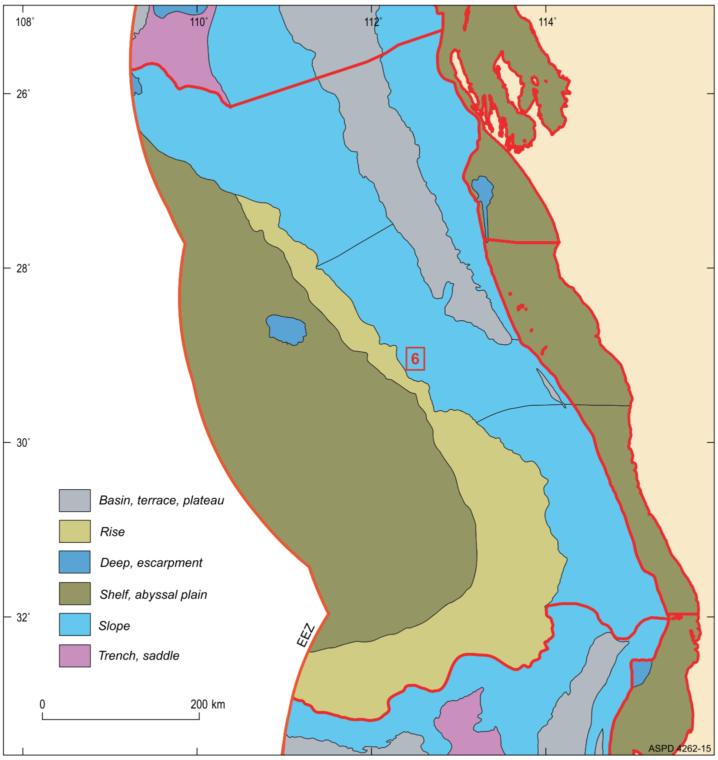
Notes (continued):

- This bioregion is one of two NBMB bioregions to contain five classes of geomorphic units.
- Class 2 in this bioregion is the 4th biggest of all the NBMB bioregions.
- Class 2 includes units defined by the spacing of submarine canyons on the slope.



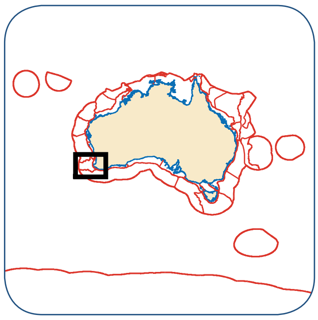
Biomes in PB6 – Central Western Province.



Geomorphic Units in PB6 – Central Western Province.

PB7 – Southwest Transition

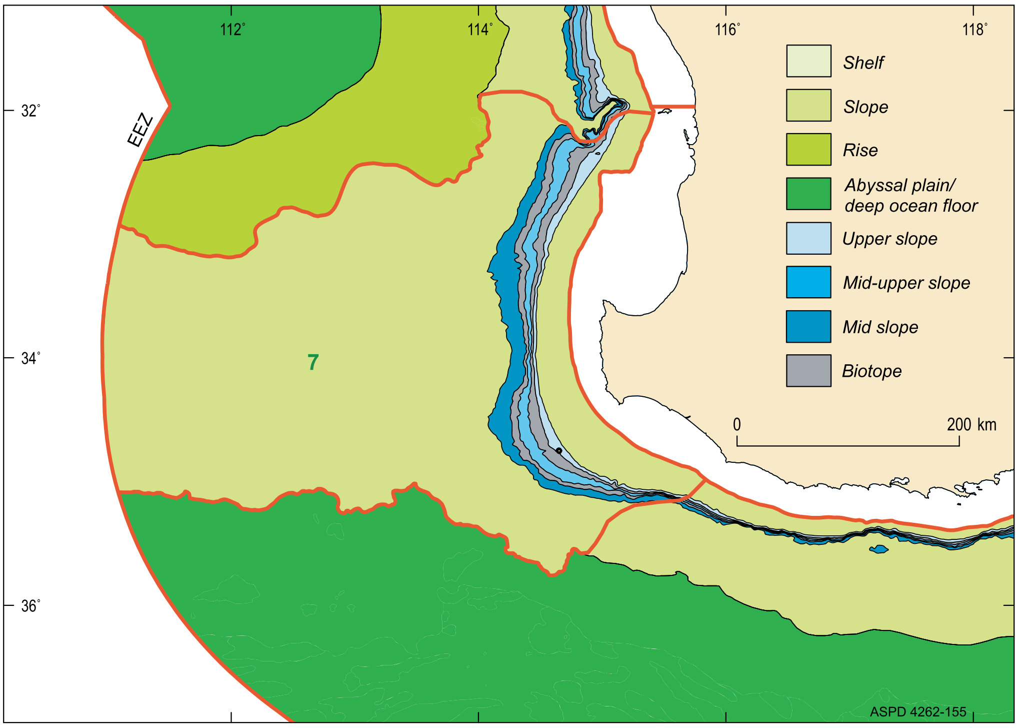
This bioregion is located on the southwest margin of Australia



Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
110,460	-48	-5,902	-2,414	1,287

Primary Bathymetric Units (km²)			Biomes (km²) $N = 6$		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
109,830	–	–	1,770	2,440	4,390

No. of Demersal Fish Species:	398 (5 string nodes)
Key Indicator Demersal Fish Species:	N/A
No. of Endemics:	N/A
Strength:	N/A



Biomes in PB7 – Southwest Transition.

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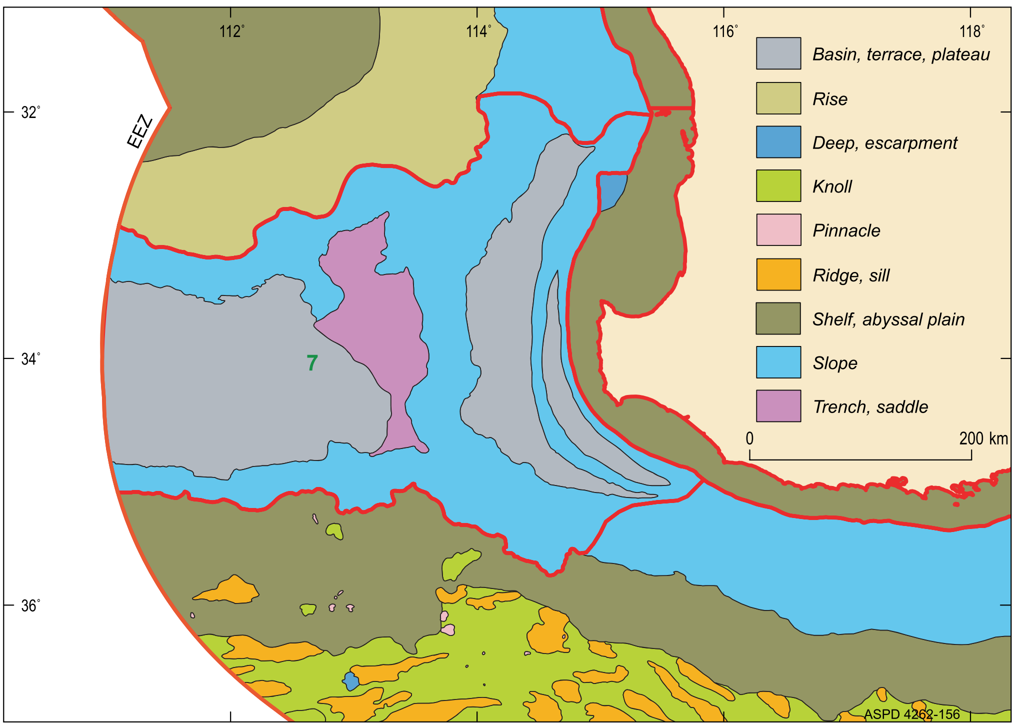
Geomorphic Units (km^2) N = 5													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	1	54,350	–	–	–	–	–	–	1	8,950	3	46,980
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	–	–	–	–	–	–	–	–	–	–	–	–

Notes:

- This bioregion is one of six NBMB bioregions to cover only one Primary Bathymetric Unit, and one of five to occur only on the slope.
- This bioregion is one of 14 NBMB bioregions to contain all of the biome types.
- Biomes defined by the demersal fish depth structure are the 6th largest in terms of their total area and cover the 7th largest area as a percentage of the bioregion area for all the NBMB bioregions.
- This bioregion is one of four NBMB bioregions to contain three classes of geomorphic units.
- Class 2 includes units defined by the spacing of submarine canyons on the slope.
- This bioregion is centred on the Naturaliste Plateau, a 90,000 km2 submerged continental fragment that rises from water depths of >5000 m to 2,000 m and surrounded by deep ocean floor. This bioregion represents a completely different environment from the surrounding seabed and adjacent Provinces.

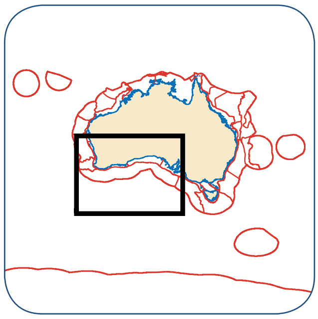


Geomorphic Units in PB7 – Southwest Transition.

PB8 – Southern Province

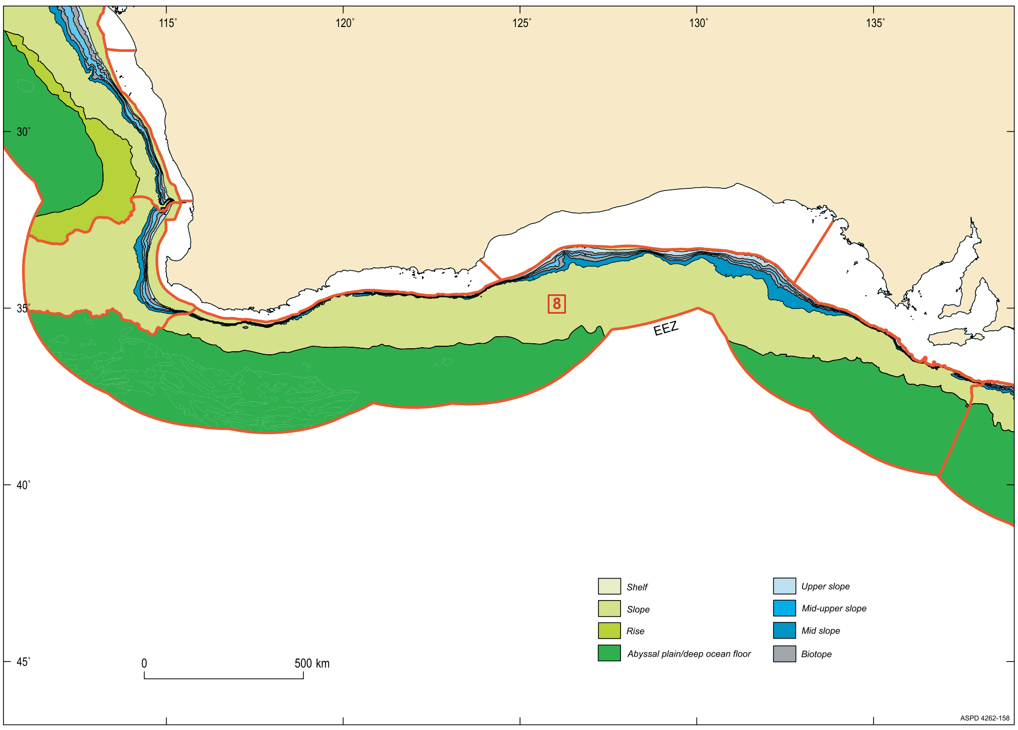
This bioregion is located on the southern margin of Australia

Total Area	Water Depth (m)			
(km^2)	Minimum	Maximum	Mean	Std Dev.
774,120	N/C	N/C	N/C	N/C



Primary Bathymetric Units (km^2)			Biomes (km^2) $N = 21$		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
362,020	–	412,000	10,310	5,950	21,510

No. of Demersal Fish Species:	463 (52 string nodes)
Key Indicator Demersal Fish Species:	*Bathyraja* sp., *Centroberyx* sp., *Dicrolene* sp., *Notoraja* sp., *Nybelinella* sp., *Paraliparis australiensis*, *Paraliparis avellaneus*, *Pavoraja* sp.
No. of Endemics:	26
Strength:	4.8 (strongly defined)



Biomes in PB8 – Southern Province.

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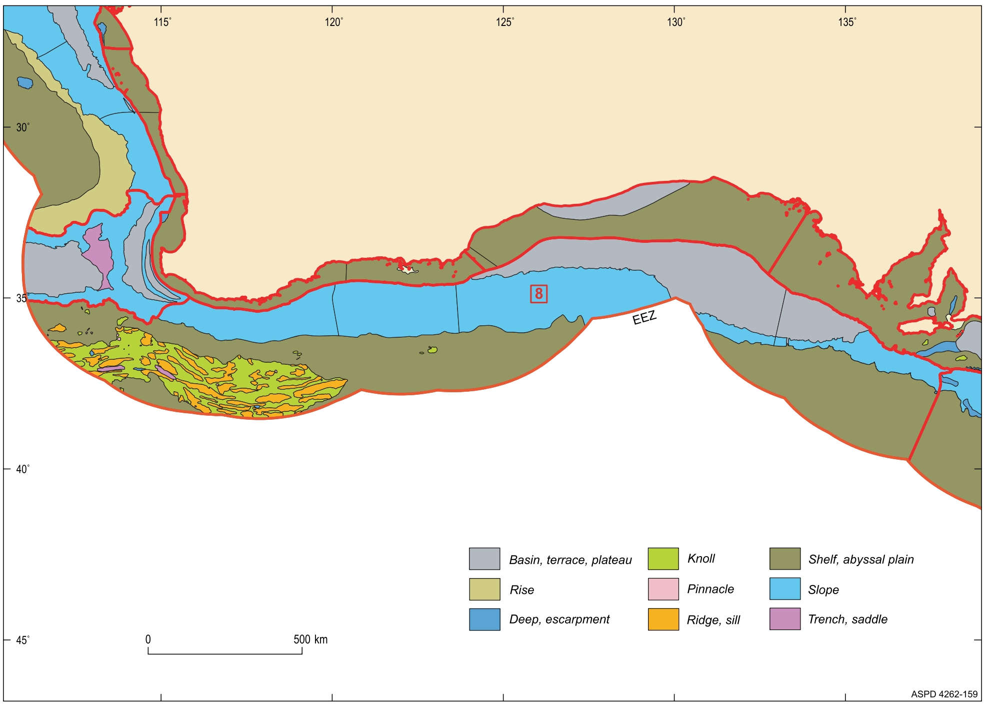
Geomorphic Units (km²) *N* = 99													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
3	305,330	6	225,430	–	–	51	38,130	–	–	2	1,560	2	136,570
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
10	66,710	–	–	21	350	–	–	4	450	–	–	–	–

Notes:

- This bioregion is one of 11 NBMB bioregions to cover two Primary Bathymetric Units, and one of nine to occur on the slope and abyssal plain/deep ocean floor.
- This bioregion contains the 2nd largest area of abyssal plain/deep ocean floor and 4th largest slope area of all the NBMB bioregions.
- This bioregion is one of 14 NBMB bioregions to contain all of the biome types.
- The ratio of endemics to total fish species is the lowest for all the NBMB bioregions.
- The central distribution of demersal fishes is located in the Great Australian Bight (Last et al., 2005).
- Biomes defined by the demersal fish depth structure are the third largest in terms of their total area and cover the 11th largest area as a percentage of the bioregion area for all the NBMB bioregions.
- This bioregion is one of five NBMB bioregions to contain eight classes of geomorphic units.
- Class 2 includes units defined by the spacing of submarine canyons on the slope.
- This bioregion contains the largest Class 2, 2nd largest Class 1, and 5th largest Class 7 unit of all the NBMB bioregions.
- The province also contains the Diamantina Fracture Zone a region of very rugged seabed comprised of numerous deep-sea ridges and troughs which represents. This is a unique region of deep-sea habitats.

Reference

Last, P., Lyne, V., Yearsley, G., Gledhill, D., Gomon, M., Rees, T. and White, W., 2005. Validation of National Demersal Fish Datasets for the Regionalisation of the Australian Continental Slope and Outer Shelf. Draft CSIRO Report to the National Oceans Office, Sept, 2004. CSIRO Marine Research, Hobart.

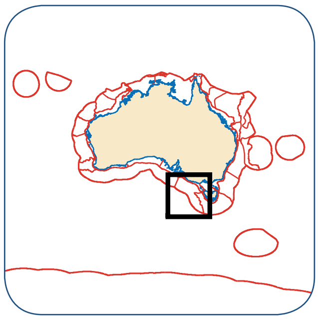


Geomorphic Units PB8 – Southern Province.

PB9 – West Tasmania Transition

This bioregion is located west of Tasmania on the southeast margin of Australia

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
289,850	-36	-5,645	-3,918	1,482



Primary Bathymetric Units (km²)			Biomes (km²) *N* = 4		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
89,980	–	10,460	2,690	1,100	2,820

No. of Demersal Fish Species:	456 (15 string nodes)
Key Indicator Demersal Fish Species:	N/A
No. of Endemics:	N/A
Strength:	N/A

Geomorphic Units (km²) *N* = 14													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
1	199,040	3	84,350	–	–	–	–	–	–	–	–	1	2,960
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
7	1,330	–	–	–	–	–	–	2	2,170	–	–	–	–

Notes:

- This bioregion is one of 11 NBMB bioregions to cover two Primary Bathymetric Units, and one of nine to occur on the slope and abyssal plain/deep ocean floor.
- This bioregion contains the 7th largest area of abyssal plain/deep ocean floor of all the NBMB bioregions.
- This bioregion is one of 14 NBMB bioregions to contain all of the biome types.
- Biomes defined by the demersal fish depth structure are the 13th largest in terms of their total area and cover the 12th largest area as a percentage of the bioregion area for all the NBMB bioregions.
- This bioregion is one of two NBMB bioregions to contain five classes of geomorphic units.
- Class 2 includes units defined by the spacing of submarine canyons on the slope.

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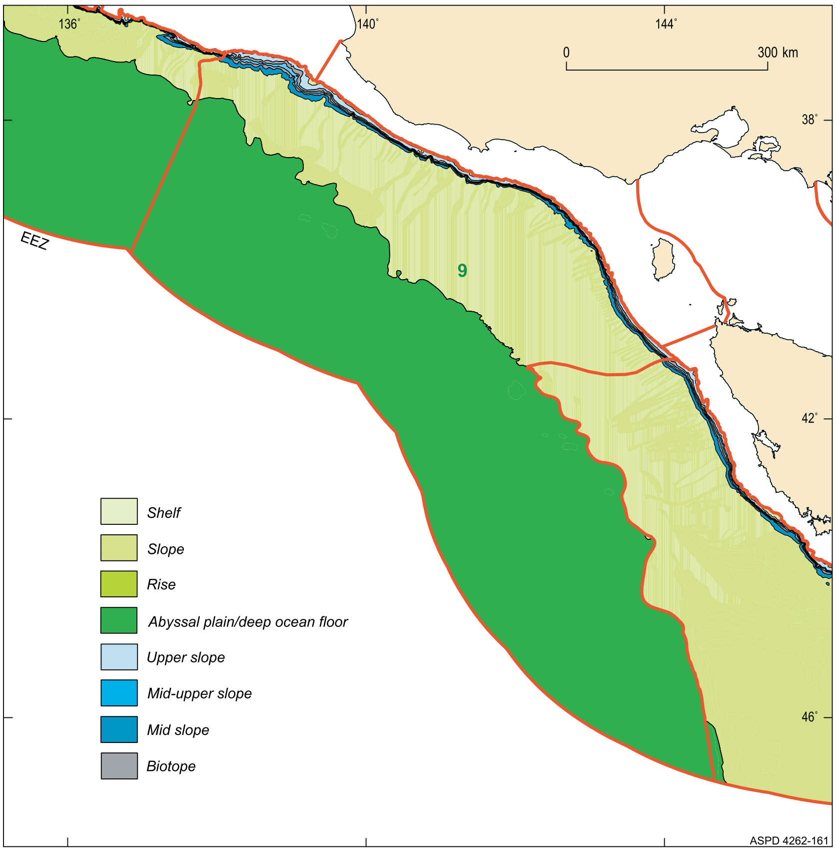
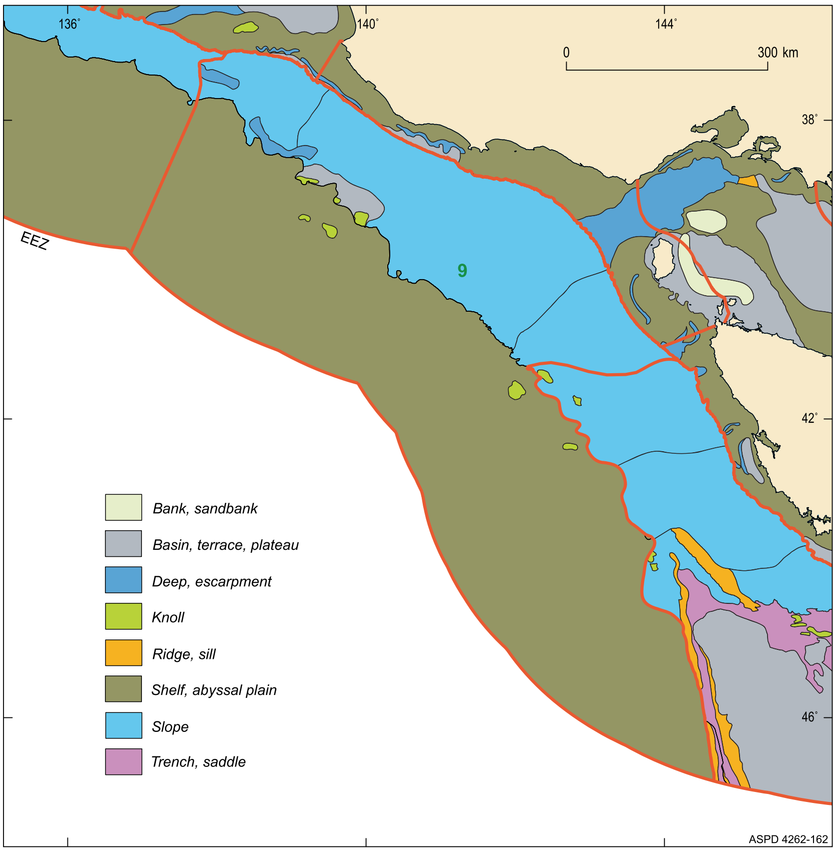


Biomes in PB9 – West Tasmania Province.

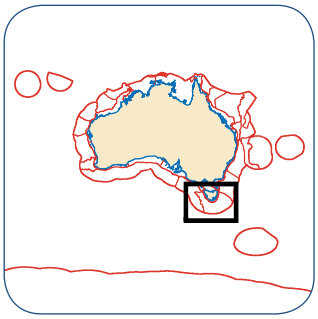


Geomorphic Units in PB9 – West Tasmania Province.

PB10 – Tasmania Province

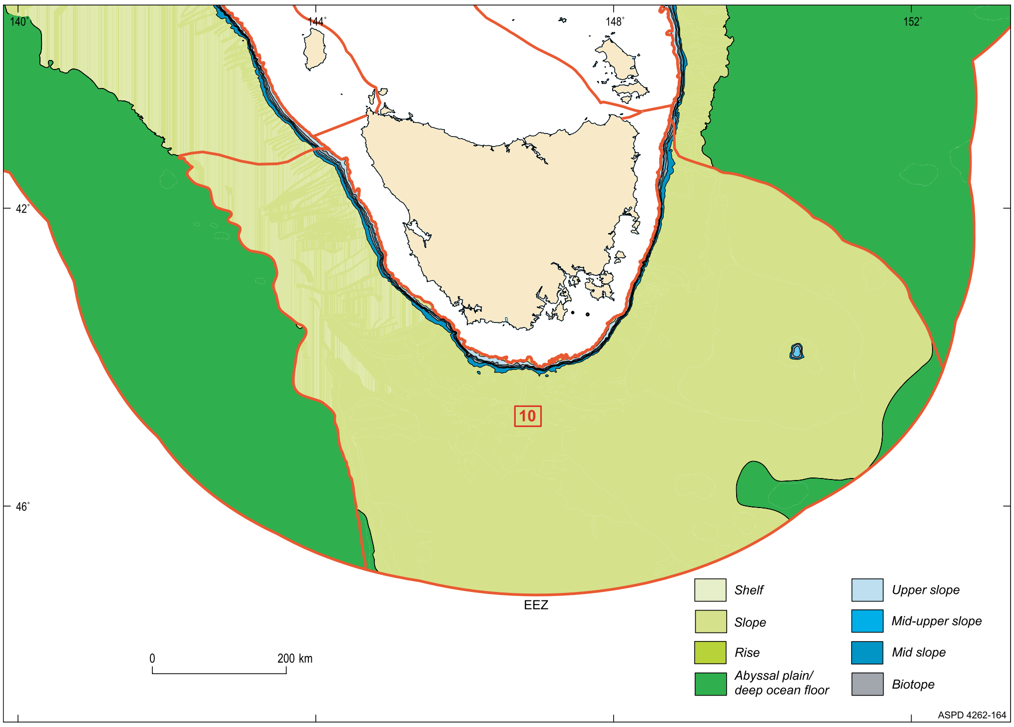
This bioregion is located south of Tasmania on the southeast margin of Australia

Total Area	Water Depth (m)			
(km^2)	Minimum	Maximum	Mean	Std Dev.
300,190	-36	-5,584	-3,220	1,073



Primary Bathymetric Units (km^2)			Biomes (km^2) N = 15		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
289,580	–	10,460	1,930	1,080	2,690

No. of Demersal Fish Species:	486 (23 string nodes)
Key Indicator Demersal Fish Species:	*Cataetyx* spp, *Guttigadus* sp., *Monomitopus cf kumae, Paraliparis anthracinus, Paraliparis ater, Rhinochimaera africana*
No. of Endemics:	52
Strength:	4.3 (strongly defined)



Biomes in PB10 – Tasmania Province.

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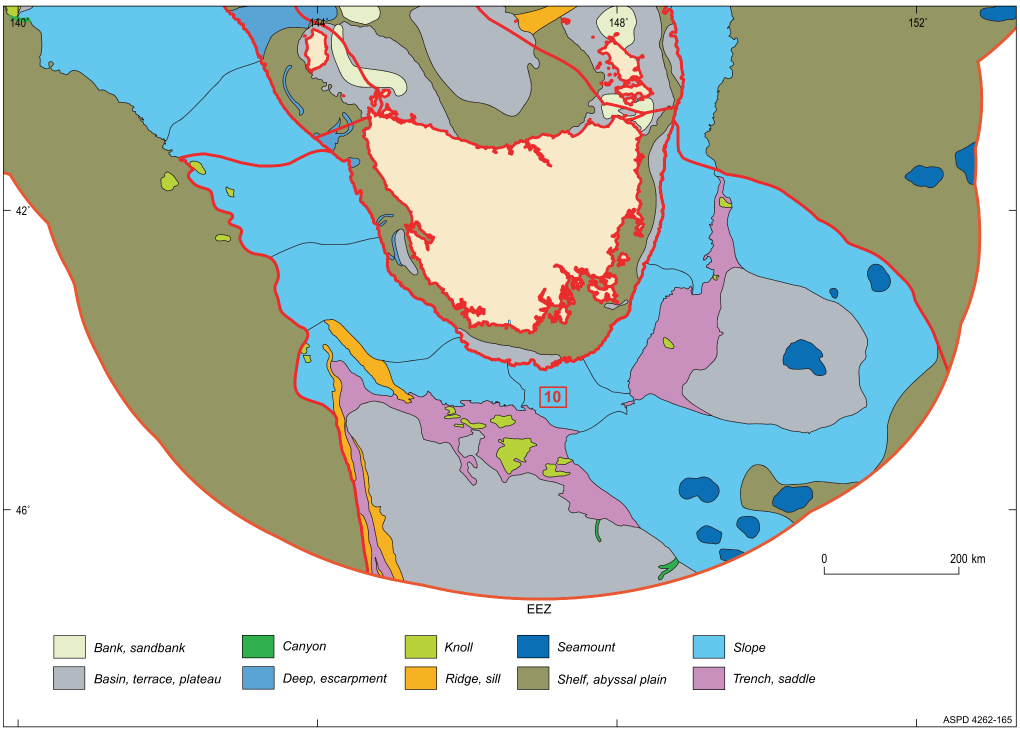
Geomorphic Units (km²) *N* = 44													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
2	3,950	8	158,750	–	–	5	5,850	8	6,250	2	32,780	2	84,640
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
15	3,160	2	320	–	–	–	–	–	–	–	–	–	–

Notes:

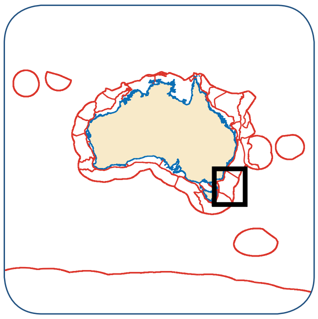
- This bioregion is one of 11 NBMB bioregions to cover two Primary Bathymetric Units, and one of nine to occur on the slope and abyssal plain/deep ocean floor.
- This bioregion contains the 5th largest area of slope of all the NBMB bioregions.
- This bioregion is one of 14 NBMB bioregions to contain all of the biome types.
- The demersal fish data indicate that the fish fauna in this bioregion may have some overlap with the demersal fish fauna of the PB8.
- Biomes defined by the demersal fish depth structure are the 14th largest in terms of their total area and cover the smallest area as a percentage of the bioregion area for all the NBMB bioregions.
- This bioregion is one of five NBMB bioregions to contain eight classes of geomorphic units.
- Class 2 in this bioregion is the 2nd largest of all the NBMB bioregions and includes units defined by the spacing of submarine canyons on the slope.
- This bioregion is characterised by a large number of seamounts that contain endemic fishes. The Cascade Seamount is included because its fauna is more closely associated with fauna found on other seamounts in the Southern Ocean. Because of its shallow depth the South Tasman Rise contains species of fish otherwise found on the upper slope of the Tasmanian margin. Studies have shown that the benthic fauna at the foot of the slope and the abyssal plain in this bioregion are similar and distinct from benthic fauna on the top of the Cascade Plateau.



Geomorphic Units in PB10 – Tasmania Province.

PB11 – Southeast Transition

This bioregion is located on the southeast margin of Australia



Total Area	Water Depth (m)			
(km^2)	Minimum	Maximum	Mean	Std Dev.
241,940	-37	-5,534	-3,827	1,281

Primary Bathymetric Units (km^2)			Biomes (km^2) N = 4		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
41,250	–	200,610	2,680	1,340	1,100

No. of Demersal Fish Species:	536 (21 string nodes)
Key Indicator Demersal Fish Species:	N/A
No. of Endemics:	N/A
Strength:	N/A

Geomorphic Units (km^2) N = 8

CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
1	202,340	4	41,270	–	–	–	–	3	2,840	–	–	–	–

CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	–	–	–	–	–	–	–	–	–	–	–	–

Notes:

- This bioregion is one of 11 NBMB bioregions to cover two Primary Bathymetric Units, and one of nine to occur on the slope and abyssal plain/deep ocean floor.
- This bioregion contains the 6th largest area of abyssal plain/deep ocean floor of all the NBMB bioregions.
- This bioregion is one of 14 NBMB bioregions to contain all of the biome types.
- Biomes defined by the demersal fish depth structure are the smallest in terms of their total area and cover the 14th largest area as a percentage of the bioregion area for all the NBMB bioregions.
- This bioregion is one of four NBMB bioregions to contain three classes of geomorphic units.
- Class 2 includes units defined by the spacing of submarine canyons on the slope.

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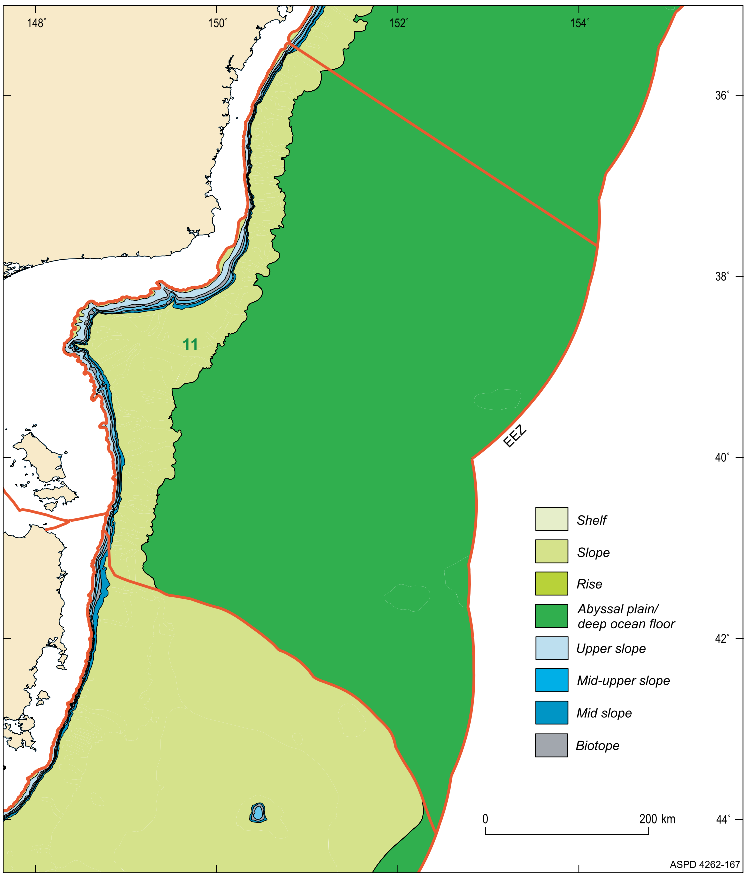
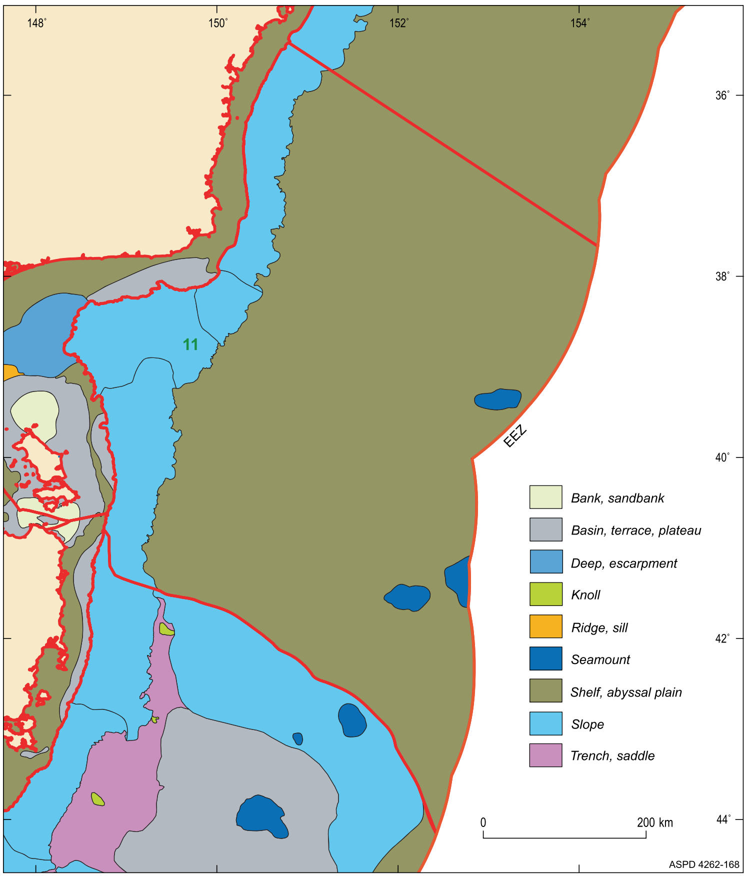


Biomes in PB11 – Southeast Transition.

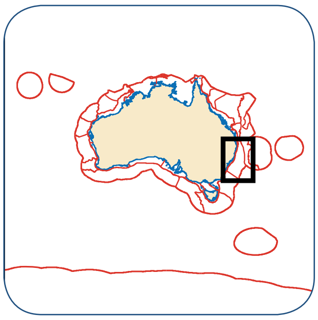


Geomorphic Units in PB11 – Southeast Transition.

PB12 – Central Eastern Province

This bioregion is located on the eastern margin of Australia

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
268,850	-79	-5,590	-4,175	1,229



Primary Bathymetric Units (km²)			Biomes (km²) *N* = 13		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
65,260	–	203,430	2,870	2,410	1,890

No. of Demersal Fish Species:	639 (17 string nodes)
Key Indicator Demersal Fish Species:	*Bembrops morelandi*, *Chaunax* sp., *Halieutopsis* sp., *Lepidoperca magna*, *Malthopsis* sp., *Paraliparis eastmani*, *Paraulopus okamurai*, *Dupturus* sp. C, *Solocisquama* sp.
No. of Endemics:	56
Strength:	3.4 (strongly defined)

Geomorphic Units (km²) *N* = 5													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
1	203,430	3	64,170	–	–	–	–	–	–	–	–	1	2,280
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	–	–	–	–	–	–	–	–	–	–	–	–

Notes:

- This bioregion is one of 11 NBMB bioregions to cover two Primary Bathymetric Units, and one of nine to occur on the slope and abyssal plain/deep ocean floor.
- This bioregion contains the 5th largest area of abyssal plain/deep ocean floor of all the NBMB bioregions.
- This bioregion is one of 14 NBMB bioregions to contain all of the biome types.
- Biomes defined by the demersal fish depth structure are the 12th largest in terms of their total area and cover the 13th largest area as a percentage of the bioregion area for all the NBMB bioregions.
- This bioregion is one of four NBMB bioregions to contain three classes of geomorphic units.
- Class 2 includes units defined by the spacing of submarine canyons on the slope.
- This bioregion contains the 4th largest Class 1 unit for all the NBMB bioregions.

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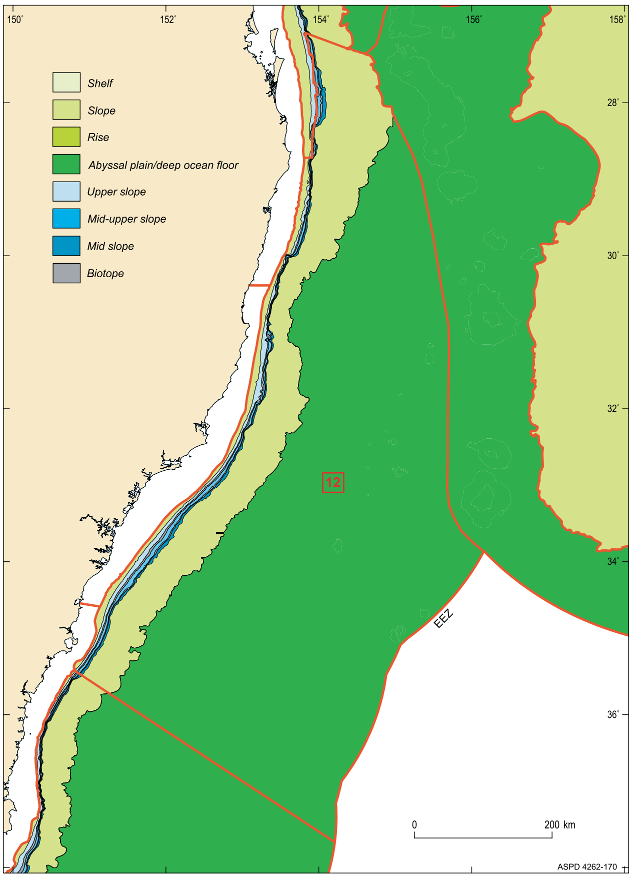
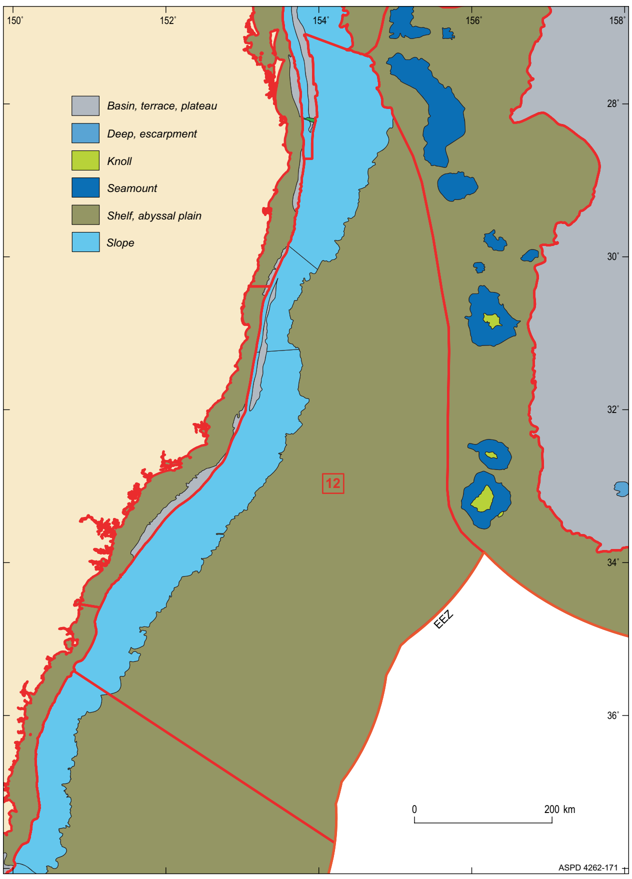


Biomes in PB12 – Central Eastern Province.

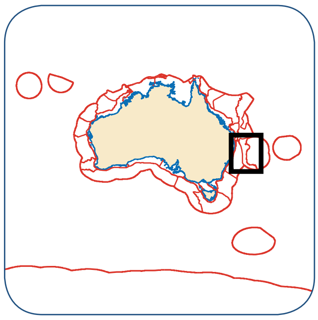


Geomorphic Units in PB12 – Central Eastern Province.

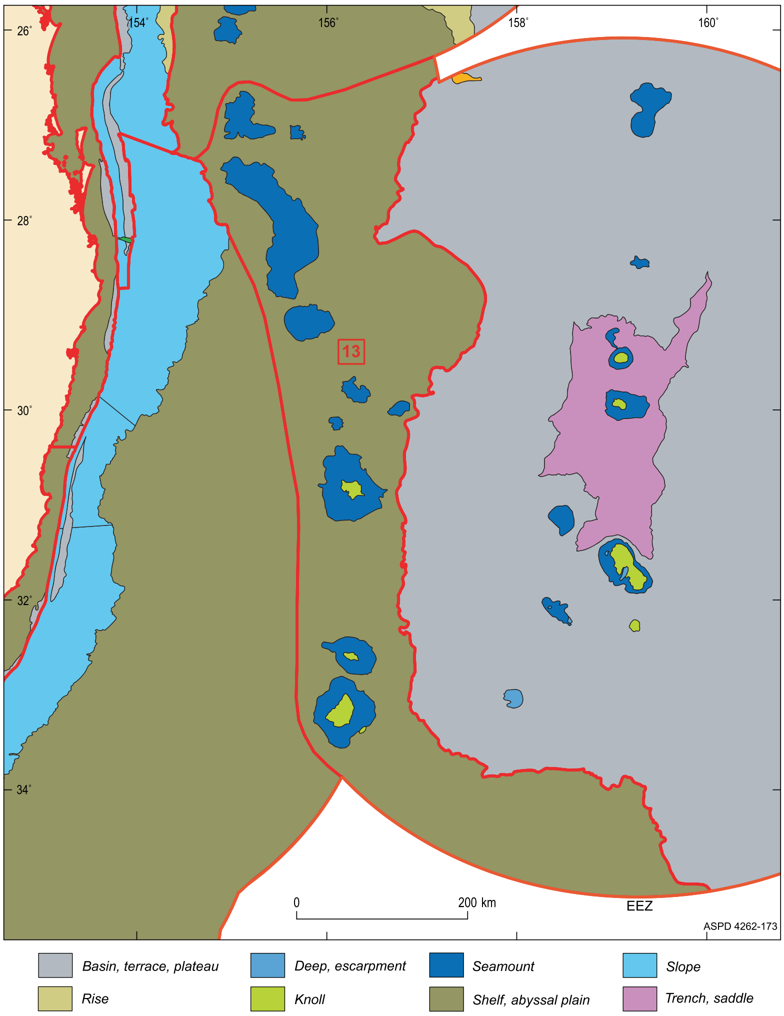
PB13 – Tasman Basin Province

This bioregion occurs in the Tasman Sea between the mainland and Lord Howe Island on the east margin of Australia

Total Area	Water Depth (m)			
(km^2)	Minimum	Maximum	Mean	Std Dev.
155,680	-71	-5,855	-4,420	782



Primary Bathymetric Units (km^2)			Biomes (km^2) *N* = 0		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
–	–	154,780	–	–	–



Geomorphic Units in PB13 – Tasman Basin Province.

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No. of Demersal Fish Species:	N/A
Key Indicator Demersal Fish Species:	N/A
No. of Endemics:	N/A
Strength:	N/A

Geomorphic Units (km²) *N* = 15													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
1	136,840	–	–	–	–	–	–	10	18,530	–	–	–	–
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
4	1,050	–	–	–	–	–	–	–	–	–	–	–	–

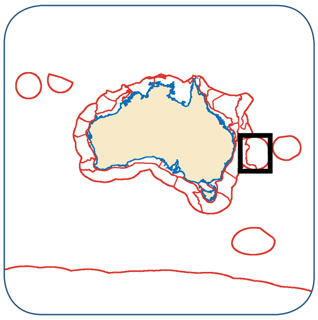
Notes:

- This is one of six NBMB bioregions to cover only one Primary Bathymetric Unit, and the only bioregion to occur only on the abyssal plain/deep ocean floor.
- This bioregion is one of nine NBMB bioregions to contain no Biomes.
- This bioregion does not correspond to any demersal fish province. Despite demersal fish data being relatively poor from this area, this bioregion specifically captures the assemblage of demersal fishes (and other biota) associated with extensive range of seamounts in the central Tasman Sea, which appears to be different from the coastal seas and Lord Howe Rise regions.
- Biomes defining the demersal fish depth structure as well as the rise do not occur in this province.
- This is one of four NBMB bioregions to contain three classes of geomorphic units.
- This bioregion contains the 2nd largest area of Class 5 units of all the NBMB bioregions.
- The seamounts are part of the Tasmantid Seamounts that form a near-continuous chain of high-relief steep-sided features extending right along the deep eastern margin of Australia (Fig. 2.1). Like their counterparts in the Southern Ocean, the well-developed and numerous seamounts in this bioregion are likely to have associated fauna, including many endemics. Because they are located in warm temperate waters, the fauna associated with the seamounts in this bioregion is likely to differ from the fauna associated with seamounts located in the warm tropical waters to the north (i.e., PB16).

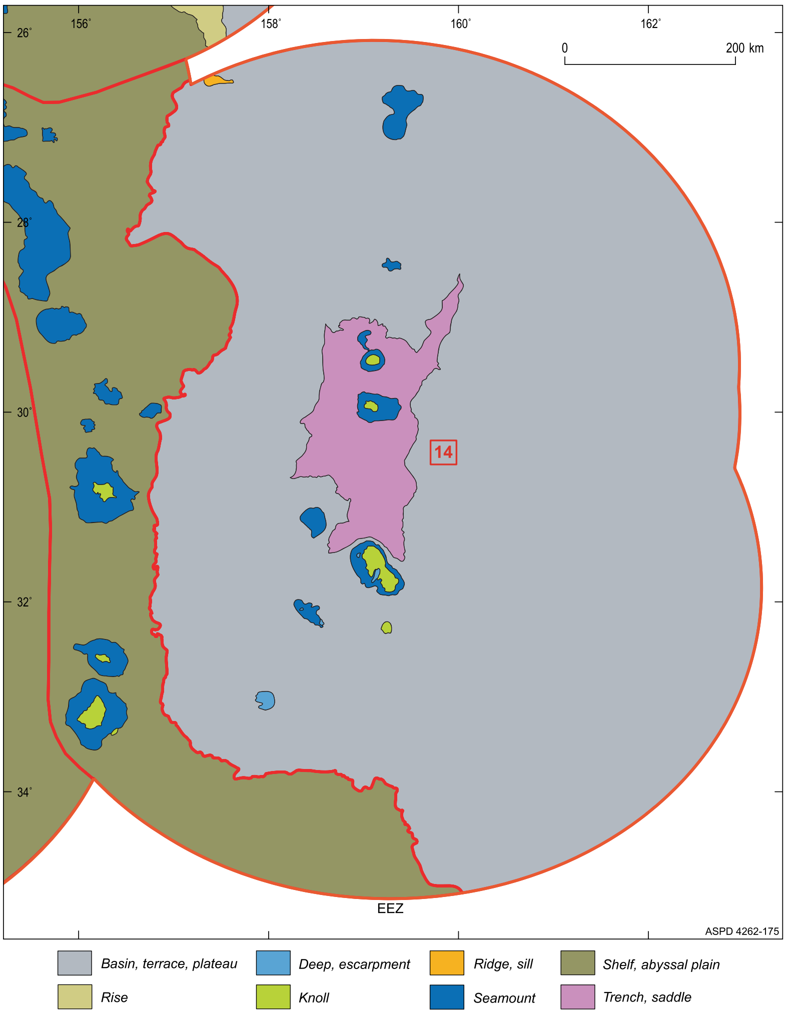
PB14 – Lord Howe Province

This bioregion surrounds Lord Howe Island in the Tasman Sea on the east margin of Australia

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
486,020	0	-5,025	-2,329	972



Primary Bathymetric Units (km²)			Biomes (km²) *N* = 0		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
484,540	–	–	–	–	–



Geomorphic Units in PB14 – Lord Howe Province.

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No. of Demersal Fish Species:	N/A
Key Indicator Demersal Fish Species:	N/A
No. of Endemics:	N/A
Strength:	N/A

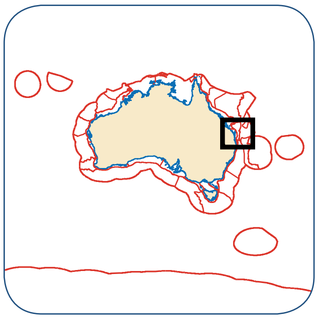
Geomorphic Units (km²) *N* = 20													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	–	–	–	–	1	220	8	5,480	1	23,470	1	454,490
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
4	1,260	–	–	–	–	–	–	5	410	–	–	–	–

Notes:

- This bioregion is one of six NBMB bioregions to cover only one Primary Bathymetric Unit, and one of five to occur only on the slope.
- This bioregion contains the largest slope area of all the NBMB bioregions.
- This bioregion is one of nine NBMB bioregions not to contain any Biomes.
- This bioregion does not correspond to any demersal fish province but specifically captures endemic demersal fish species more closely associated with the Lord Howe Rise.
- This bioregion is the only NBMB bioregion to contain six classes of geomorphic units.
- This bioregion contains the largest Class 7 unit of all the NBMB bioregions.

PB15 – Central Eastern Transition

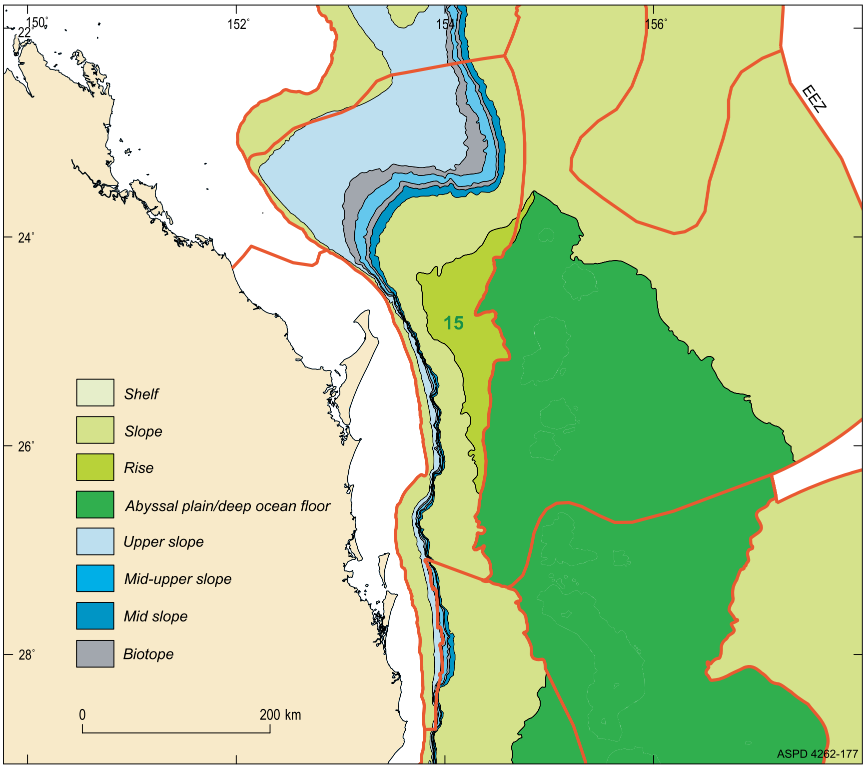
This bioregion is located on the east margin of Australia



Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
74,020	-20	-4,867	-1,536	1,442

Primary Bathymetric Units (km²)			Biomes (km²) *N* = 5		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
63,020	9,950	–	20,770	3,750	2,790

No. of Demersal Fish Species:	518 (14 string nodes)
Key Indicator Demersal Fish Species:	N/A
No. of Endemics:	N/A
Strength:	N/A



Biomes in PB15 – Central Eastern Province.

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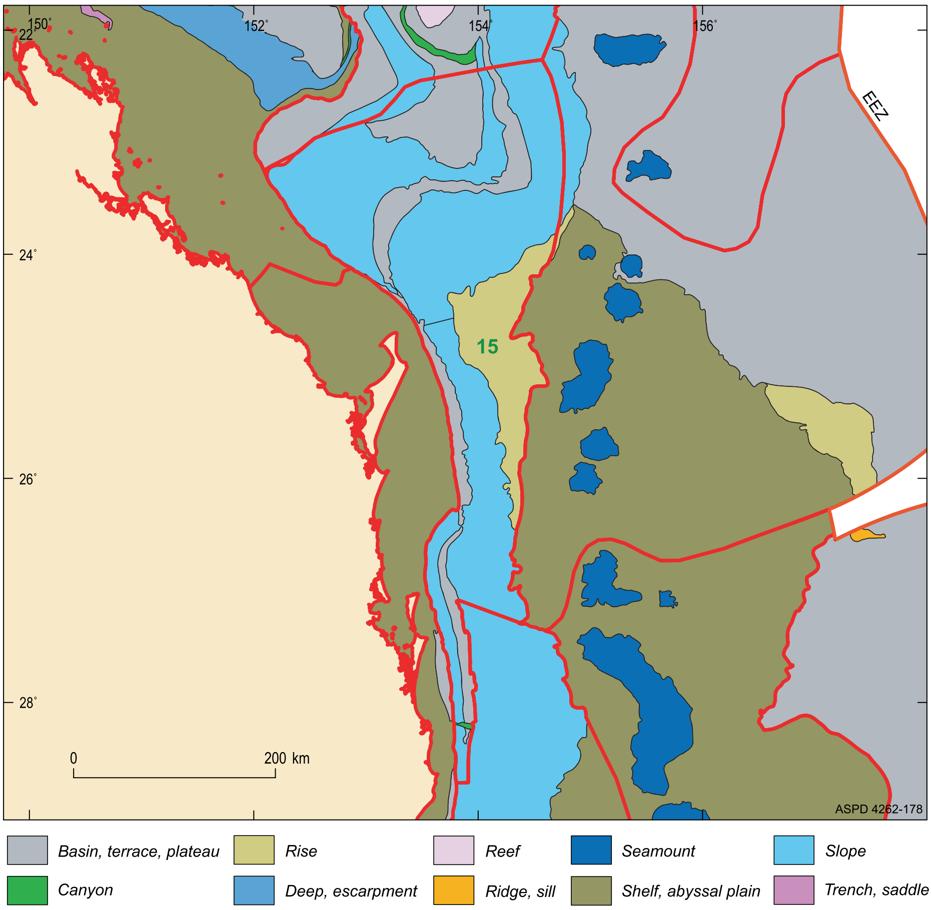
Geomorphic Units (km²) *N* = 72													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	4	48,210	1	10,050	–	–	–	–	–	–	6	14,840
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	1	60	–	–	–	–	–	–	–	–	–	–

Notes:

- This bioregion is one of 11 NBMB bioregions to cover two Primary Bathymetric Units, and one of two to occur only on the slope and rise.
- This bioregion is one of 14 NBMB bioregions to contain all of the biome types.
- Biomes defined by the demersal fish depth structure are the 5th largest in terms of their total area and cover the largest area as a percentage of the bioregion area for all the NBMB bioregions.
- This bioregion is the only NBMB bioregion to contain four classes of geomorphic units.
- This bioregion contains the 3rd largest area of Class 3 of all the NBMB bioregions. This class is the largest on the east margin.
- Class 2 includes units defined by the spacing of submarine canyons on the slope.



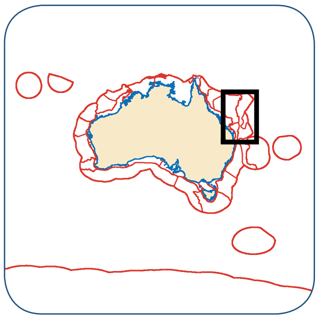
Geomorphic Units in PB15 – Central Eastern Province.

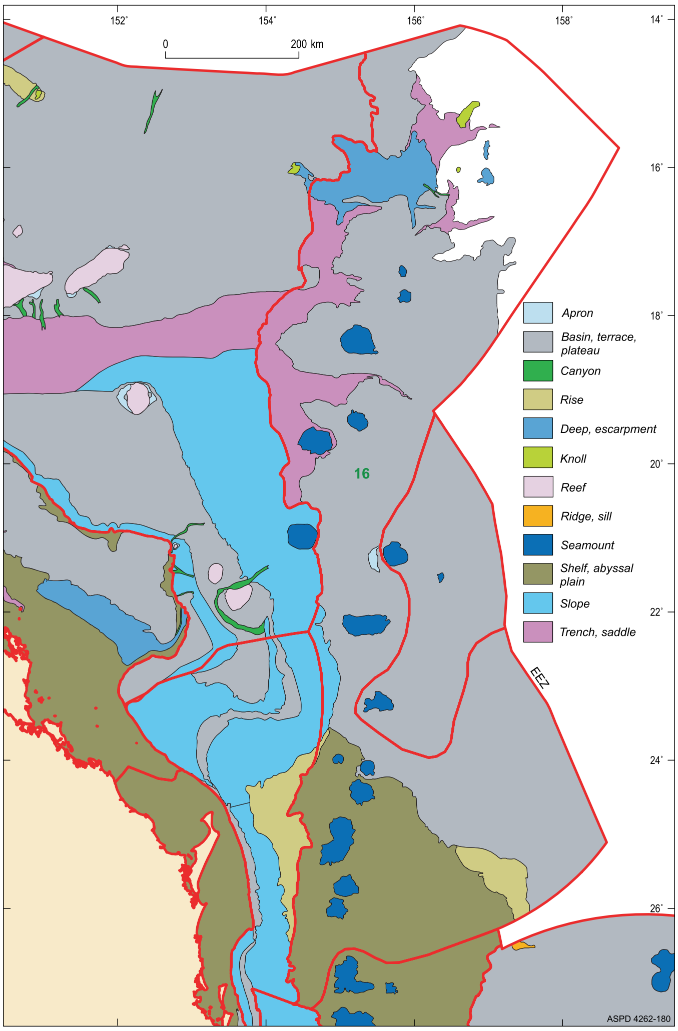
PB16 – Kenn Transition

This bioregion is located in the north Tasman Sea on the northeast margin of Australia

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
376,480	0	-5,106	-3,129	854

Primary Bathymetric Units (km²)			Biomes (km²) *N* = 0		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
246,750	250	64,620	–	–	–





Geomorphic Units in PB16 – Kenn Transition.

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No. of Demersal Fish Species:	N/A
Key Indicator Demersal Fish Species:	N/A
No. of Endemics:	N/A
Strength:	N/A

Geomorphic Units (km²) *N* = 30													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
1	60,470	1	3,360	2	5,380	–	–	12	10,490	4	32,110	3	186,520
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
2	590	1	110	–	–	–	–	3	13,010	1	360	–	–

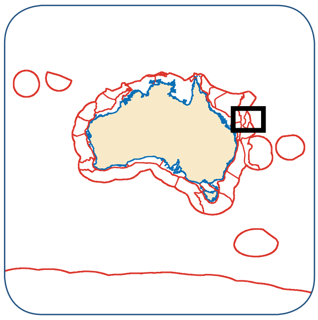
Notes:

- This bioregion is one of seven NBMB bioregions to cover all three Primary Bathymetric Units.
- This bioregion contains the smallest area of rise of all the NBMB bioregions.
- This bioregion is one of nine NBMB bioregions not to contain any Biomes.
- This deep-water bioregion specifically captures the mixing and heterogeneity between the demersal fish species that are endemic to both New Caledonia and Australia.
- This is bioregion defines a complex region that represents a transition zone between tropical and temperate fauna, as well as a transition zone between Australian and New Caledonian fauna. In the north, the fauna associated with the seamounts is likely to be dominated by tropical species (including coral reef species) that would be more similar to the eastern Australian margin than the Lord Howe Rise margin. The northern seamounts are also likely to contain endemic fauna that is different to fauna associated with seamounts in southern and temperate regions.
- This bioregion is one of three NBMB bioregions to contain 10 classes of geomorphic units.
- This bioregion contains the 4th largest Class 7 unit of all the NBMB bioregions.

PB17 – Kenn Province

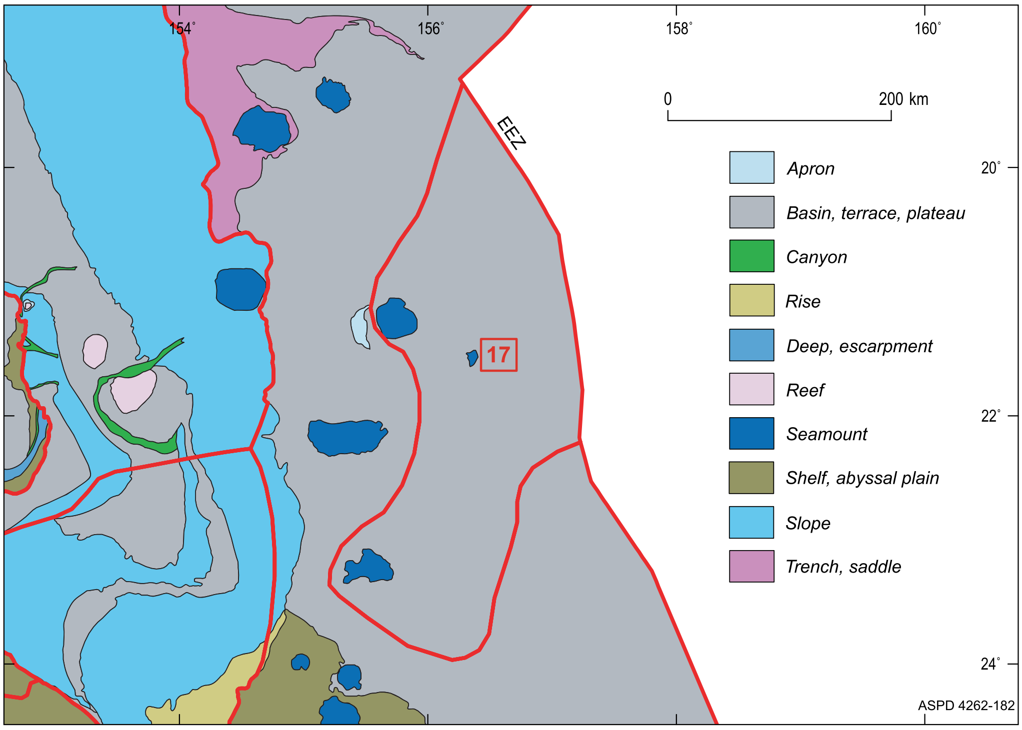
This bioregion is located on the Kenn Plateau (Tasman Sea) on the northeast margin of Australia

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
57,420	-20	-4,867	-1,536	1,442



Primary Bathymetric Units (km²)			Biomes (km²) *N* = 0		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
57,420	–	–	–	–	–

No. of Demersal Fish Species:	N/A
Key Indicator Demersal Fish Species:	N/A
No. of Endemics:	N/A
Strength:	N/A



Geomorphic Units in PB17 – Kenn Province

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Geomorphic Units (km²) *N* = 4													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	–	–	–	–	–	–	3	1,750	–	–	1	55,670
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	–	–	–	–	–	–	–	–	–	–	–	–

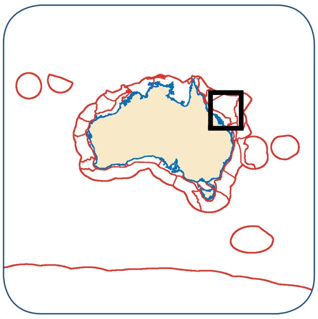
Notes:

- This bioregion is one of six NBMB bioregions to cover only one Primary Bathymetric Unit, and one of five to occur only on the slope.
- This bioregion is one of nine NBMB bioregions not to contain any Biomes.
- This deep-water bioregion centered on the shallower regions of the Kenn Plateau does not correspond to any demersal fish province.
- It specifically captures endemic fish species that are more closely associated with New Caledonia fauna. The regions of deep ocean floor in the Tasman Sea and Cato Basin located in PB16 that separate the continental margin from the Kenn Plateau probably act as significant barriers to dispersal, with the 2,000 m bathymetric contour likely to be a major faunal boundary.
- This bioregion is the only NBMB bioregion to contain only two geomorphic unit classes, and it also contains the least number of geomorphic unit classes of all the NBMB bioregions.

PB18 – Northeast Province

This bioregion is located in the southern Coral Sea on the northeast margin of Australia

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
454,990	0	-4,725	-1,640	1,341



Primary Bathymetric Units (km²)			Biomes (km²) *N* = 40		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
384,710	2,440	67,840	60,940	21,510	68,420

No. of Demersal Fish Species:	441 (19 string nodes)
Key Indicator Demersal Fish Species:	*Arnoglossus nigrifrons*, *Aulopus* sp., *Bembrops* sp., *Caelorinchus shcherbachevi*, *Halieutaea* spp, *Mastigopterus* sp., *Pterygotrigla robersti*.
No. of Endemics:	70
Strength:	4.7 (strongly defined)

Geomorphic Units (km²) *N* = 87													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
–	–	6	2,190	3	2,195	–	–	1	1,310	5	60,540	6	300,030
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
2	250	12	2,490	13	210	–	–	1	480	14	1,550	24	18,350

Notes:

- This bioregion is one of seven NBMB bioregions to cover all three Primary Bathymetric Units.
- This bioregion contains the 3rd largest area of slope of all the NBMB bioregions.
- This bioregion is one of 14 NBMB bioregions to contain all of the biome types.
- This bioregion contains the highest ratio of endemic species to total fish species for all of the NBMB bioregions.
- Within this bioregion the assemblage of sponges associated with the coral reefs on the southern Queensland Plateau are distinct from the sponge assemblages associated with the coral reefs of the northern Queensland Plateau and GBR (Hooper and Ekins, 2004), which are contained in PB20 and PB40, respectively.

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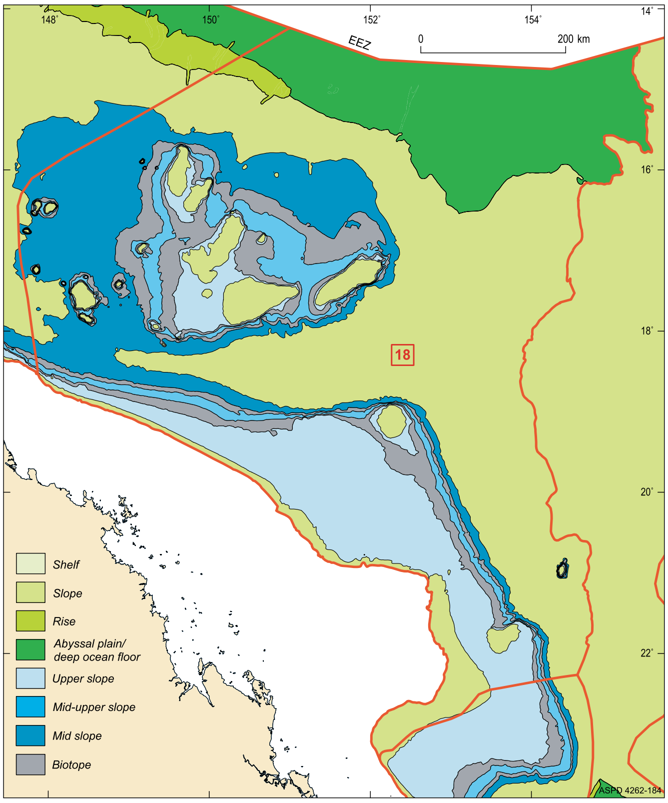
Notes (continued):

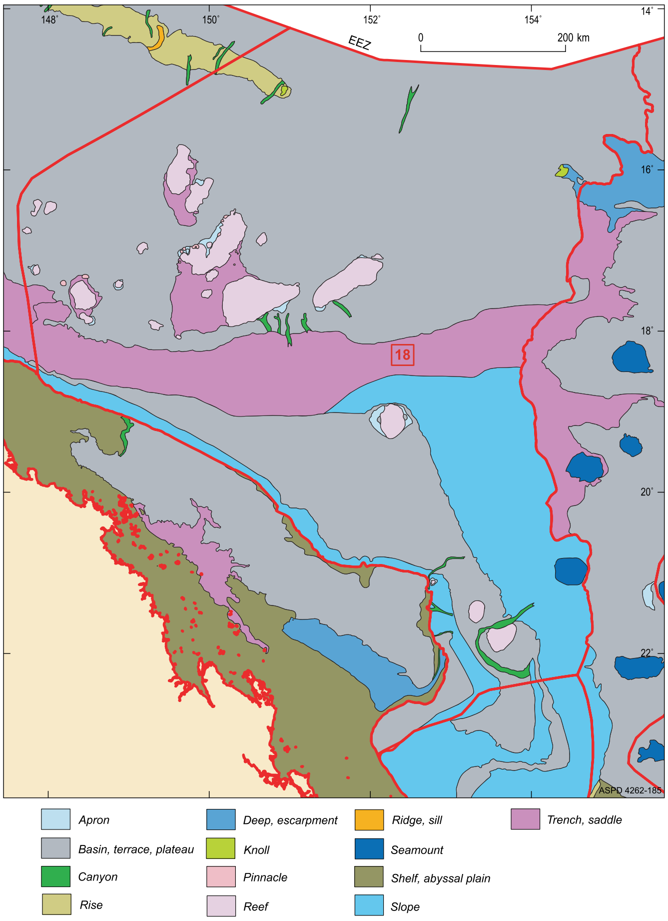
- Biomes defined by the demersal fish depth structure are the largest in terms of their total area and cover the second largest area as a percentage of the bioregion area for all the NBMB bioregions.
- This bioregion is one of two NBMB bioregions to contain 11 classes of geomorphic units, along with PB3.
- Class 2 includes units defined by the spacing of submarine canyons on the slope.
- This bioregions contains the largest units for Classes 6 and 14, and the 3rd largest unit for Class 7 for all the NBMB bioregions.

Reference

Hooper, J. and Ekins, M., 2004. Collation and validation of museum collection databases related to the distribution of marine sponges in Northern Australia (Contract National Oceans Office C2004/020). Unpublished Report to the National Oceans Office, Queensland Museum, Brisbane. 206pp.



Biomes in PB18 – Northeast Province.



Geomorphic Units in PB18 – Northeast Province.

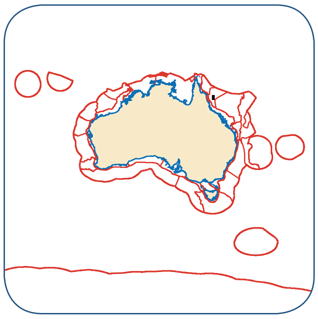
PB19 – Northeast Transition

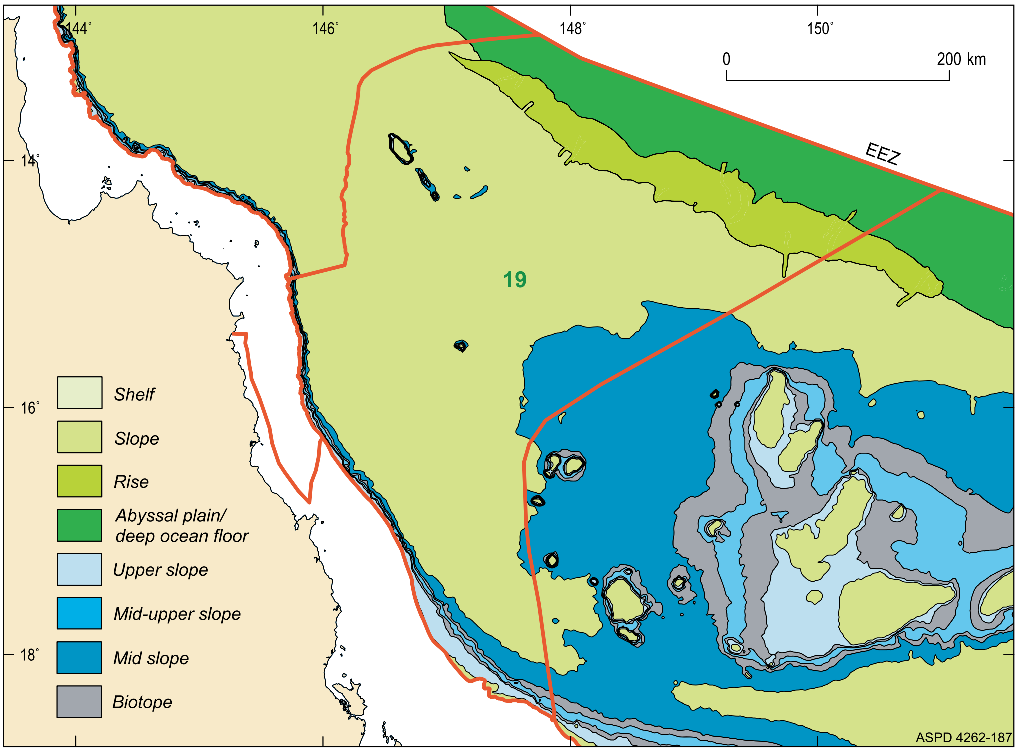
This bioregion is located in the central Coral Sea on the northeast margin of Australia

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
150,150	0	-4,719	-2,123	1,172

Primary Bathymetric Units (km²)			Biomes (km²) *N* = 21		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
117,490	12,980	19,680	2,430	1,070	11,340

No. of Demersal Fish Species:	421 (8 string nodes)
Key Indicator Demersal Fish Species:	N/A
No. of Endemics:	N/A
Strength:	N/A





Biomes in PB19 – Northeast Transition.

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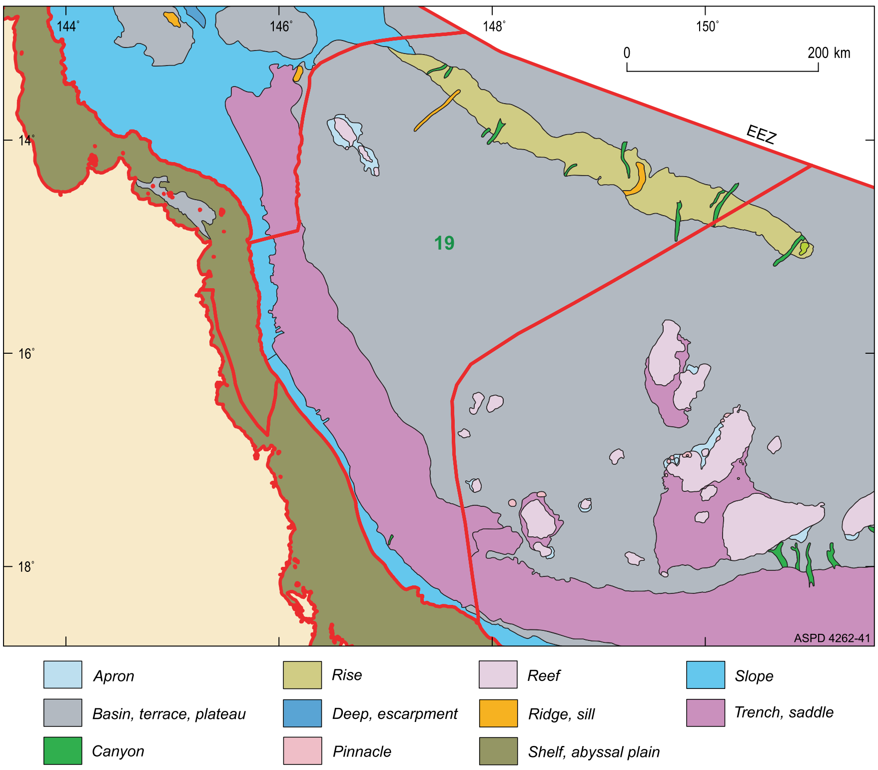
Geomorphic Units (km²) *N* = 27													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	2	6,600	3	11,970	2	440	–	–	1	27,030	3	102,200
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	10	770	–	–	–	–	–	–	2	790	4	480

Notes:

- This is one of seven NBMB bioregions to cover all three Primary Bathymetric Units.
- This bioregion contains the 2nd largest rise areas of all the NBMB bioregions.
- This bioregion is one of 14 NBMB bioregions to contain all of the biome types.
- This bioregion specifically captures the effects of the westward flowing Coral Sea current that impinges on the northeast margin in the vicinity of Cairns.
- Studies have shown that the fauna on Osprey Reef located on the Queensland Plateau is genetically more closely related to coral reefs of the Great Barrier Reef than the coral reefs located on the southern Queensland Plateau. Other studies have shown that there is also a faunal gyre to the north of Osprey Reef. This makes Osprey Reef a strong biological boundary, although it does not represent a geomorphic boundary.
- Biomes defined by the demersal fish depth structure are the 8th largest in terms of their total area and cover the 8th largest area as a percentage of the bioregion area for all the NBMB bioregions.
- This bioregion is one of five NBMB bioregions to contain eight classes of geomorphic units.
- Class 2 includes units defined by the spacing of submarine canyons on the slope.
- This bioregion contains the 2nd largest Class 3 unit of all the NBMB bioregions.

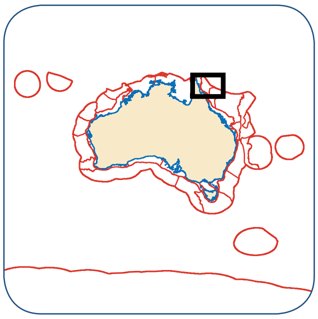


Geomorphic Units in PB19 – Northeast Transition.

PB20 – Cape Province

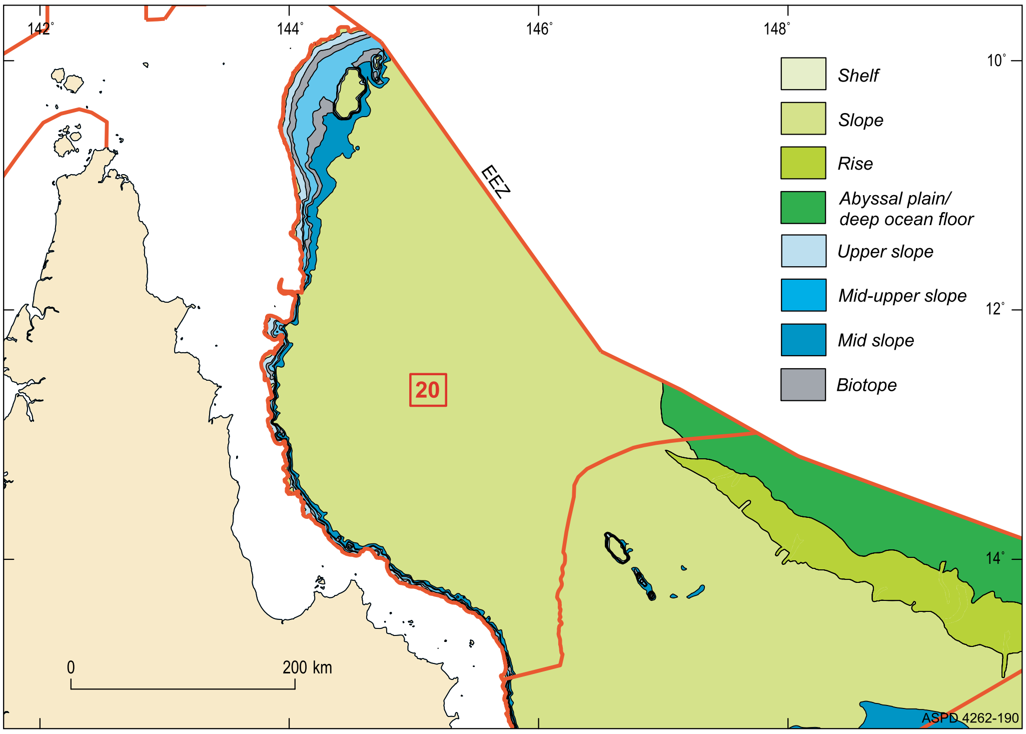
This bioregion is located in the western Coral Sea on the northeast margin of Australia

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
111,220	0	-4,186	-2,325	910



Primary Bathymetric Units (km²)			Biomes (km²) *N* = 25		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
109,120	–	2,090	2,100	3,610	3,400

No. of Demersal Fish Species:	302 (10 string nodes)
Key Indicator Demersal Fish Species:	*Aulastomatomorpha phospherops, Bassozetus compressus, Etmopterus dianthus, Halicmetus* sp., *Monomitopus garmani, Notoraja laxipell*
No. of Endemics:	24
Strength:	0.9 (weakly defined)



Biomes in PB20 – Cape Province.

...continued page 2

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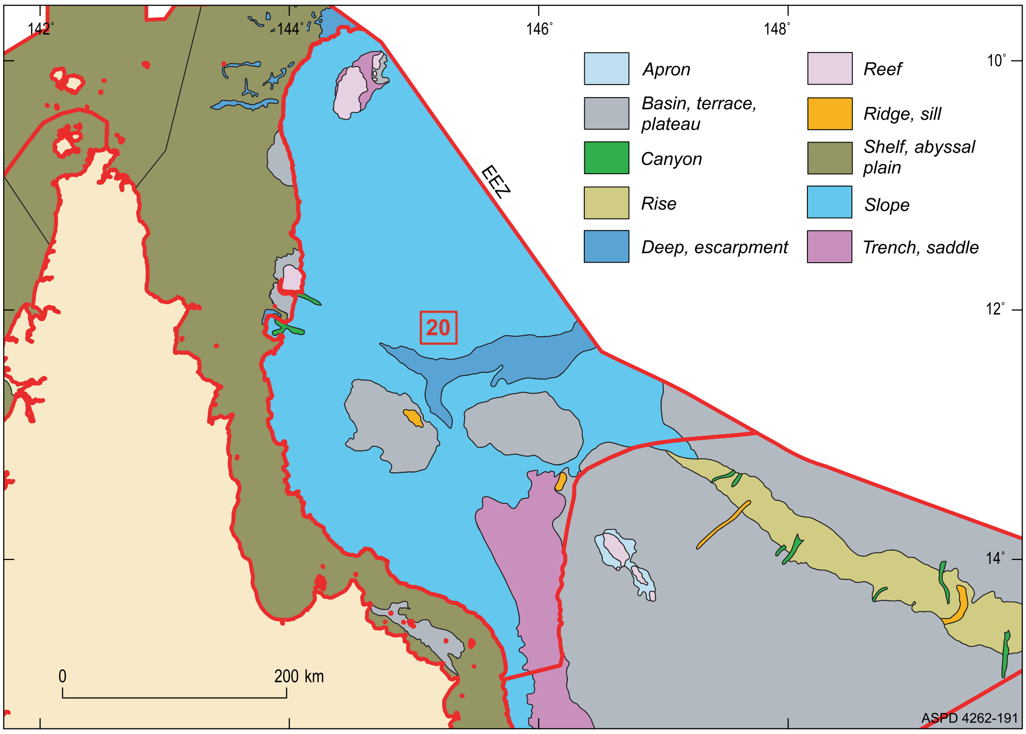
Geomorphic Units (km²) $N = 18$													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	1	83,330	–	–	2	240	–	–	3	8,620	5	12,440
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	2	280	–	–	–	–	1	5,210	–	–	4	1,030

Notes:

- This bioregion is one of 11 NBMB bioregions to cover two Primary Bathymetric Units and one of nine to occur on the slope and abyssal plain/deep ocean floor.
- This bioregion is one of 14 NBMB bioregions to contain all of the biome types.
- Biomes defined by the demersal fish depth structure are the 10th largest in terms of their total area and cover the 9th largest area as a percentage of the bioregion area for all the NBMB bioregions.
- This bioregion is one of four NBMB bioregions to contain seven classes of geomorphic units.
- Class 2 includes units defined by the spacing of submarine canyons on the slope.



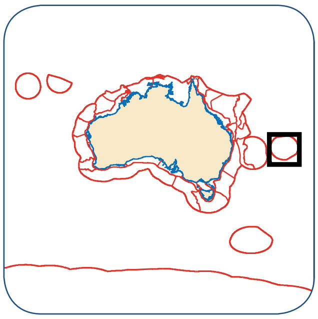
Geomorphic Units in PB20 – Cape Province.

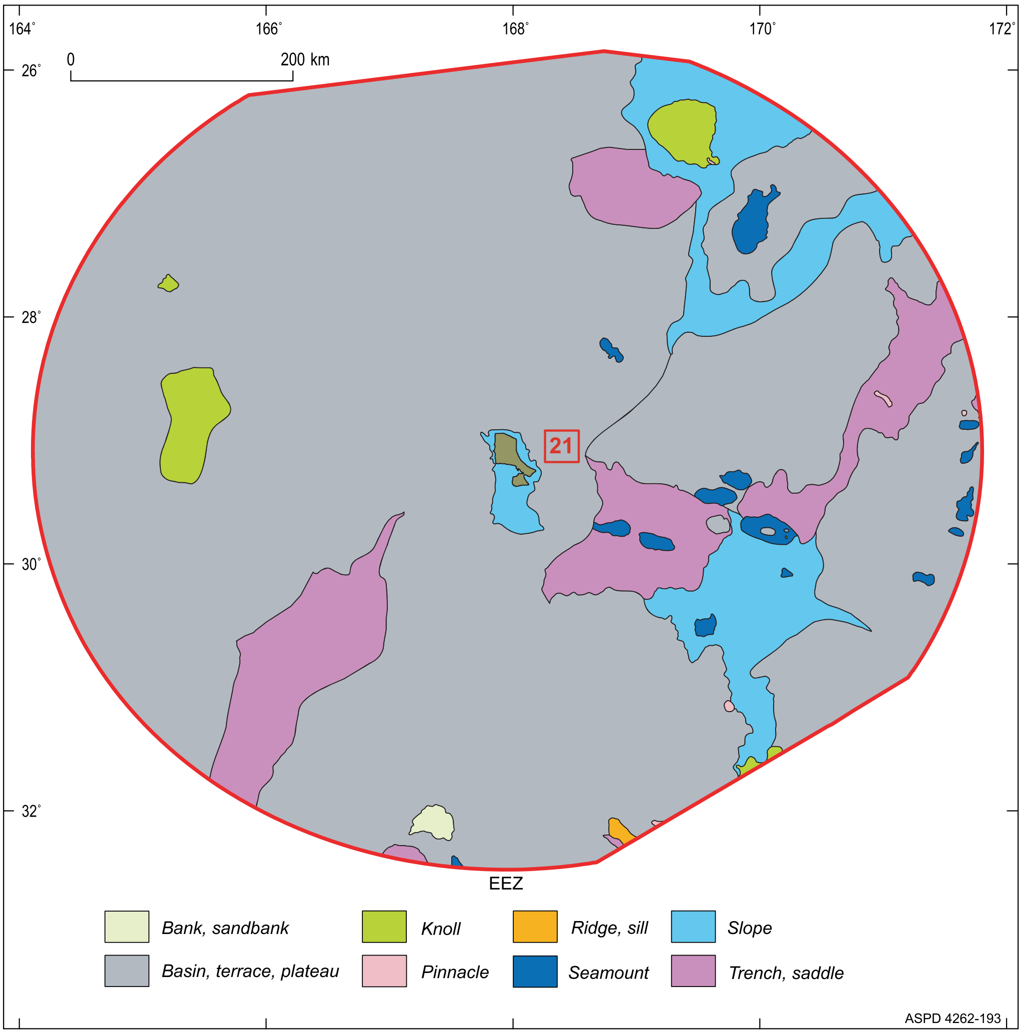
PB21 – Norfolk Island Province

This bioregion is surrounds Norfolk Island in the central Tasman Sea

Total Area	Water Depth (m)			
(km^2)	Minimum	Maximum	Mean	Std Dev.
431,160	-19	-4,827	-2,759	826

Primary Bathymetric Units (km^2)			Biomes (km^2) $N = 0$		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
430,480	–	–	–	–	–





Geomorphic Units in PB21 – Norfolk Island Province.

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No. of Demersal Fish Species:	N/A
Key Indicator Demersal Fish Species:	N/A
No. of Endemics:	N/A
Strength:	N/A

Geomorphic Units (km²) *N* = 46													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
1	680	3	31,330	–	–	1	280	15	4,370	7	39,830	7	346,950
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
5	6,800	–	–	5	190	1	720	1	10	–	–	–	–

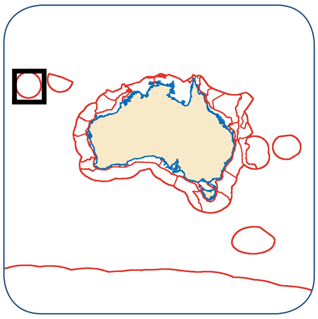
Notes:

- This bioregion is one of six NBMB bioregions to cover one Primary Bathymetric Unit and one of five to occur only on the slope.
- This bioregion contains the 2nd largest slope area of all the NBMB bioregions.
- This bioregion is one of nine NBMB bioregions not to contain any Biomes.
- This bioregion does not correspond to any demersal fish province, but specifically captures endemic fish species and other fauna more closely associated with the Norfolk Island region.
- The fauna associated with this bioregion are much different to the fauna associated with the mainland.
- This bioregion is one of three NBMB bioregions to contain 10 classes of geomorphic units.
- Class 2 includes units defined by the spacing of submarine canyons on the slope.
- This bioregion contains the 2nd largest Class 7 unit of all the NBMB bioregions.

PB22 – Cocos (Keeling) Island Province

This bioregion surrounds Cocos (Keeling) Island in the eastern Indian Ocean, northwest of Australia

Total Area	Water Depth (m)			
(km^2)	Minimum	Maximum	Mean	Std Dev.
467,260	0	-6,468	-4,988	686



Primary Bathymetric Units (km^2)			Biomes (km^2) *N* = 0		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
35,140	–	432,030	–	–	–

No. of Demersal Fish Species:	N/A
Key Indicator Demersal Fish Species:	N/A
No. of Endemics:	N/A
Strength:	N/A

Geomorphic Units (km^2) *N* = 99													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
4	291,380	1	24,140	–	–	1	18,310	22	14,900	3	16,100	28	94,420
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
40	8,010	–	–	–	–	–	–	–	–	–	–	–	–

Notes:

- This bioregion is one of 11 NBMB bioregions to cover two Primary Bathymetric Units and one of nine to occur on the slope and abyssal plain/deep ocean floor.
- This bioregion contains the largest abyssal plain/deep ocean floor area of all the NBMB bioregions.
- This bioregion is one of nine NBMB bioregions not to contain any Biomes.
- This bioregion does not correspond to any demersal fish province, but specifically captures endemic fish species and other fauna associated with the Cocos (Keeling) Islands.
- This bioregion is the deepest NBMB bioregion on average due to the relatively large areas of abyssal plain/deep ocean floor.

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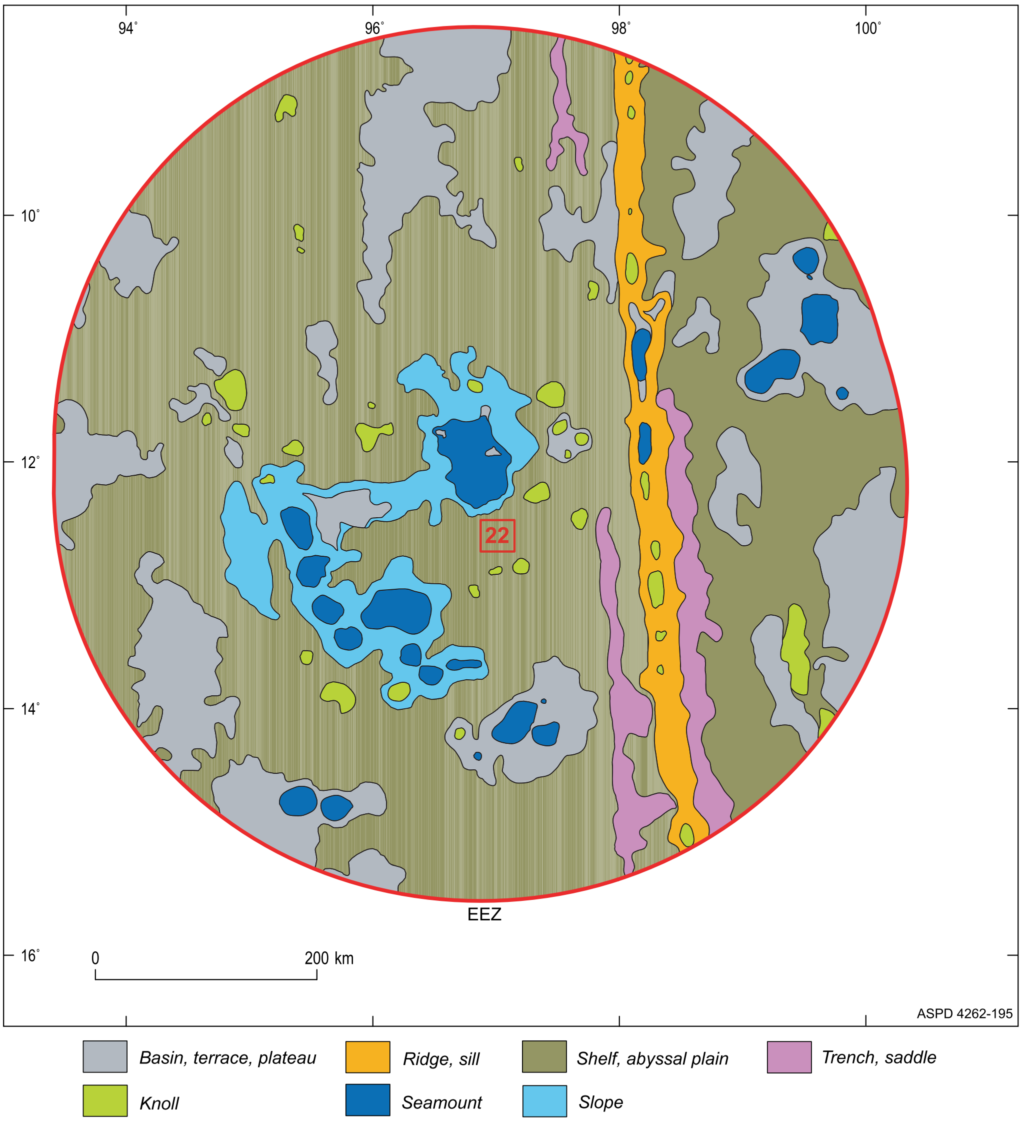
- This bioregion is one of four NBMB bioregions to contain seven classes of geomorphic units.
- Due to the similar geomorphology and location adjacent to Indonesia in the tropical Indian Ocean, the fauna contained in this bioregion is probably similar or related to the fauna associated with the Christmas Island bioregion (PB23).
- This bioregion contains the 3rd largest Class 1 and Class 4 units of all the NBMB bioregions.



Geomorphic Units in PB22 – Cocos (Keeling) Island Province.

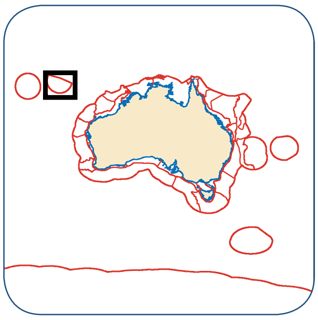
PB23 – Christmas Island Province

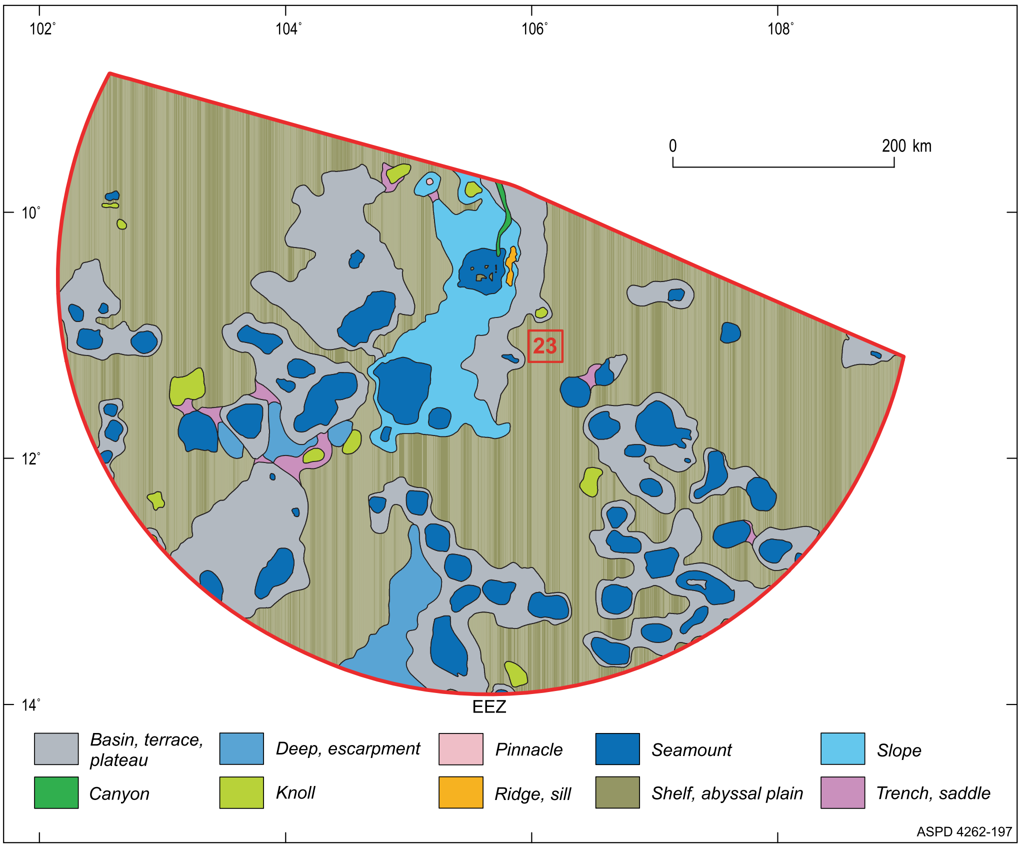
This bioregion surrounds Christmas Island in the eastern Indian Ocean, northwest of Australia.

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
277,180	0	-6,545	-5,020	792

Primary Bathymetric Units (km²)			Biomes (km²) *N* = 0		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
22,950	–	254,170	–	–	–

No. of Demersal Fish Species:	N/A
Key Indicator Demersal Fish Species:	N/A
No. of Endemics:	N/A
Strength:	N/A





Geomorphic Units in PB23 – Christmas Island Province.

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Geomorphic Units (km²) *N* = 115													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
10	165,750	2	12,290	–	–	1	180	57	26,430	9	1,930	18	61,350
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
12	2,570	1	270	1	30	–	–	4	6,380	–	–	–	–

Notes:

- This bioregion is one of 11 NBMB bioregions to cover two Primary Bathymetric Units and one of nine to occur on the slope and abyssal plain/deep ocean floor.
- This bioregion contains the 4th largest abyssal plain/deep ocean floor area and smallest area of slope of all the NBMB bioregions.
- This bioregion is one of nine NBMB bioregions not to contain any Biomes.
- This bioregion does not correspond to any demersal fish province, but specifically captures endemic fish species and other fauna associated with Christmas Island.
- This bioregion is one of three NBMB bioregions to contain 10 classes of geomorphic units.
- Due to the similar geomorphology and location adjacent to Indonesia in the tropical Indian Ocean, the fauna contained in this bioregion is probably similar or related to the fauna associated with the Cocos (Keeling) Island bioregion (PB22).
- This bioregion contains the 7th largest Class 1 unit of all the NBMB bioregions.

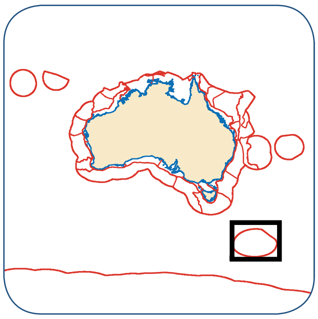
PB24 – Macquarie Island Province

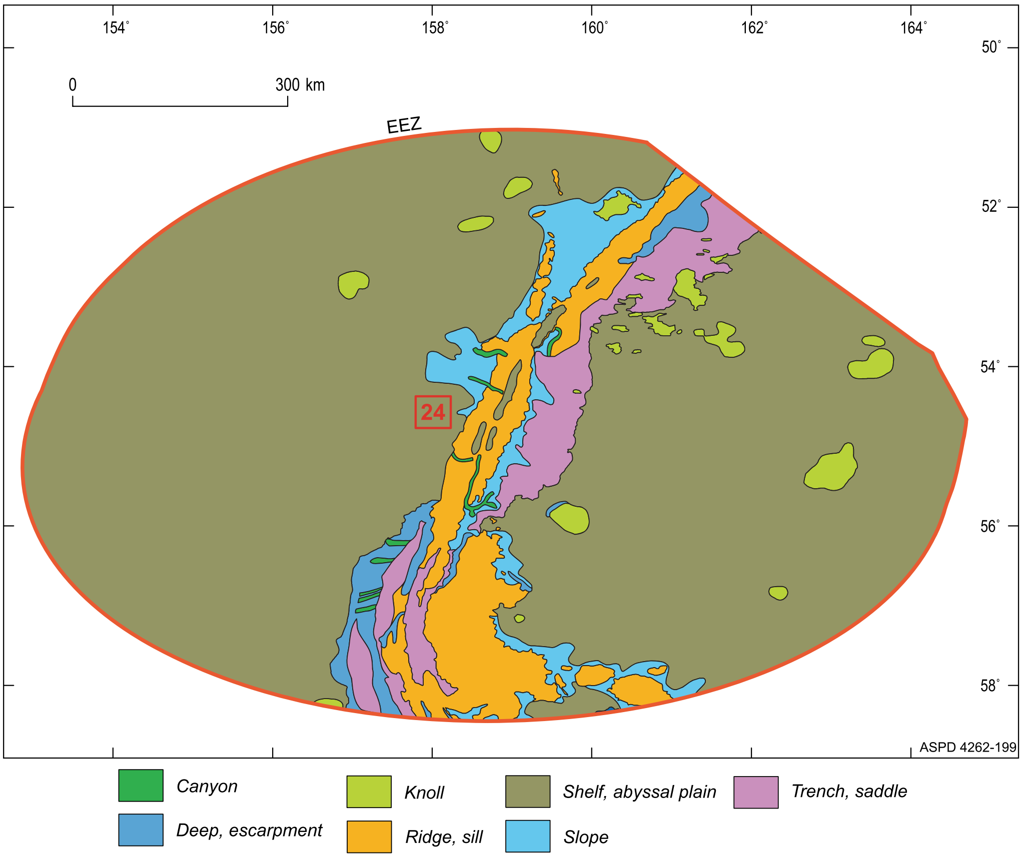
This bioregion surrounds Macquarie Island in the Southern Ocean, southeast of Australia

Total Area	Water Depth (m)			
(km^2)	Minimum	Maximum	Mean	Std Dev.
477,430	0	-6,737	-3,838	998

Primary Bathymetric Units (km^2)			Biomes (km^2) *N* = 0		
Slope	Rise	AP / DOF	Upper Slope	Mid-upper Slope	Mid Slope
64,590	–	411,330	–	–	–

No. of Demersal Fish Species:	N/A
Key Indicator Demersal Fish Species:	N/A
No. of Endemics:	N/A
Strength:	N/A





Geomorphic Units in PB24 – Macquarie Island Province.

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Geomorphic Units (km²) *N* = 84													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
8	375,170	7	19,650	–	–	16	36,690	1	80	4	24,890	–	–
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
29	10,210	10	1,420	–	–	–	–	9	9,320	–	–	–	–

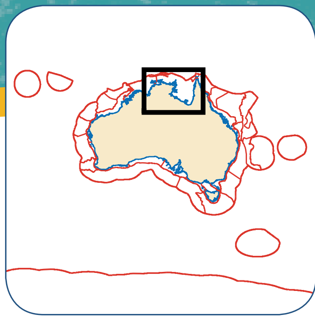
Notes:

- This bioregion is one of 11 NBMB bioregions to cover two Primary Bathymetric Units and one of nine to occur on the slope and abyssal plain/deep ocean floor.
- This bioregion contains the 3rd largest abyssal plain/deep ocean floor area of all the NBMB bioregions.
- This bioregion is one of nine NBMB bioregions not to contain any Biomes.
- This bioregion does not correspond to any demersal fish province, but specifically captures endemic fish species and other fauna associated with Macquarie Island.
- Analysis of fish data for the SE bioregionalisation (e.g., Butler et al., 2001) indicated that the Macquarie Island margin should be considered a separate province from the continental margin.
- This bioregion contains the deepest seabed environments of the EEZ due to the presence of the well-developed trench system.
- This bioregion is one of five NBMB bioregions to contain eight classes of geomorphic units.
- This bioregion contains the largest Class 1 unit of all the NBMB bioregions.

Reference

Butler, A., Harris, P., Lyne, V., Heap, A., Passlow, V., and Smith, R., 2001. An Interim, Draft bioregionalisation for the continental slope and deeper waters of the South-East Marine Region of Australia. Draft CSIRO Report to the National Oceans Office. CSIRO Marine Research, Hobart. 32pp.

PB25 – Northern IMCRA Province

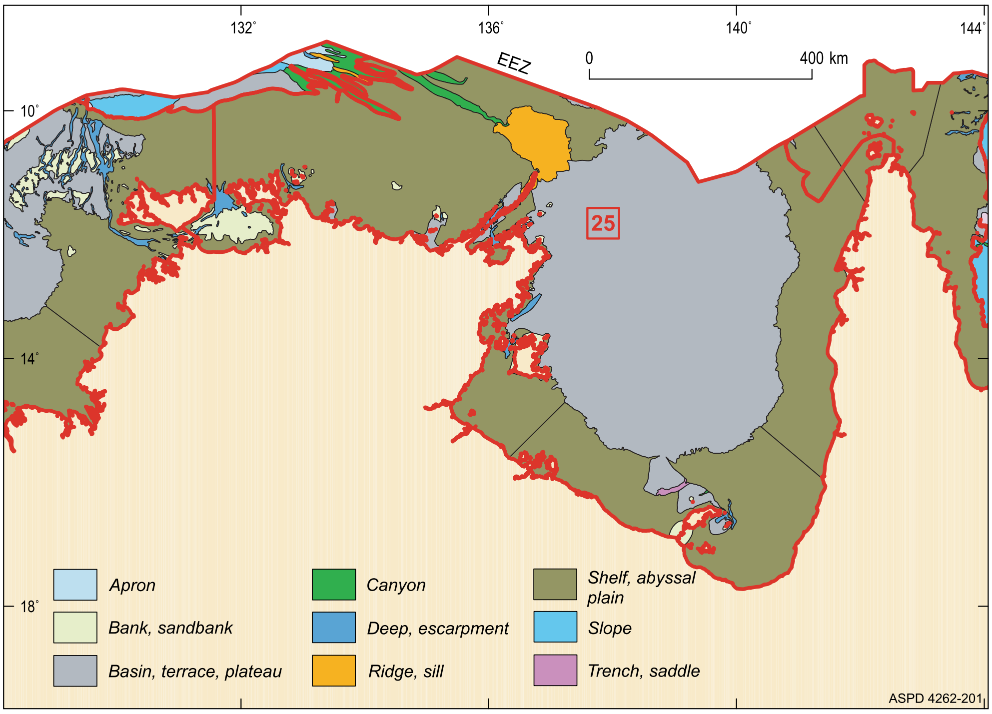


Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
556,350	0	-273	-44	27

Geomorphic Units (km²) *N* = 92													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
9	303,410	–	–	–	–	6	11,930	–	–	1	500	13	222,990
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
–	–	3	3,230	10	130	25	10,310	25	3,850	–	–	–	–

Notes:

- This bioregion is the largest of all the IMCRA shelf bioregions.
- Class 1 includes units defined by the distribution and abundance of pinnacles, banks, and sand banks.
- This bioregion contains the largest area of Class 1 units for all of the IMCRA shelf bioregions.
- This bioregion contains the largest area of Class 7 units of all IMCRA shelf bioregions, dominated by the low-gradient basin located in the Gulf of Carpentaria.
- This bioregion is the only IMCRA shelf bioregion to contain eight classes of geomorphic units.



Geomorphic Units in PB25 – North IMCRA Province.

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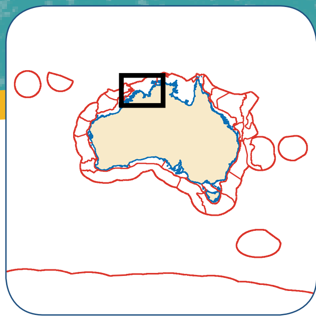
PB26 – Northwest IMCRA Transition

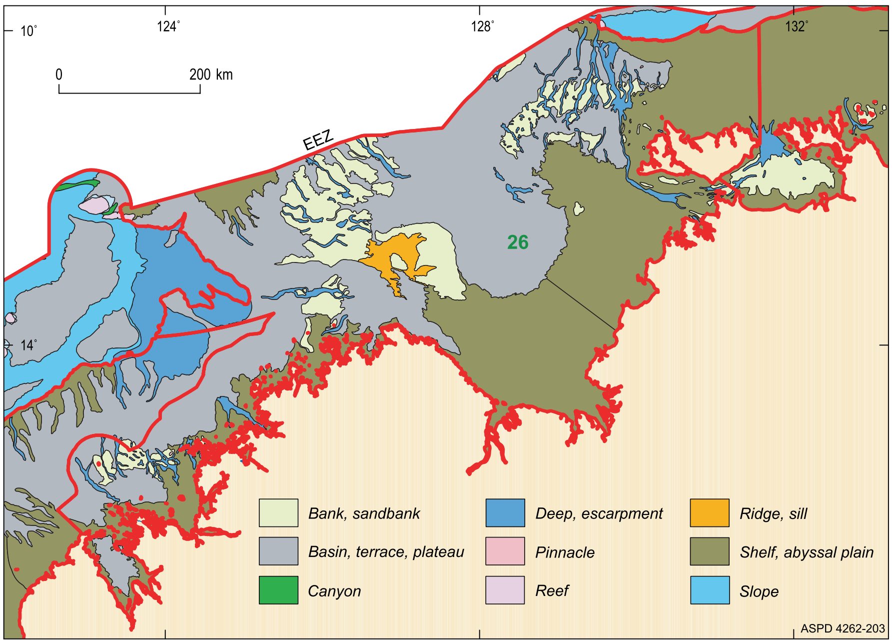


Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
305,550	0	-526	-70	41

Geomorphic Units (km²) N = 121													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
16	125,290	–	–	–	–	1	3,730	–	–	–	–	15	126,770
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
–	–	–	–	5	40	79	33,370	78	16,160	–	–	5	190

Notes:

- This bioregion is the 2nd largest of all the IMCRA shelf bioregions.
- Class 1 includes units defined by the distribution and abundance of pinnacles, banks, and sand banks.
- This bioregion contains the 3rd largest area of Class 1 units for all of the IMCRA shelf bioregions.
- This bioregion contains the 2nd largest areas of Class 7 units of all IMCRA shelf bioregions, dominated by broad shelf terraces, and the shallow basin located in the Joseph Bonaparte Gulf.
- This bioregion contains the largest area of Class 11 units of all IMCRA shelf bioregions, dominated by the extensive banks that make up the Sahul Banks and Van Diemen Rise.
- This bioregion also contains the 2nd largest area of Class 12 units of all IMCRA shelf bioregions.



Geomorphic Units in PB26 – Northwest IMCRA Transition.

- This bioregion is the only IMCRA shelf bioregions to contain seven classes of geomorphic units.

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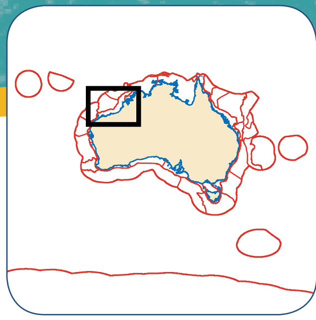
PB27 – Northwest IMCRA Province

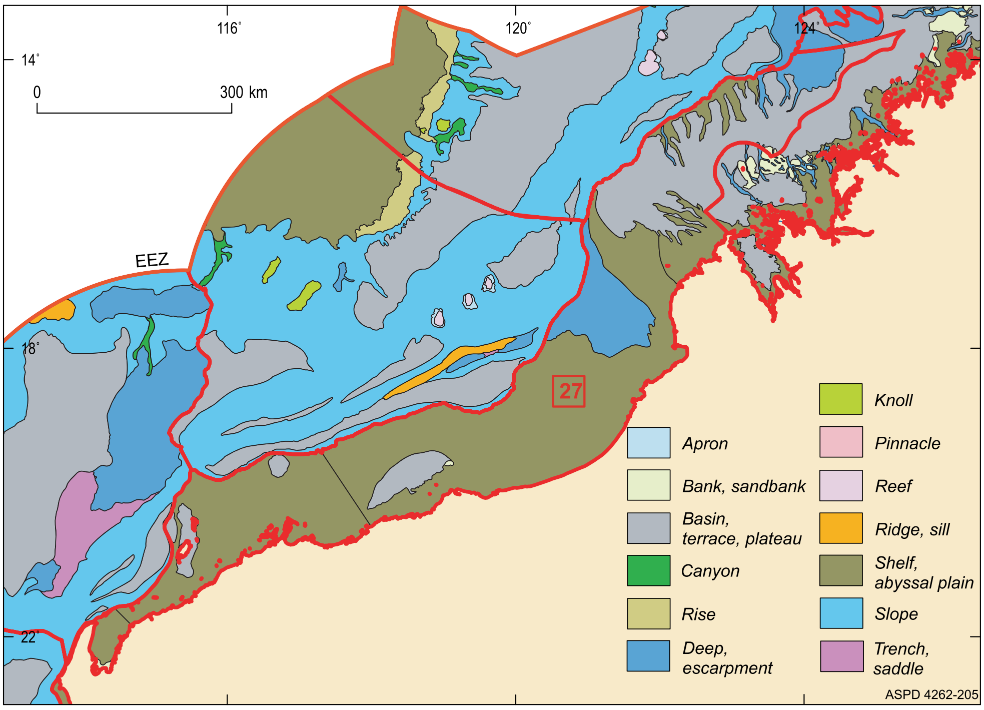


Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
193,480	0	-140	-49	32

Geomorphic Units (km²) *N* = 23													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
5	130,030	–	–	–	–	–	–	–	–	–	–	7	43,260
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	–	–	–	–	3	680	8	19,510	–	–	–	–

Notes:

- This bioregion is the 3rd largest of all the IMCRA shelf bioregions.
- Class 1 includes units defined by the distribution and abundance of pinnacles, banks, and sand banks.
- This bioregion contains the 2nd largest area of Class 1 units of all the IMCRA shelf bioregions.
- This bioregion is one of four IMCRA shelf bioregions to contain five classes of geomorphic units.



Geomorphic Units in PB27 – Northwest IMCRA Province.

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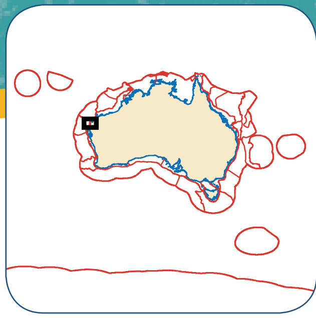
PB28 – Central Western IMCRA Transition

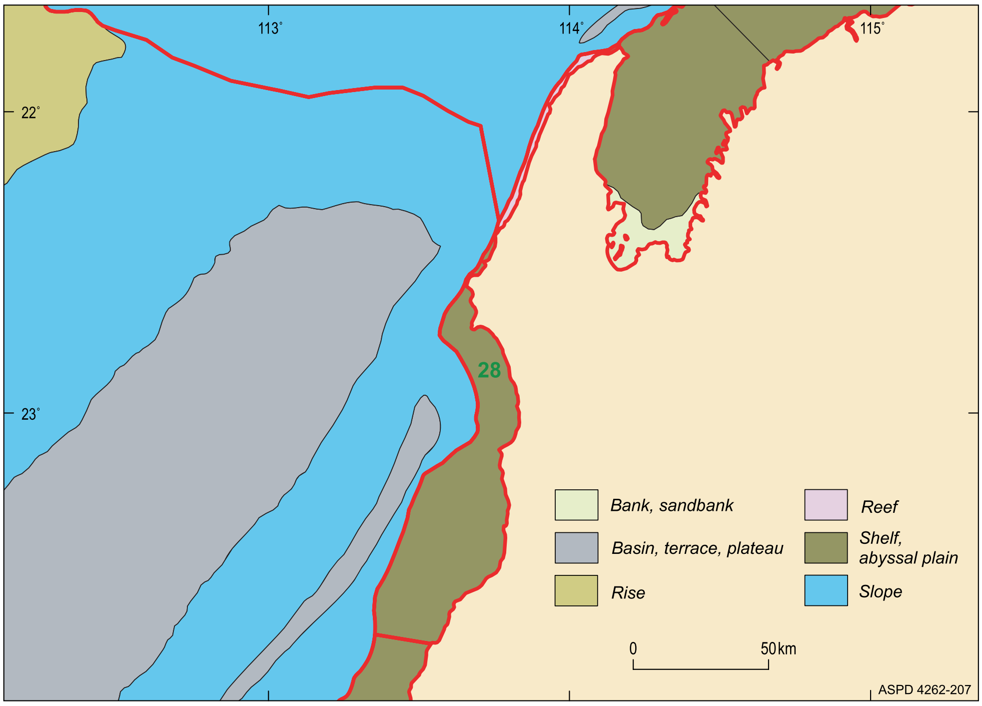


Total Area	Water Depth (m)			
(km^2)	Minimum	Maximum	Mean	Std Dev.
3,080	0	-106	-51	27

Geomorphic Units (km^2) $N = 3$													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
2	2,920	–	–	–	–	–	–	–	–	–	–	–	–
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
–	–	–	–	–	–	–	–	–	–	–	–	1	160

Notes:

- This bioregion is the smallest of the IMCRA shelf bioregions.
- Class 1 units are overwhelmingly the dominant geomorphic class in this bioregion.
- This bioregion is one of six IMCRA shelf bioregions to contain two classes of geomorphic units.



Geomorphic Units in PB28 – Central Western IMCRA Transition.

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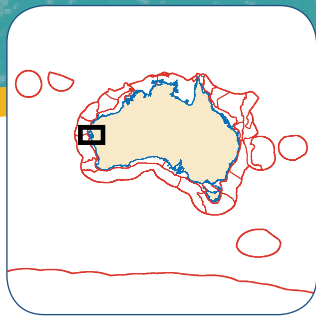
PB29 – Central Western IMCRA Province

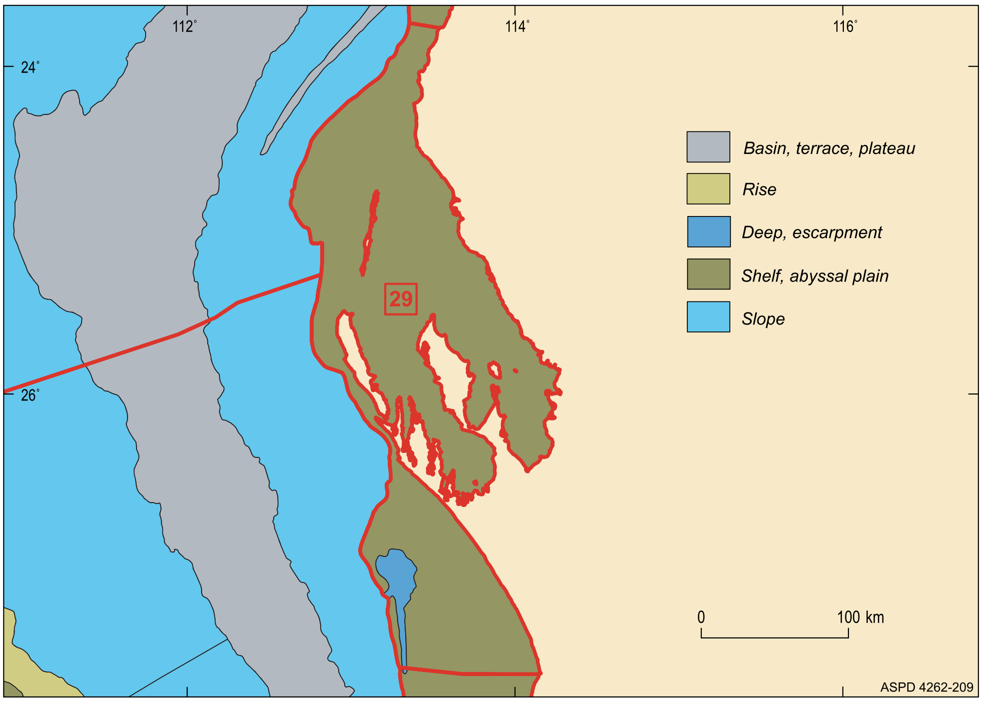


Total Area	Water Depth (m)			
(km^2)	Minimum	Maximum	Mean	Std Dev.
32,680	0	-112	-38	37

Geomorphic Units (km^2) $N = 3$													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
2	31,890	–	–	–	–	–	–	–	–	–	–	–	–
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
–	–	–	–	–	–	–	–	1	790	–	–	–	–

Notes:

- This bioregion has the second shallowest mean water depth of all the IMCRA shelf bioregions.
- Class 1 units are overwhelmingly the dominant geomorphic class in this bioregion.
- This bioregion is one of six IMCRA shelf bioregions to contain two classes of geomorphic units.



Geomorphic Units in PB29 – Central Western IMCRA Province.

For further information, please contact:
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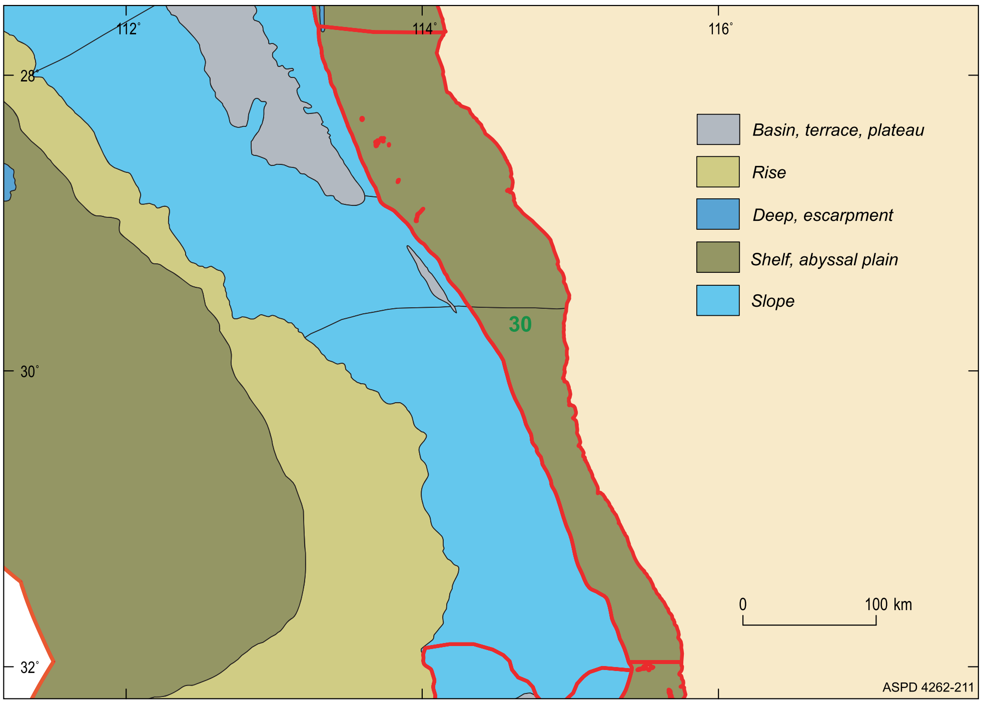
PB30 – Southwest IMCRA Transition

Total Area	Water Depth (m)			
(km^2)	Minimum	Maximum	Mean	Std Dev.
27,110	0	-296	-41	17

Geomorphic Units (km^2) *N* = 3													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
2	27,100	–	–	–	–	–	–	–	–	–	–	–	–
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
–	–	–	–	–	–	–	–	1	10	–	–	–	–

Notes:

- This bioregion is the second smallest of all the IMCRA shelf bioregions.
- Class 1 includes units defined by the distribution and abundance of pinnacles, banks, and sand banks.
- This bioregion is one of six IMCRA shelf bioregions to contain only two classes of geomorphic units.



Geomorphic Units in PB30 – Southwest IMCRA Transition.

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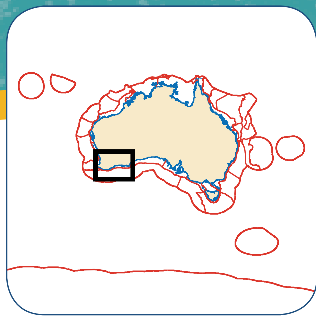
PB31 – Southwest IMCRA Province

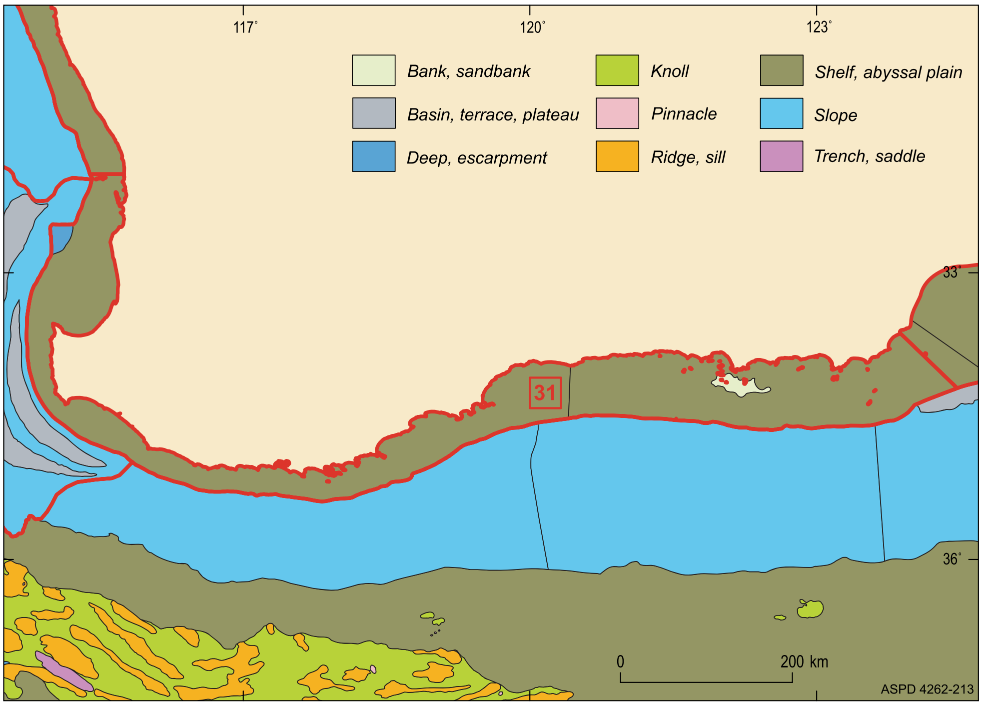


Total Area	Water Depth (m)			
(km^2)	Minimum	Maximum	Mean	Std Dev.
61,360	0	-600	-54	28

Geomorphic Units (km^2) N = 5													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
3	60,030	–	–	–	–	–	–	–	–	–	–	–	–
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	–	–	–	–	1	740	1	60	–	–	–	–

Notes:

- This bioregion contains the second deepest seabed habitats of all the IMCRA shelf bioregions.
- Class 1 includes units defined by the distribution and abundance of pinnacles, banks, and sand banks.
- This bioregion is only IMCRA shelf bioregion to contain three classes of geomorphic units.



Geomorphic Units in PB31 – Southwest IMCRA Province.

For further information, please contact:

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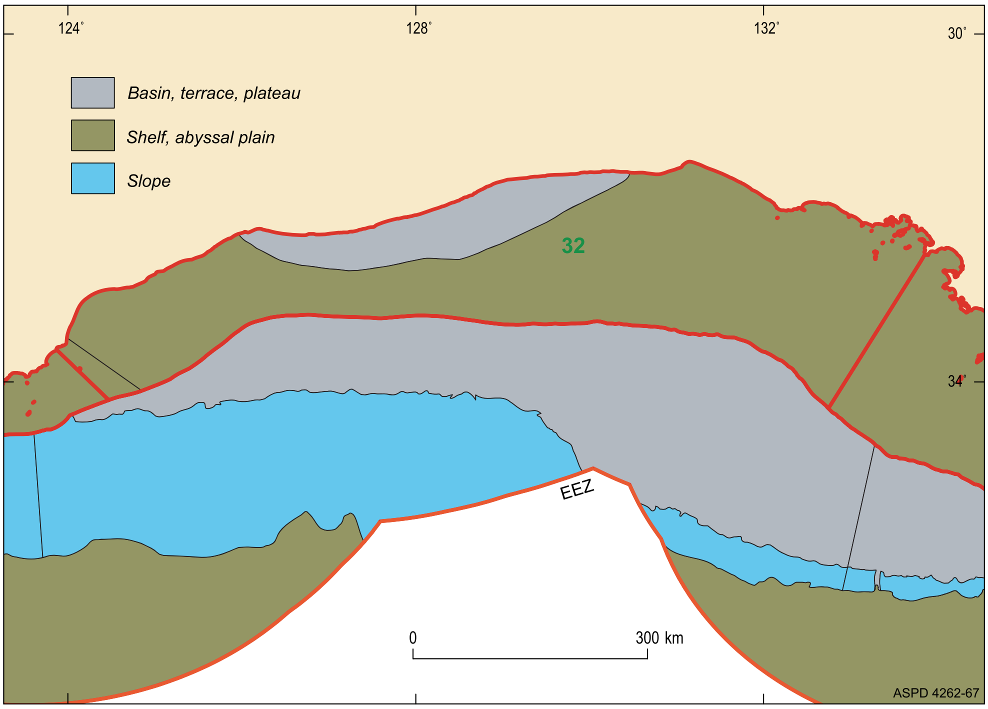
PB32 – Great Australian Bight IMCRA Transition

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
144,970	0	-354	-74	32

Geomorphic Units (km²) $N = 3$													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
2	123,710	–	–	–	–	–	–	–	–	–	–	1	21,260
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	–	–	–	–	–	–	–	–	–	–	–	–

Notes:

- This bioregion is the 5th largest bioregion of the IMCRA shelf bioregions.
- Class 1 includes units defined by the distribution and abundance of pinnacles, banks, and sand banks.
- This bioregion contains the 4th largest area of Class 1 units and 6th largest area of Class 7 units of all the IMCRA shelf bioregions.
- This bioregion is one of six IMCRA shelf bioregions that contain two classes of geomorphic units.



Geomorphic Units in PB32 – Great Australian Bight IMCRA Transition.

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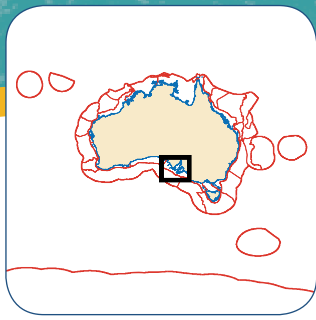
PB33 – Spencer Gulf IMCRA Province

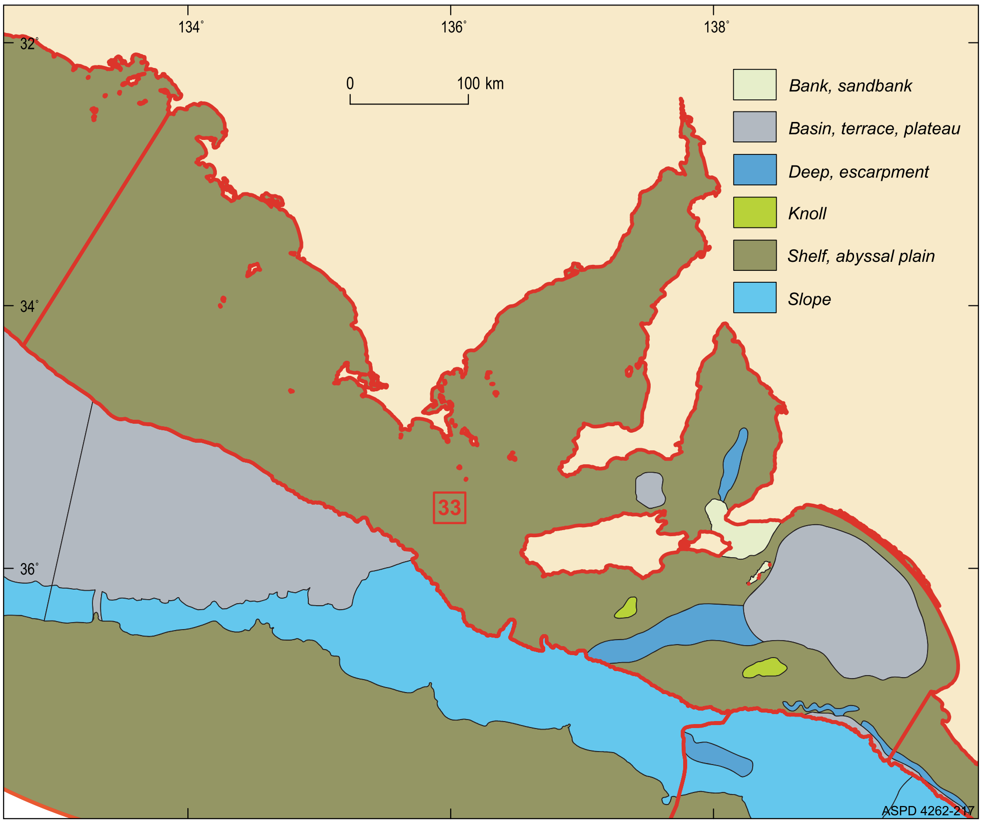


Total Area	Water Depth (m)			
(km^2)	Minimum	Maximum	Mean	Std Dev.
132,860	0	-603	-60	50

Geomorphic Units (km^2) *N* = 13													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
2	115,340	–	–	–	–	–	–	–	–	–	–	3	11,940
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
2	510	–	–	–	–	2	1,370	4	3,700	–	–	–	–

Notes:

- This bioregion is the 6th largest bioregion of the IMCRA shelf bioregions.
- Class 1 includes units defined by the distribution and abundance of pinnacles, banks, and sand banks.
- This bioregion is one of four IMCRA shelf bioregions to contain five classes of geomorphic units.



Geomorphic Units in PB33 – Gulf IMCRA Province.

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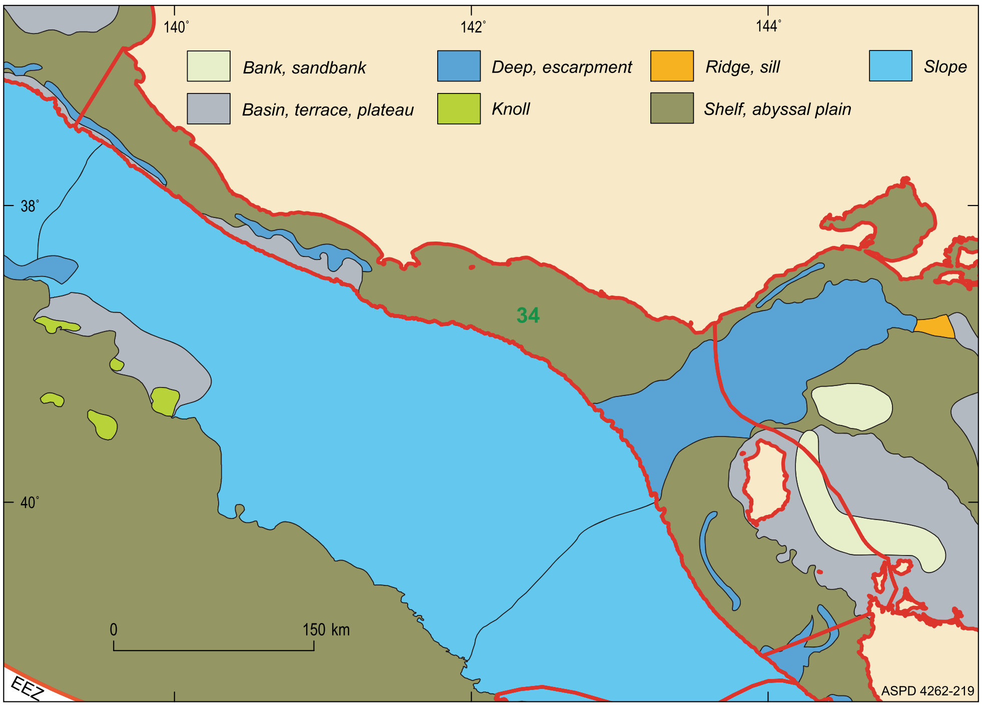
PB34 – Western Bass Strait IMCRA Transition

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
37,130	0	-272	-75	45

Geomorphic Units (km²) *N* = 15													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
3	24,880	–	–	–	–	–	–	–	–	–	–	4	5,080
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	–	–	–	–	1	1,430	7	5,740	–	–	–	–

Notes:

- This bioregion is the 11th largest bioregion of the IMCRA shelf bioregions.
- This is one of four IMCRA shelf bioregions to contain four classes of geomorphic units.
- This bioregion contains the 5th largest area of Class 1 units of all the IMCRA shelf bioregions.



Geomorphic Units in PB34 – Western Bass Strait IMCRA Transition.

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PB35 – Bass Strait IMCRA Province

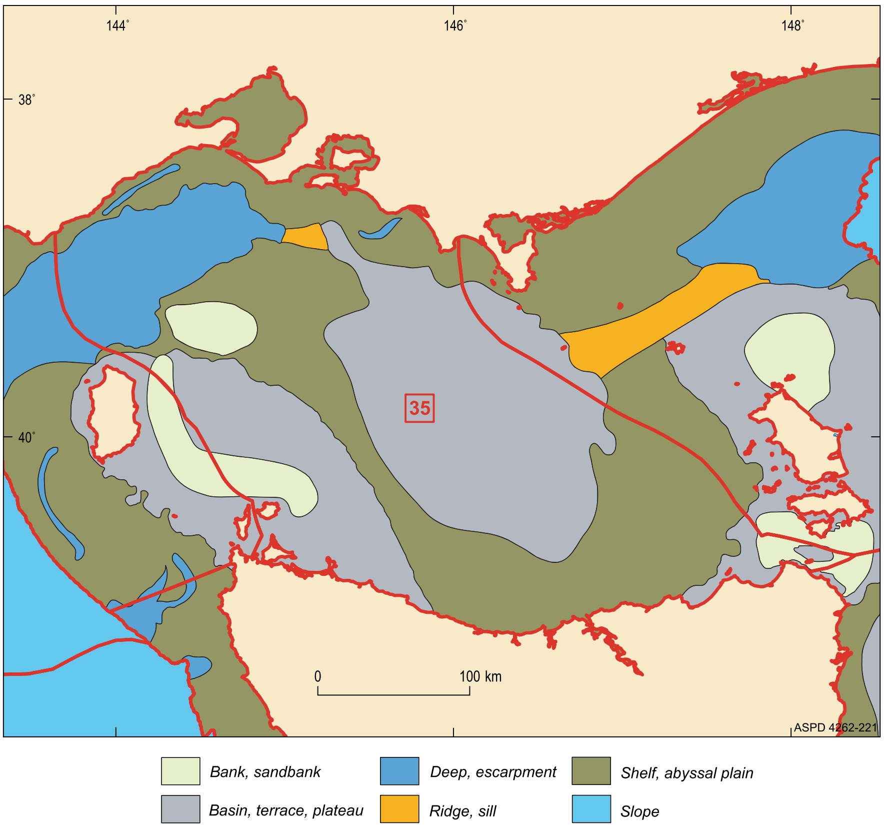
Total Area	Water Depth (m)			
(km^2)	Minimum	Maximum	Mean	Std Dev.
96,670	0	-90	-61	23

Geomorphic Units (km^2) $N = 18$

CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
2	27,600	–	–	–	–	1	280	–	–	–	–	8	26,410
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	–	–	–	–	4	3,180	3	7,110	–	–	–	–

Notes:

- This bioregion is the 8th largest bioregion of the IMCRA shelf bioregions.
- This bioregion contains the 5th largest area of Class 7 and 4th largest Class 12 units of all the IMCRA shelf bioregions.
- This bioregion is one of four IMCRA shelf bioregions to contain five classes of geomorphic units.



Geomorphic Units in PB35 – Bass IMCRA Province.

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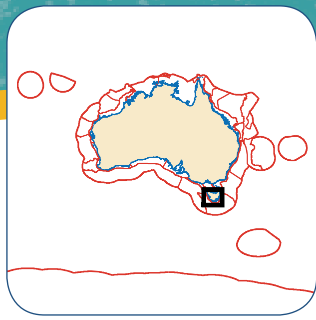
PB36 – Tasmanian IMCRA Province

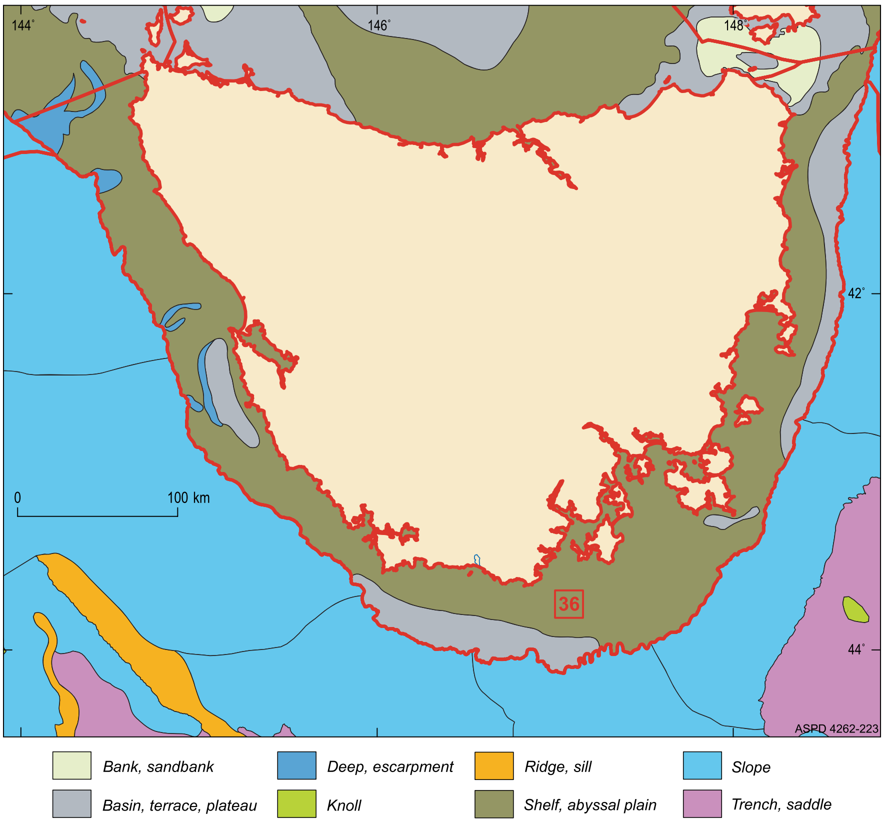


Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
59,300	0	-834	-97	62

Geomorphic Units (km²) *N* = 17													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
3	24,935	–	–	–	–	–	–	–	–	–	–	7	5,770
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	–	–	–	–	2	370	5	1,030	–	–	–	–

Notes:

- This bioregion is the 14th largest bioregion of the IMCRA shelf bioregions.
- This bioregion contains the deepest seabed habitats and is the deepest bioregion on average of all the IMCRA shelf bioregions.
- This bioregion is one of four IMCRA shelf bioregions to contain four classes of geomorphic units.



Geomorphic Units in PB36 – Tasmania IMCRA Province.

For further information, please contact:

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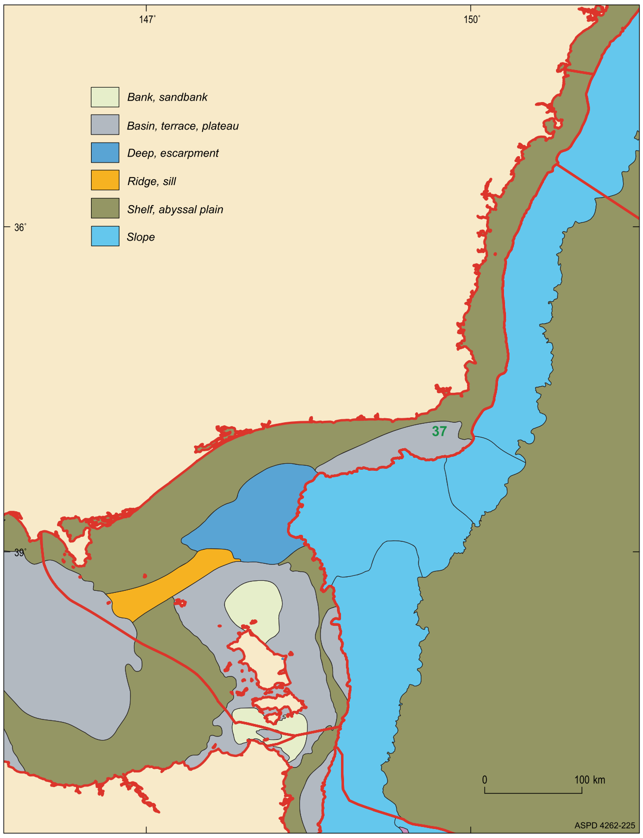
PB37 – Southeast IMCRA Transition

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
175,540	0	-359	-64	50

Geomorphic Units (km²) *N* = 13													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
4	31,240	–	–	–	–	1	2,510	–	–	–	–	5	16,370
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	–	–	–	–	2	2,970	1	6,210	–	–	–	–



Notes:

- This bioregion is the 10th largest bioregion of the IMCRA shelf bioregions.
- This bioregion is one of four IMCRA shelf bioregions to contain five classes of geomorphic units.
- This bioregion contains the 3rd largest Class 4 unit, 4th largest Class 11 unit and 5th largest Class 12 unit of all the IMCRA shelf bioregions.

Geomorphic Units in PB37 – Southeast IMCRA Transition.

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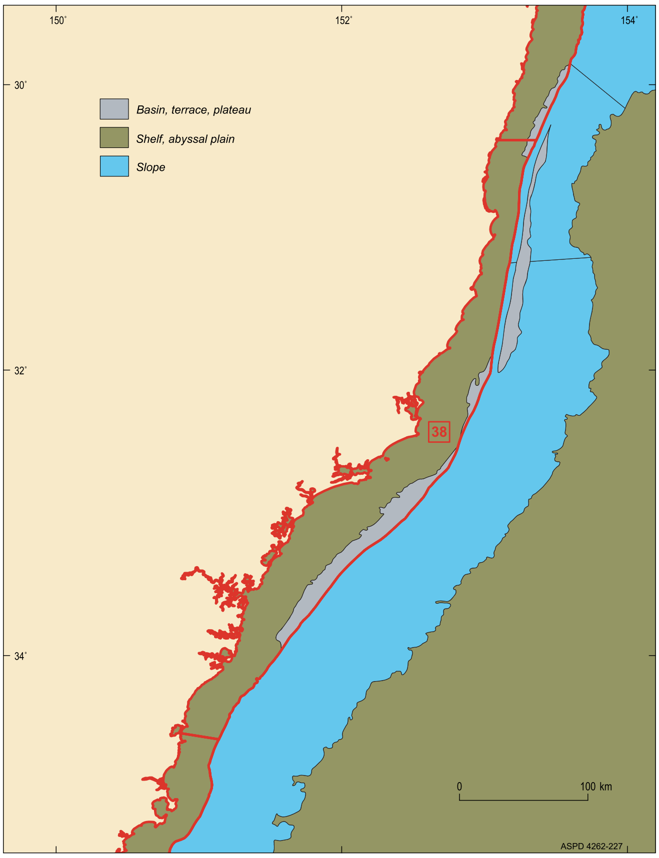
PB38 – Central Eastern IMCRA Province

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
36,180	0	-181	-83	44

Geomorphic Units (km²) *N* = 4													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
1	15,230	–	–	–	–	–	–	–	–	–	–	3	2,310
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
–	–	–	–	–	–	–	–	–	–	–	–	–	–



Notes:

- This bioregion is the 2nd smallest bioregion of the IMCRA shelf bioregions.
- This bioregion is the second deepest on average of all the IMCRA shelf bioregions.
- This bioregion is one of six IMCRA shelf bioregions that contains two classes of geomorphic units.

Geomorphic Units in PB38 – Central Eastern IMCRA Province.

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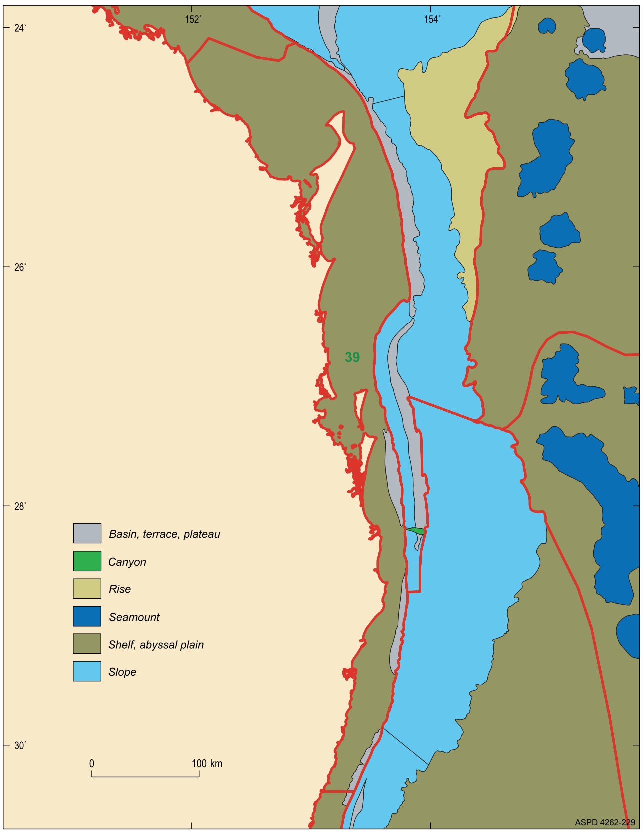
PB39 – Central Eastern IMCRA Transition

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
170,990	0	-114	-31	33

Geomorphic Units (km²) *N* = 4													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
1	34,590	–	–	–	–	–	–	–	–	–	–	3	1,590
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	–	–	–	–	–	–	–	–	–	–	–	–



Geomorphic Units in PB39 – Central Eastern IMCRA Transition.

Notes:

- This bioregion is the 12th largest bioregion of the IMCRA shelf bioregions.
- This bioregion is the shallowest on average of all the IMCRA shelf bioregions.
- Class 1 includes units defined by the distribution and abundance of pinnacles, banks, and sand banks.
- This bioregion is one of six IMCRA shelf bioregions to contain two classes of geomorphic units.

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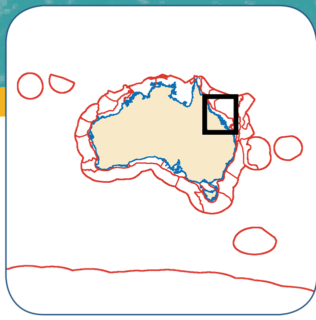
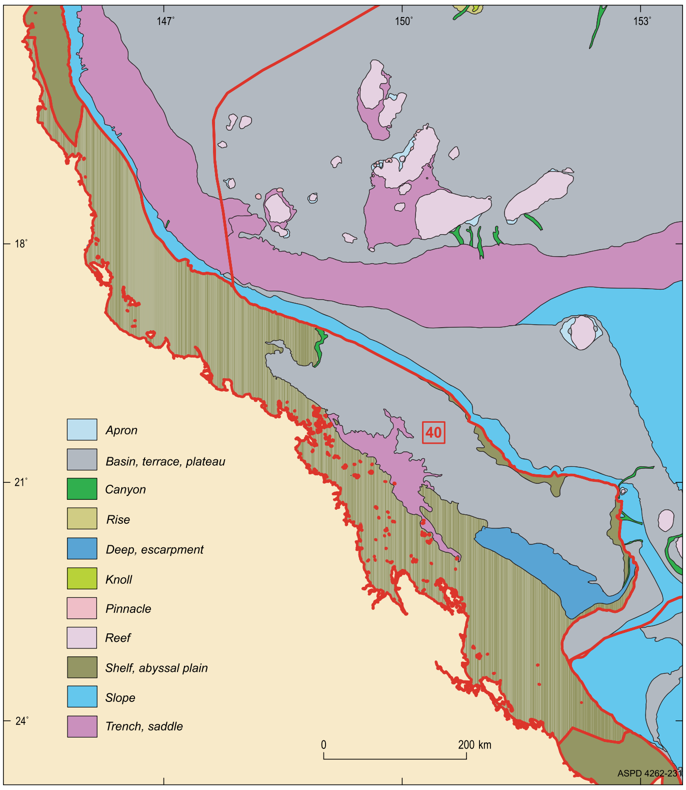
PB40 – Northeast IMCRA Province



Total Area	Water Depth (m)			
(km^2)	**Minimum**	**Maximum**	**Mean**	**Std Dev.**
95,530	0	-314	-21	29

Geomorphic Units (km^2) N = 11													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
6	107,850	–	–	–	–	–	–	–	–	1	6,810	1	47,700
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	2	380	–	–	–	–	1	8,250	–	–	–	–



Notes:

- This bioregion is the 4th largest of all the IMCRA shelf bioregions.
- Class 1 includes units defined by the distribution and abundance of pinnacles, banks, and sand banks.
- This bioregion is one of four IMCRA shelf bio-regions to contain five classes of geomorphic units.
- This bioregion contains the larges Class 6 unit, 6th largest Class 1 unit, and 3rd largest Class 7 and Class 12 units of all the IMCRA shelf bioregions.
- The bioregion is contains many coral reefs of the Great Barrier Reef.

Geomorphic Units in PB40 – Northeast IMCRA Province.

For further information, please contact:

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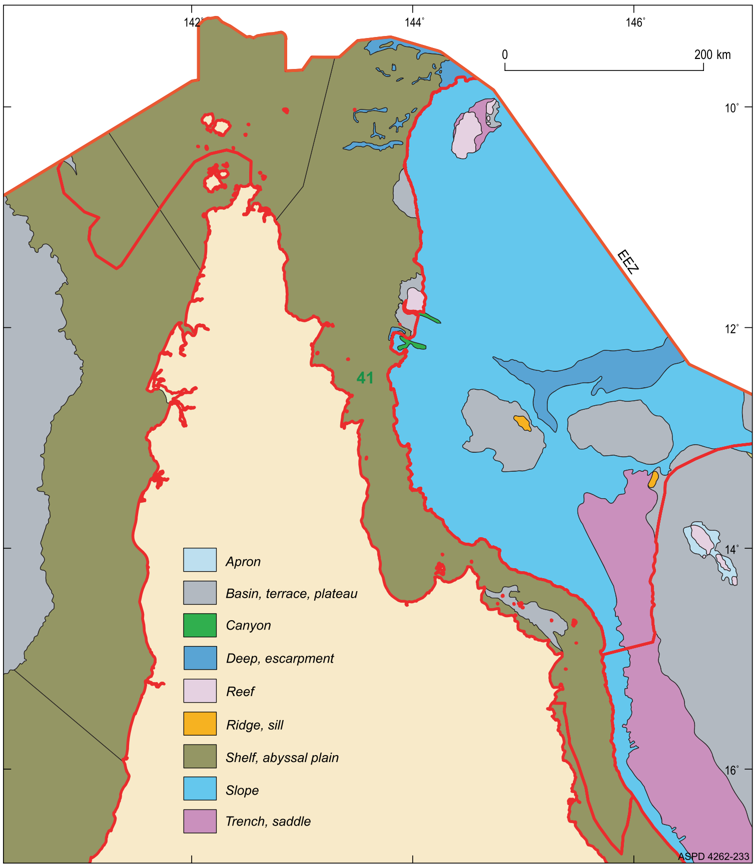
PB41 – Northeast IMCRA Transition

Total Area	Water Depth (m)			
(km²)	Minimum	Maximum	Mean	Std Dev.
75,450	0	1184	-4	15

Geomorphic Units (km²) *N* = 23													
CLASS 1		CLASS 2		CLASS 3		CLASS 4		CLASS 5		CLASS 6		CLASS 7	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
5	90,330	–	–	–	–	–	–	–	–	–	–	5	2,940
CLASS 8		CLASS 9		CLASS 10		CLASS 11		CLASS 12		CLASS 13		CLASS 14	
No.	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**	**No.**	**Area**
–	–	–	–	–	–	–	–	12	1,870	–	–	1	390



Geomorphic Units in PB41 – Northeast IMCRA Transition.

Notes:

- This bioregion is the 7th largest bioregion of the IMCRA shelf bioregions.
- Class 1 includes units defined by the distribution and abundance of pinnacles, banks, and sand banks.
- This bioregion is one of four IMCRA shelf bioregions to contain four classes of geomorphic units.
- The bioregion contains many coral reefs of the Great Barrier Reef.

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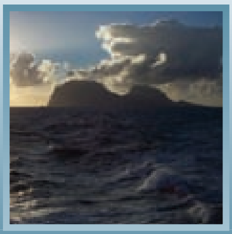



Appendix 4 – Description of the Water Masses (pelagic regionalisation)

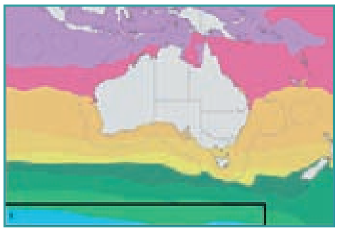
The descriptions contained within this appendix have been sourced from the following report to the National Oceans Office on the development of the Pelagic Regionalisation of Australia.

Lyne, V & Hayes, D, 2005, *Pelagic Regionalisation: National Marine Bioregionalisation Integration Project*. CSIRO Report to the National Oceans Office. CSIRO Marine Research, Hobart.

The information provided details the location and principal features for each of the 23 Water Masses described in the report. Further detail on the derivation of these bodies of water can be found in Lyne & Hayes (2005).

Water Mass 1

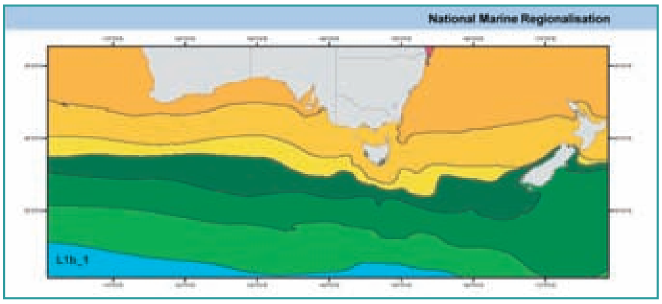
Southern Sub-Antarctic Front



Description: Water Mass 1 lies to the south of the Sub-Antarctic Front. Energetic levels are not as intense as in the sub-Antarctic frontal zone, but nitrate and silicate levels are higher. This level is at the southern extremity of the study region, so some caution is required in our interpretations. In particular, boundary effects may prevent us from seeing the full context and extent of this water mass.

Water Mass 1	Mean	Min	Max	Std. Dev.
Temperature (°C)	1.09	land	2.21	0.53
Salinity	34.04	33.80	34.52	0.15
Oxygen (mm/l)	7.06	4.76	7.95	0.84
Nitrate (mg/l)	27.67	22.62	34.26	2.42
Silicate (mg/l)	32.82	7.60	76.22	13.41

Depth (m):	90	**Longitude (°E):**	115.2
Latitude (°S):	-57.4	**Volume (km^3/106):**	0.57



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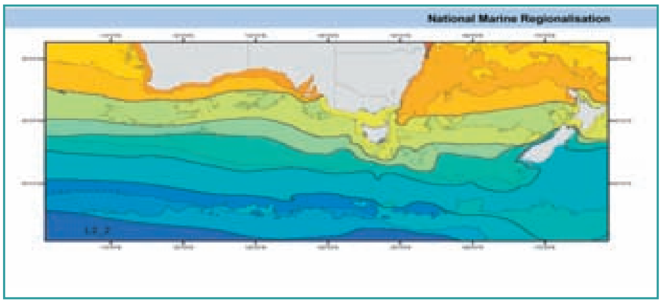

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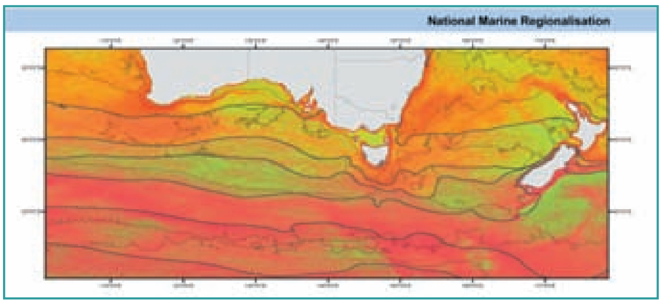

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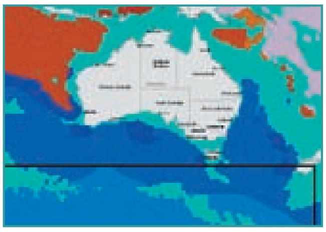
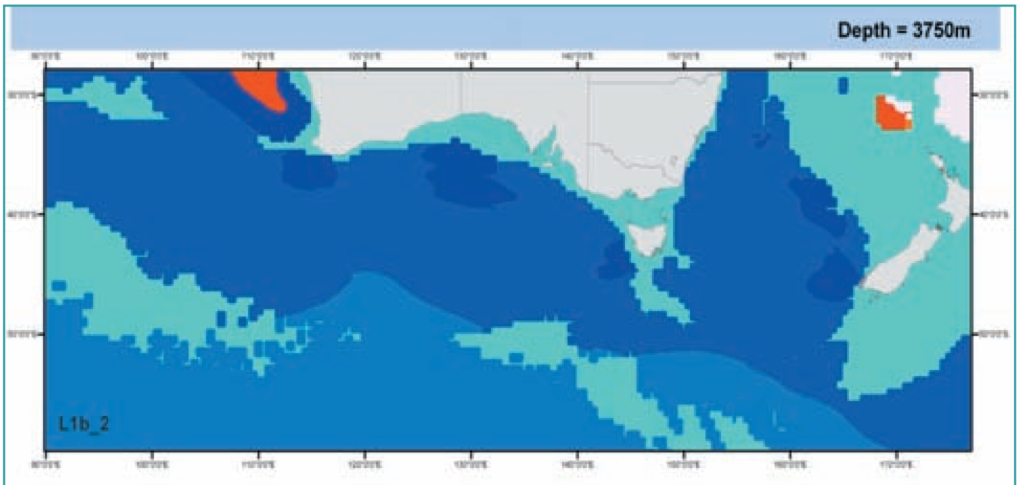
Water Mass 2

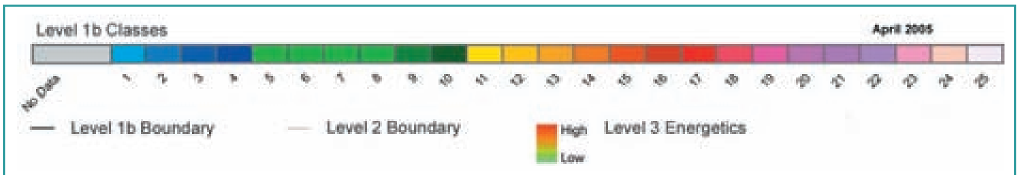


Description: A large body of deep water comprising over 12 million cubic kilometres in the study region. Antarctic deep water is restricted in its northward excursion by the sub-Antarctic ridge system, although there is some "leakage" into the South Australian Basin south of the Great Australian Bight.

Water Mass 2	Mean	Min.	Max.	Std Dev.
Temperature (ºC)	0.53	land	1.67	0.35
Salinity	34.70	34.44	34.72	0.02
Oxygen (mm/l)	5.01	4.46	5.79	0.21
Nitrate (mg/l)	32.05	25.04	38.30	1.59
Silicate (mg/l)	120.59	53.15	138.63	7.09

Depth (m):	3750	**Longitude (°E):**	123.4
Latitude (°S):	-55.5	**Volume (km^3/106):**	12.45





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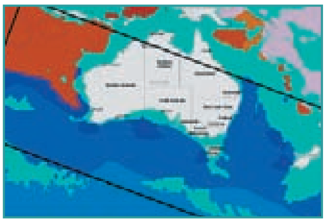
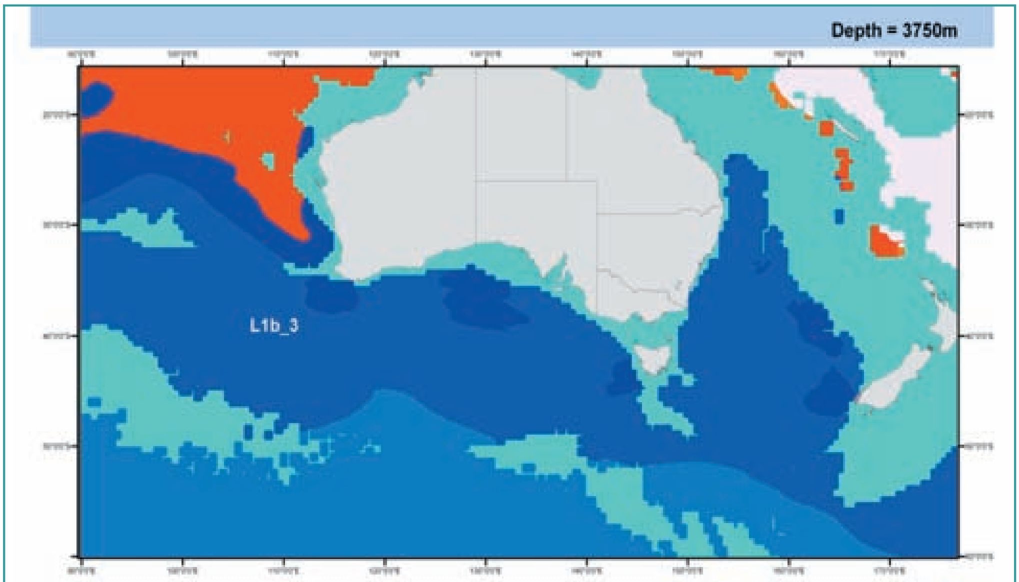
Water Mass 3

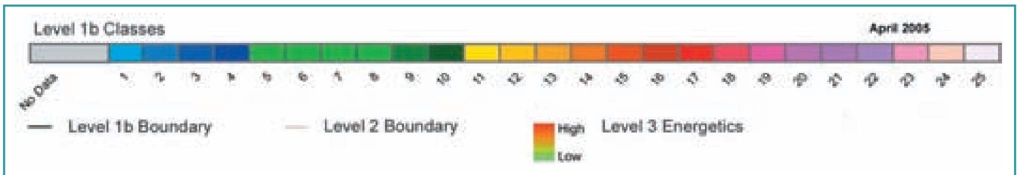


Description: This is the largest body of deep water in the study region. It is located in shallower depth to the east but gradually deepens to the north and to the west. In the Pacific, its northward excursion is limited by the confines of the Tasman Abyssal Plain, while in the Indian Ocean it infiltrates further north at depth.

Water Mass 3	Mean	Min.	Max.	Std Dev.
Temperature (ºC)	1.17	0.65	1.75	0.16
Salinity	34.72	34.70	34.76	0.01
Oxygen (mm/l)	4.65	4.36	4.95	0.11
Nitrate (mg/l)	32.49	25.55	38.16	1.87
Silicate (mg/l)	114.48	83.96	141.95	10.18

Depth (m):	3750	**Longitude (°E):**	119.6
Latitude (°S):	-44.4	**Volume (km³/106):**	22.71





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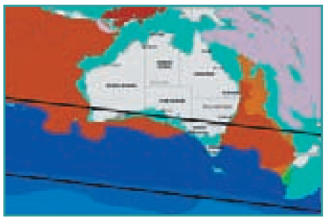
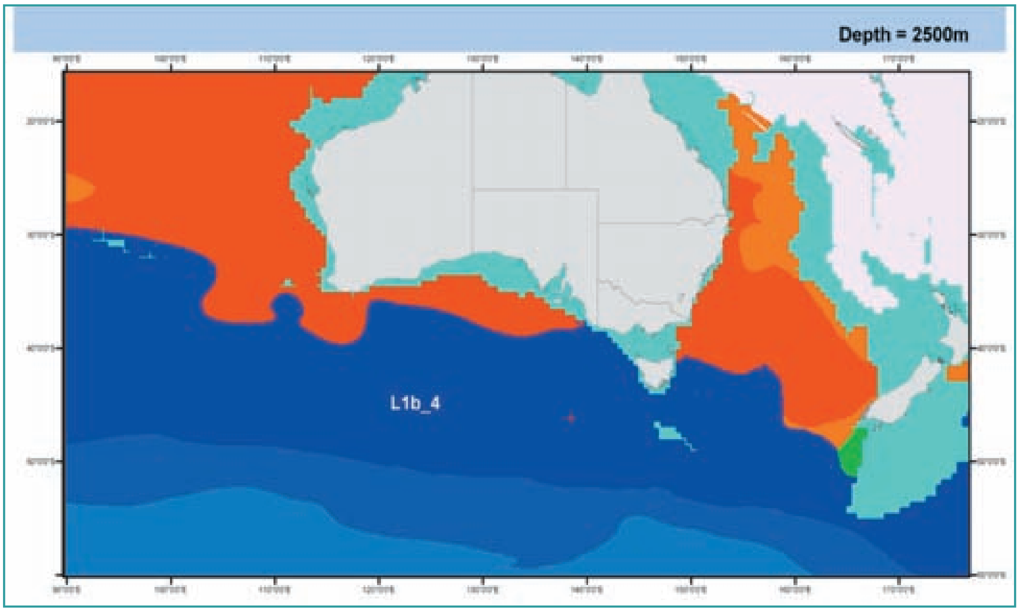
Water Mass 4

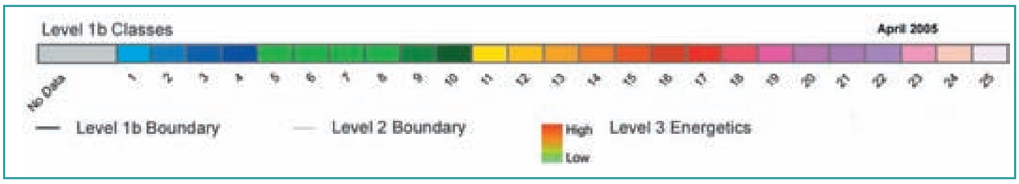
Description: A large body of deep Antarctic bottom water that appears to the north of and shallower than, the extensive Water Mass 3 unit. It has a similar distribution and limits to Water Mass 3.



Water Mass 4	Mean	Min	Max	Std. Dev.
Temperature (ºC)	1.73	0.95	2.35	0.27
Salinity	34.74	34.68	34.77	0.01
Oxygen (mm/l)	4.43	4.01	4.73	0.12
Nitrate (mg/l)	32.05	25.99	40.36	1.96
Silicate (mg/l)	96.54	70.90	144.66	13.77

Depth (m):	2500	**Longitude (°E):**	121.8
Latitude (°S):	-48.8	**Volume (km³/106):**	18.05





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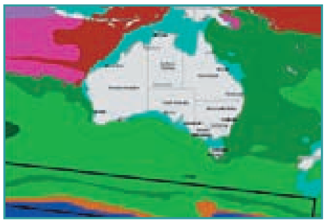
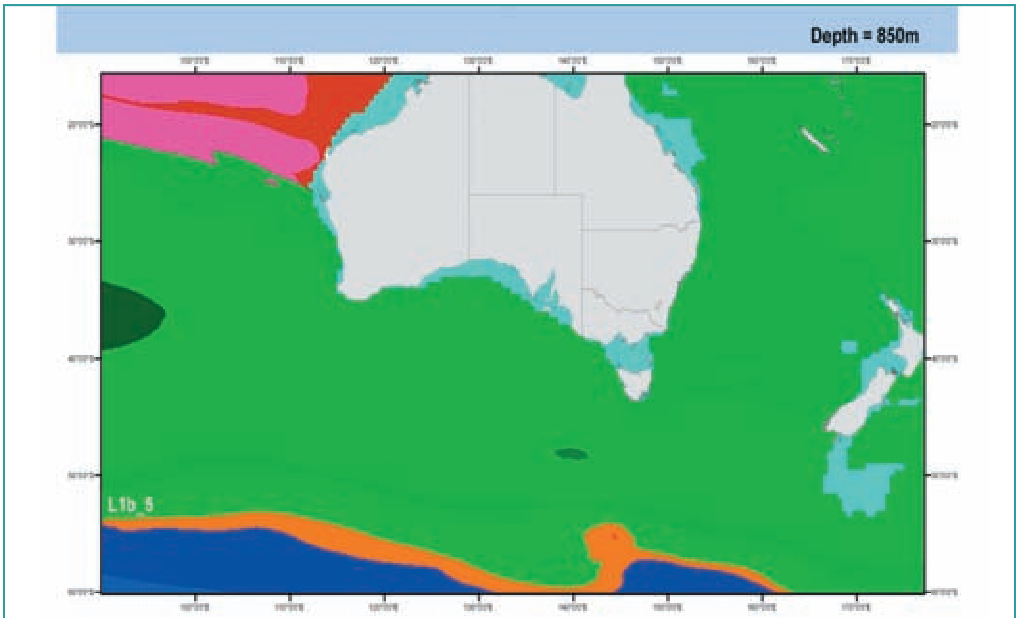
Water Mass 5

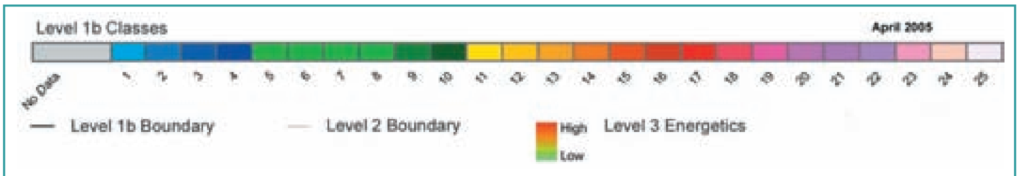


Description: This is an intermediate-depth water mass. It intrudes into the study region at a depth of about 200 m and at its maximum extent occupies the entire South Australian Basin at a depth of about 1600 m.

Water Mass 5	Mean	Min.	Max.	Std Dev.
Temperature (ºC)	2.24	1.15	9.78	0.65
Salinity	34.63	34.40	34.72	0.06
Oxygen (mm/l)	4.18	3.74	4.60	0.12
Nitrate (mg/l)	32.73	14.22	41.38	1.84
Silicate (mg/l)	74.81	8.59	118.90	8.18

Depth (m):	850	**Longitude (°E):**	127.8
Latitude (°S):	-54.5	**Volume (km^3/106):**	5.81





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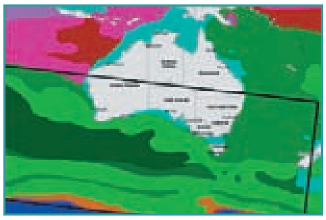
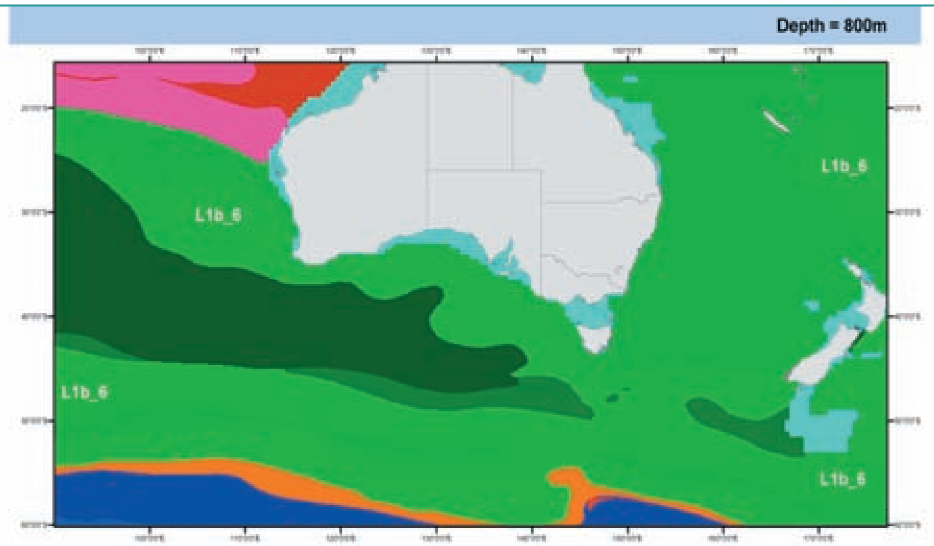
Water Mass 6

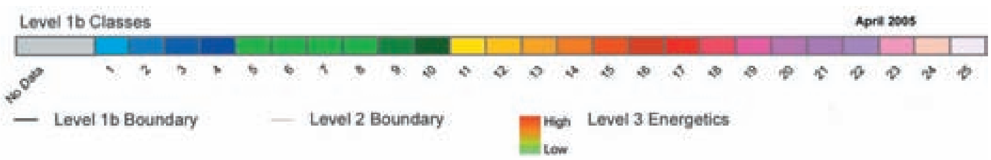


Description: Part of the Antarctic Intermediate Water that appears in the study region at about 150 m and migrates northward with depth until it fills the southern portion of the study region at about 850 m depth. Its maximum depth is about 1400 m. An apparent bifurcation of the water mass at about 600–700 m suggests that different sources or circulation pathways may be operating.

Water Mass 6	Mean	Min.	Max.	Std Dev.
Temperature (ºC)	4.47	0.83	8.70	1.72
Salinity	34.41	34.15	34.62	0.07
Oxygen (mm/l)	4.74	4.31	5.67	0.24
Nitrate (mg/l)	29.94	15.73	38.09	3.10
Silicate (mg/l)	35.77	8.97	78.54	14.66

Depth (m):	800	**Longitude (°E):**	133.2
Latitude (°S):	-47.2	**Volume (km³/106):**	6.60





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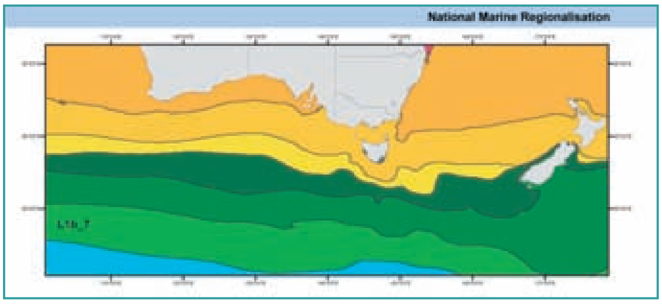
Water Mass 7

Description: Water Mass 7 lies to the south of the sub-Antarctic frontal zone. It is a region of strong energetics, very high nutrients, and low salinity and temperature.

Water Mass 7	Mean	Min	Max	Std. Dev.
Temperature (°C)	3.46	1.72	5.90	0.96
Salinity	33.99	33.80	34.37	0.11
Oxygen (mm/l)	6.97	5.19	7.78	0.54
Nitrate (mg/l)	24.24	15.70	33.00	2.71
Silicate (mg/l)	14.02	0.82	54.29	8.67

Depth (m):	80	**Longitude (°E):**	131
Latitude (°S):	-53.7	**Volume (km³/106):**	0.93



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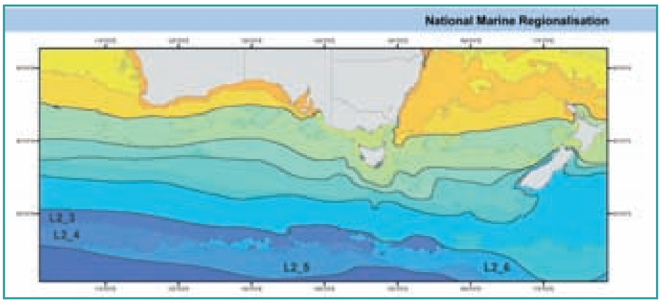

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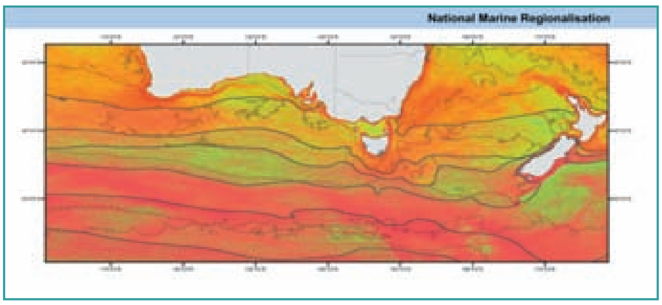
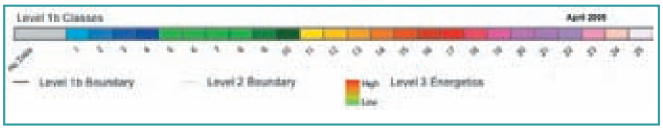


Level 3



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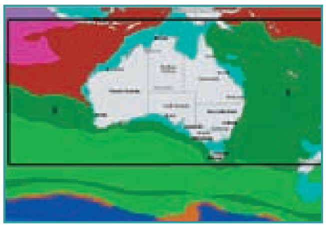
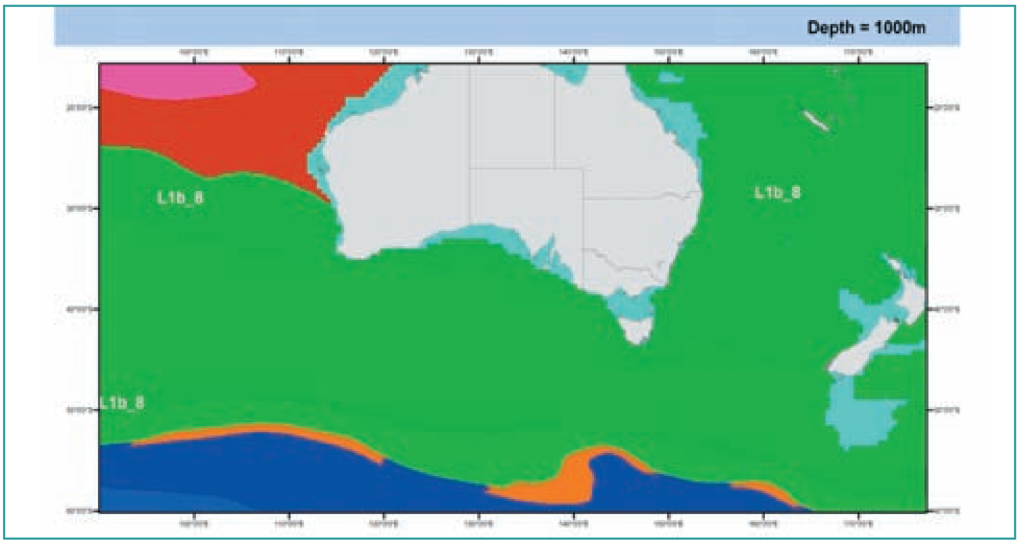
Water Mass 8

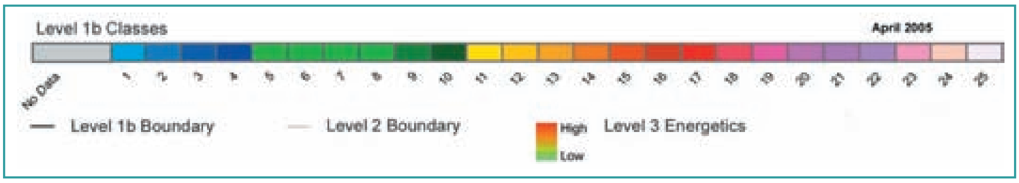


Description: A large body of water that is part of the Antarctic Intermediate Water (located beneath Water Mass 6), with a complex distribution. It appears in the study region in the northern Pacific at about 500 m depth. With increasing depth, it expands to fill the Pacific at about 650 m, with a narrow frontal band extending off towards Africa from about North-West Cape in Western Australia. It shifts southwards with depth, contracts and then disappears at about 1600 m depth.

Water Mass 8	Mean	Min.	Max.	Std Dev.
Temperature (ºC)	4.72	1.93	9.94	1.77
Salinity	34.50	34.38	34.72	0.06
Oxygen (mm/l)	4.08	3.36	4.64	0.26
Nitrate (mg/l)	31.61	14.55	41.54	4.15
Silicate (mg/l)	48.16	land	100.06	20.24

Depth (m):	1000	**Longitude (°E):**	156.7
Latitude (°S):	-33.4	**Volume (km^3/106):**	13.70





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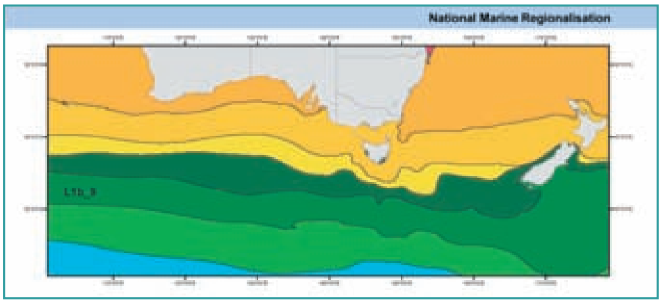
Water Mass 9

Sub-Antarctic Front

Description: This region is the Sub-Antarctic Front, which separates the Subtropical Convergence zone in the north from sub-Antarctic water masses to the south. The water mass is aligned with a current system whose magnitude and direction can be clearly visualised in Appendix G (Figure G-4) and which corresponds closely with the region of higher energy in the Level 3 map. The strong and pervasive energetics in this region reflect the mixing processes of a sub-Antarctic current interacting with the sub-Antarctic ridge system. Nutrient levels are very high and salinities are relatively low.

Water Mass 9	Mean	Min	Max	Std. Dev.
Temperature (°C)	7.14	4.32	15.31	1.24
Salinity	34.28	33.79	34.53	0.14
Oxygen (mm/l)	6.38	4.90	7.24	0.48
Nitrate (mg/l)	18.59	0.56	32.96	4.47
Silicate (mg/l)	7.65	0.65	38.03	5.51

Depth (m):	100	**Longitude (°E):**	151.7
Latitude (°S):	-49.6	**Volume (km^3/106):**	2.05



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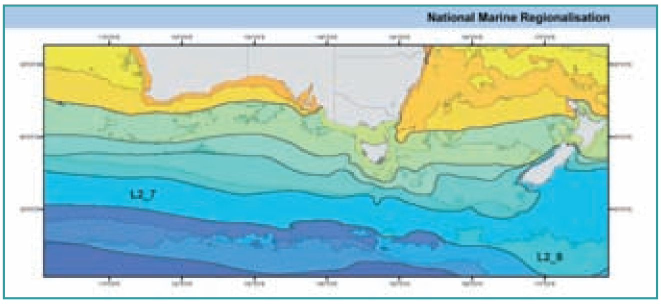

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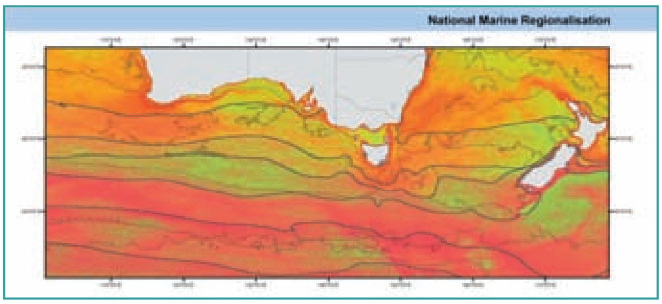
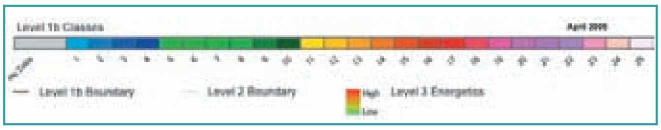


Level 3



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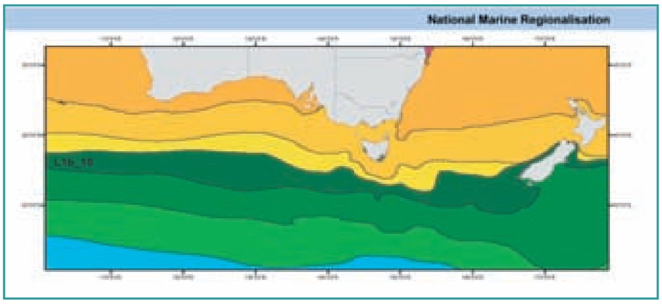
Water Mass 10

Southern Sub-Tropical Convergence

Description: This region, which is bounded to the south by the Sub-Antarctic Front (see Level 2 map adjacent), forms the southern part of the Subtropical Convergence. It is the deepest, largest part of the Subtropical Convergence and has the highest nutrient concentrations, but it otherwise has similar formation dynamics to Water Mass 11 to the north.

Water Mass 10	Mean	Min	Max	Std. Dev.
Temperature (°C)	8.93	5.30	21.99	0.98
Salinity	34.60	34.40	34.73	0.06
Oxygen (mm/l)	5.75	4.45	6.63	0.49
Nitrate (mg/l)	16.22	0.04	28.59	4.82
Silicate (mg/l)	6.90	0.94	32.41	3.81

Depth (m):	400	**Longitude (°E):**	127.5
Latitude (°S):	-44.1	**Volume (km^3/106):**	4.40



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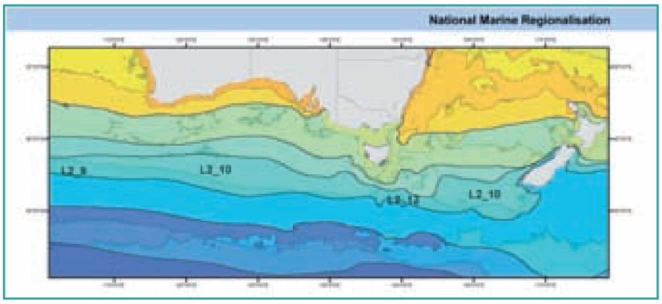

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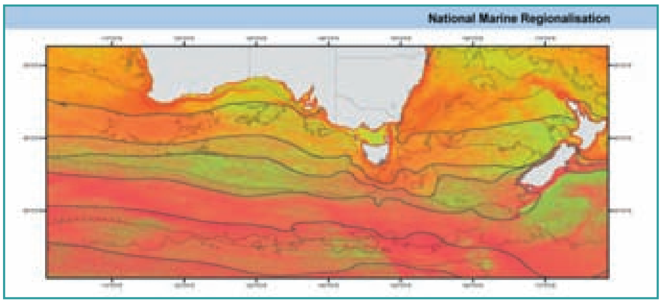

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Water Mass 11

Central Sub-Tropical Convergence

Description: While this water mass appears narrower and less extensive at the surface than Water Mass 12 just to its north, it is a larger and deeper body of water. It is one of the main bodies of waters of the Subtropical Convergence. The Subtropical Front or Subtropical Convergence (Water Mass 11) is the interface between sub-Antarctic and subtropical water masses above 400 m. This dynamically active zone has significant exchange across the boundary and large seasonal variability. It is just to the south of the topographically influenced Water Mass 12 band. Significant mixing processes occur in this band at its eastern end and to the south of Tasmania where it intersects the South Tasman Rise. Nutrient levels are generally high and subject to seasonal drawdowns during phytoplankton blooms in spring and autumn.

Water Mass 11	Mean	Min	Max	Std. Dev.
Temperature (°C)	10.64	8.60	15.47	0.90
Salinity	34.83	34.69	35.08	0.08
Oxygen (mm/l)	5.74	4.36	6.40	0.34
Nitrate (mg/l)	10.63	0.37	24.41	4.05
Silicate (mg/l)	4.27	0.74	20.09	2.00

Depth (m):	250
Latitude (°S):	-40.9
Longitude (°E):	116.5
Volume (km^3/106):	2.59

...continued page 2

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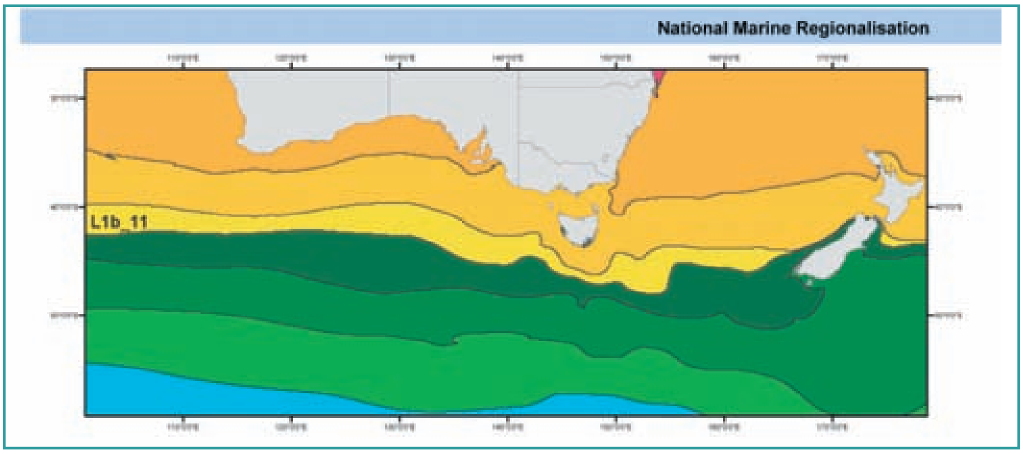

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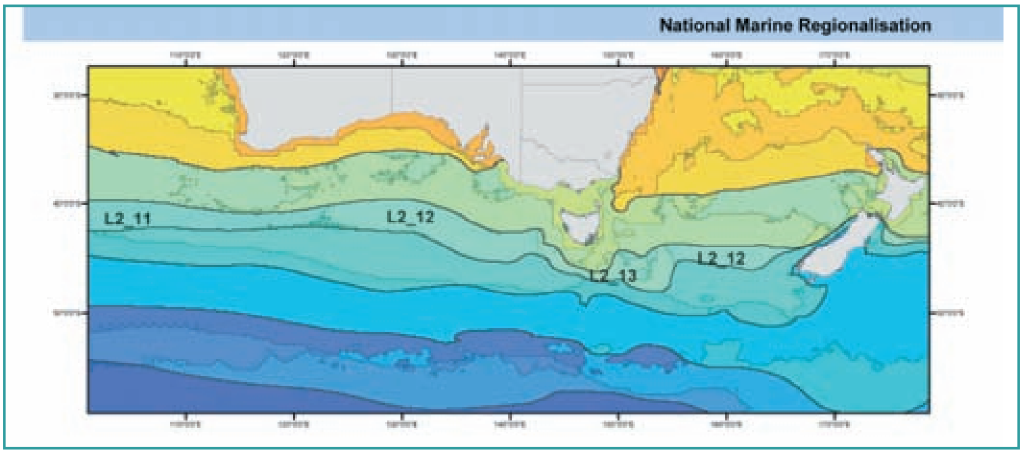

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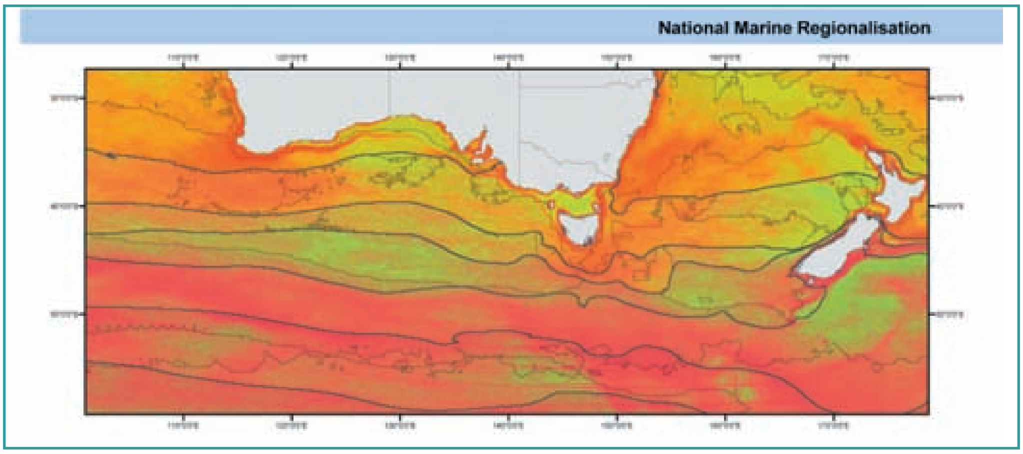
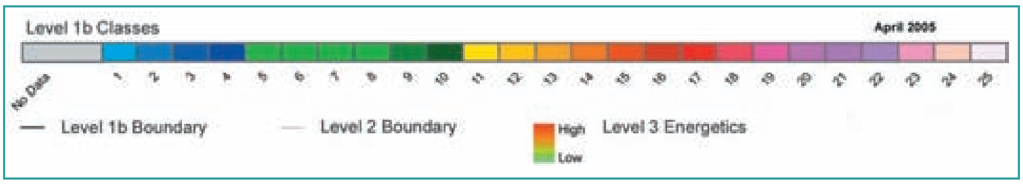
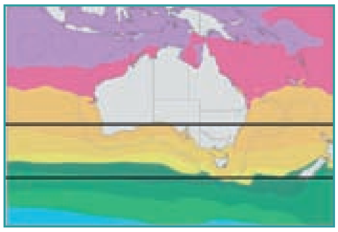


Level 3



Water Mass 12

Northern Sub-Tropical Convergence



Description

Region 1b_12 between Tasmania and New Zealand is part of the Tasman Sea region; it is probably the core of the Tasman Sea. This water is formed and subducted in the Subtropical Convergence and is cooler and fresher than the water north of the Tasman Front. The north-eastward orientation of this water mass in the Tasman Sea suggests that its alignment is under the control of large-scale circulatory processes that deflect the water mass northward, under topographic steering forces, as it approaches New Zealand.

Indian Region and Central Region of 1b_12

The broad structure of this band of water mass is characterised by meanders that, by and large, appear to be influenced by the topography of southern Australia and Tasmania. A narrowing of the band as it approaches Cape Leeuwin is accompanied by increased enegetics (see Level 3 map).

Likewise, as the water mass circulates around Tasmania, energetics increase to the south and east.

The Level 2 structure shows that the substructure consists of a southern band terminating in the mixed region surrounding Tasmania. Part of it continues into the Tasman Sea.

Water Mass 12	Mean	Min	Max	Std. Dev.
Temperature (°C)	13.59	10.06	19.67	1.44
Salinity	35.24	34.74	35.72	0.17
Oxygen (mm/l)	5.58	4.73	6.22	0.27
Nitrate (mg/l)	4.33	0.02	18.80	3.07
Silicate (mg/l)	2.71	0.27	14.17	1.42

Depth (m):	100
Latitude (ºS):	-37.9
Longitude (ºE):	127.5
Volume (km^3/106):	1.95

...continued page 2

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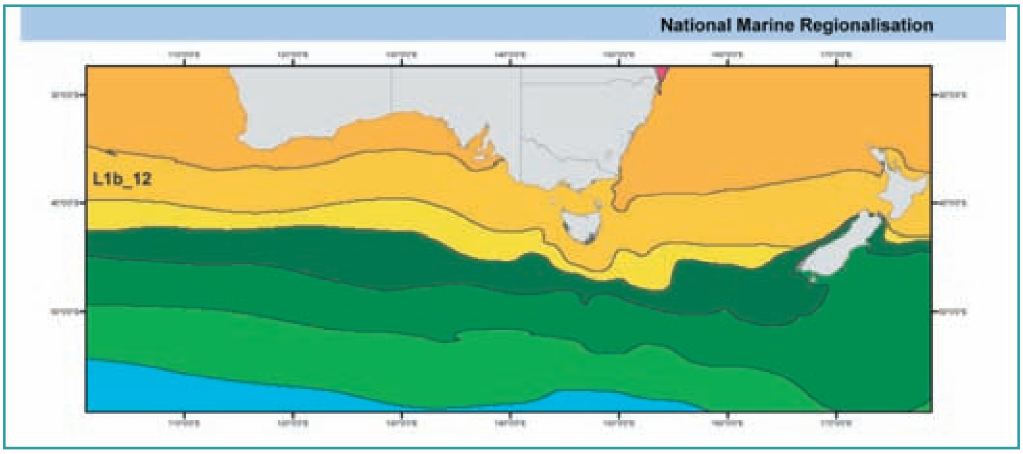

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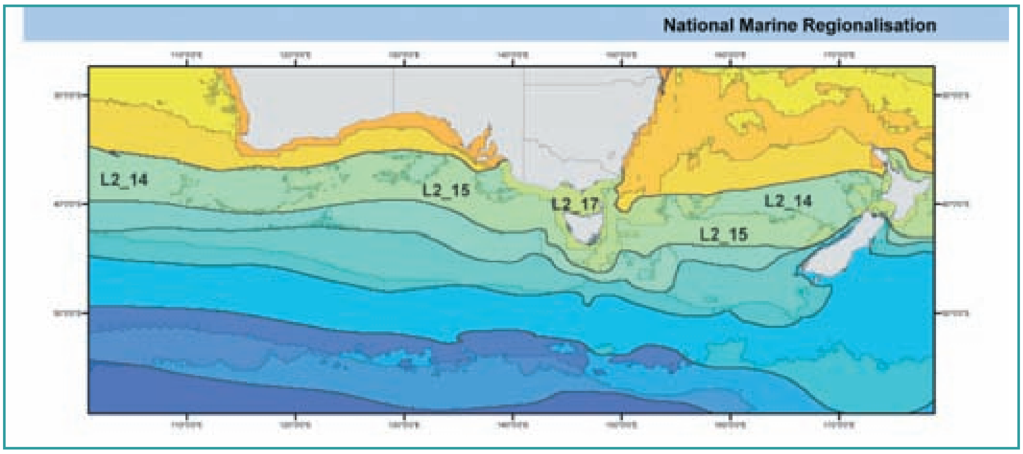
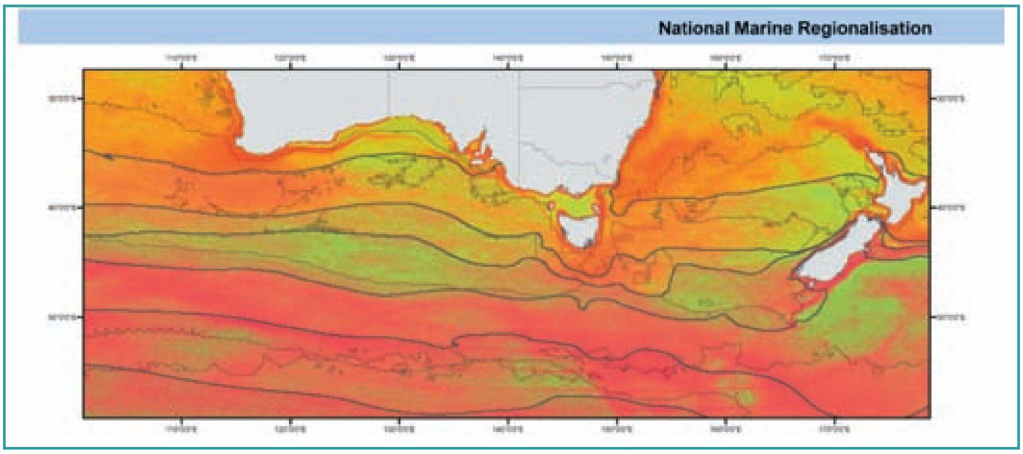


Level 2



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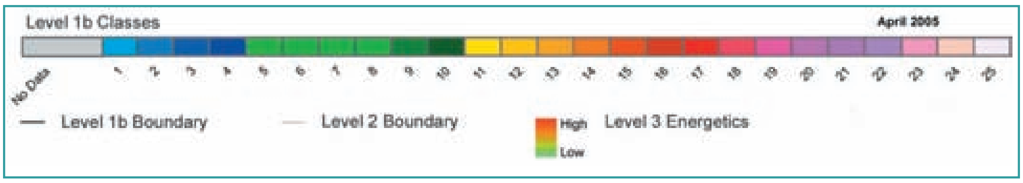
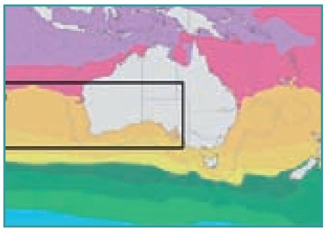


Water Mass I13

Indian Central Region: Indian Central Core Water Mass



Description: A core water body in the Central Indian Ocean that shares the same water properties as the Coral Sea Circulation Region in the Pacific (P13). The seasonal Leeuwin Current, which flows down the west Australian coast from an origin around Shark Bay, suggests there will be seasonal changes in the circulation of this water mass. The bulk of the seasonal eastward drift feeding the Leeuwin Current continues around Cape Leeuwin and floods over the shelf of the Great Australia Bight, ending just to the east of Kangaroo Island in south Australia. The change in direction of the current around Cape Leeuwin coincides with increased eddy activity in the south-west shelf and offshore region of western Australia. This is indicated in the Level 3 energetics map, which also clearly demarcates the offshore edge of this current system.

Near the central Great Australia Bight, the Leeuwin Current appears to dissipate and at the same time a core homogeneous water mass appears at the head of the bight. The extension of the Leeuwin Current reappears to the east of this region.

Water Mass I13	Mean	Min	Max	Std. Dev.
Temperature (°C)	19.15	12.89	26.25	2.50
Salinity	35.64	35.13	37.56	0.14
Oxygen (mm/l)	5.09	4.61	5.95	0.23
Nitrate (mg/l)	1.36	0.00	13.09	1.57
Silicate (mg/l)	2.55	0.31	16.21	1.58

Depth (m):	70
Latitude (°S):	-29.1
Longitude (°E):	153.4
Volume (km^3/106):	1.58

...continued page 2

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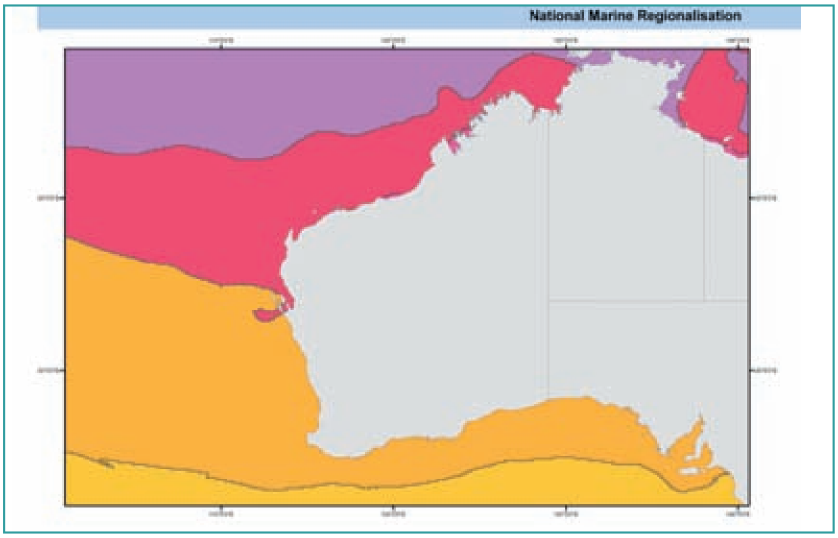

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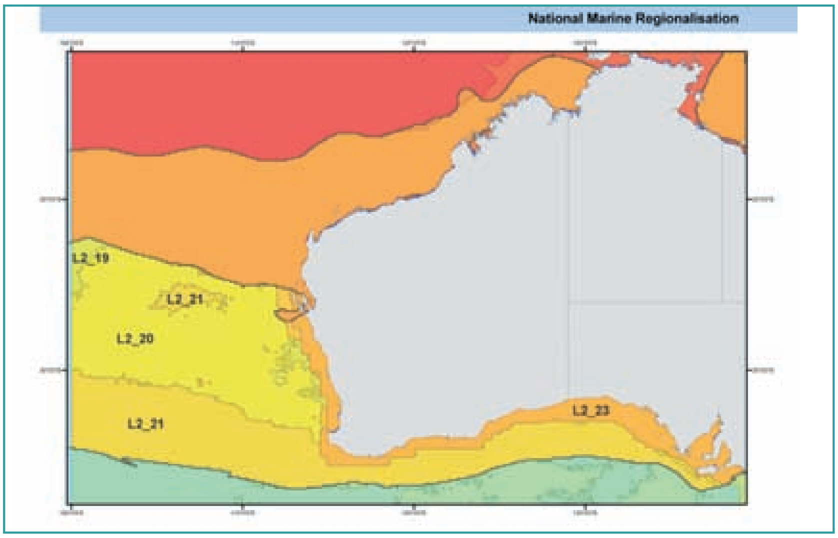

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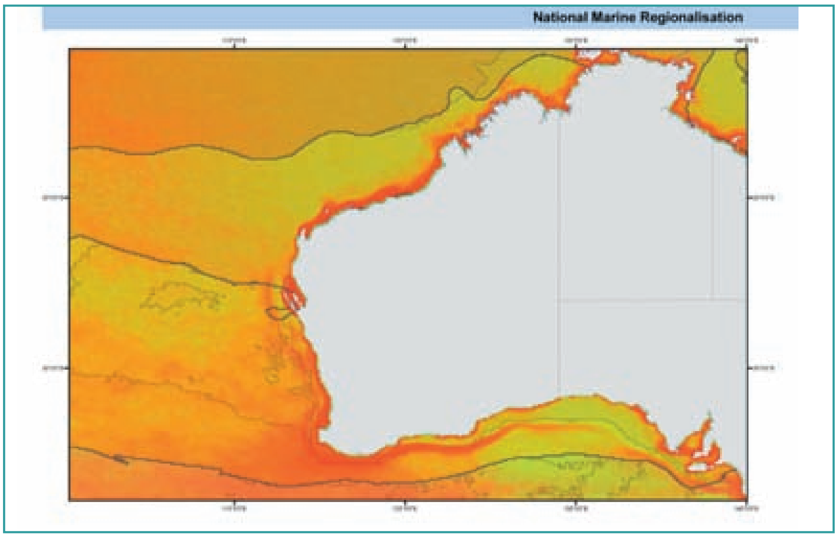

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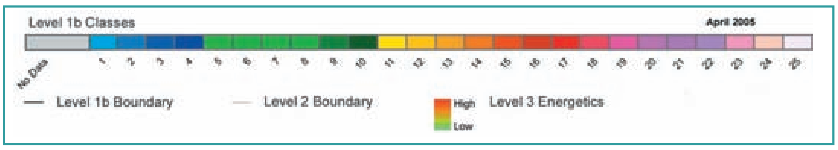
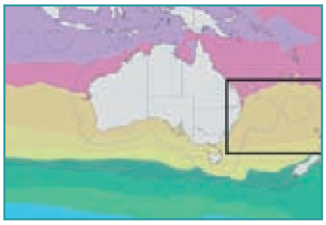


Water Mass P13

Coral Sea Circulation: Pacific Central-South Sub-Tropical Water Mass



Description: The Coral Sea Circulation region contains the East Australian Current waters and associated eddy fields. This current which is the western boundary current in the South Pacific Ocean, leaves the Australian coast at about 34ºS to flow around the northern end of New Zealand and down its east coast (East Auckland Current). The path of the current between Australia and New Zealand is known as the Tasman Front. This front separates the cooler, fresher waters of the Tasman Sea region (L2_21) from the warmer and more saline waters of the Coral Sea region (L2_19).

The presence of these fields can be seen in the Level 2 map adjacent (L2_22). These fields can be further refined by the Level 3 energetics map. The path of the East Australian current down the coast and across the Tasman sea (Tasman Front) can be seen clearly. The lighter shades of red to the south of the Tasman Front represent disturbances that move westward with Rossby speed.

When these reach the Australian coast, they separate from the main current and form eddies, which move southwards. Generally, the meander of the Rossby wave extends southward at the Australian coast, trapping the warmer Coral Sea water. The East Australian Current generally spawns only warm-core eddies (anticyclonic eddies). The eddy field can be seen in the Level 2 map as the southward projection of L2_22 along the east coast of Australia.

Examination of the Level 3 energy maps shows that the eddy fields have higher "energetics" than the East Australian Current – an indication that the core jet of that current is relatively stable (as regards temperature variations), while mixing associated with the current occurs at its offshore edge. Note also that the current interacts strongly with the slope/shelf extending south to Tasmania.

Water Mass P13	Mean	Min	Max	Std. Dev.
Temperature (ºC)	19.15	12.89	26.25	2.50
Salinity	35.64	35.13	37.56	0.14
Oxygen (mm/l)	5.09	4.61	5.95	0.23
Nitrate (mg/l)	1.36	0.00	13.09	1.57
Silicate (mg/l)	2.55	0.31	16.21	1.58

Depth (m):	70	**Longitude (°E):**	153.4
Latitude (°S):	-29.1	**Volume (km^3/106):**	1.58

...continued page 2

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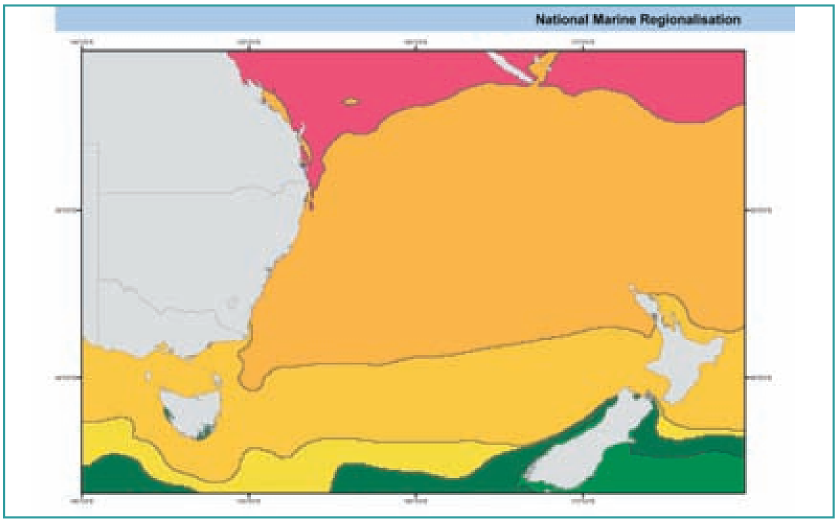

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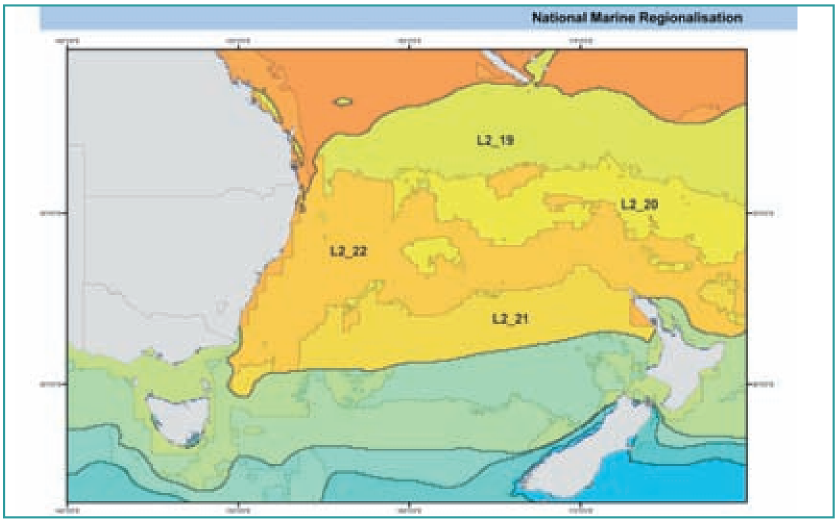
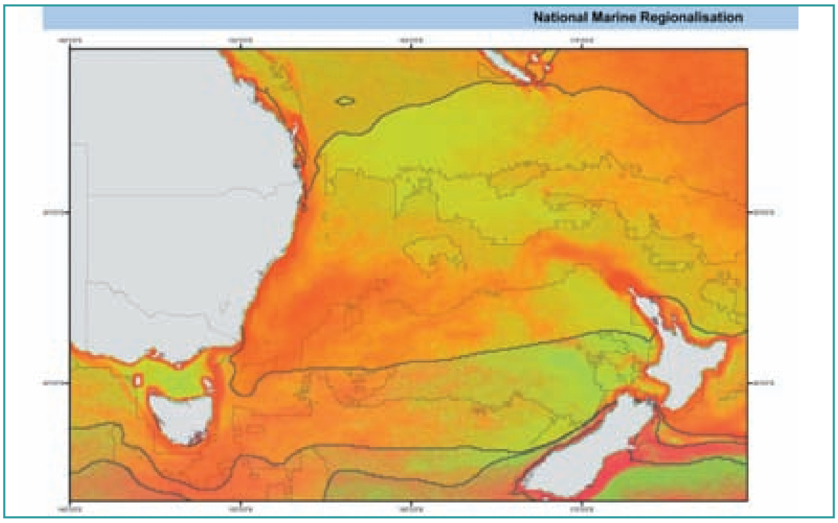


Level 2



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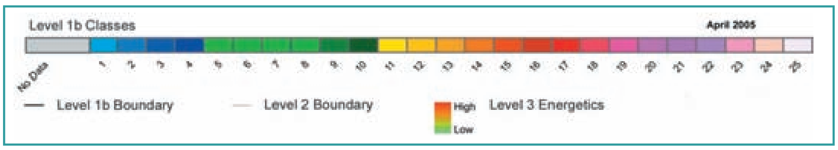
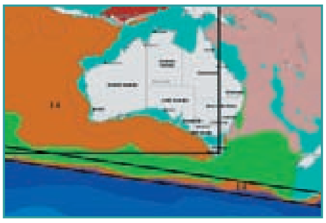


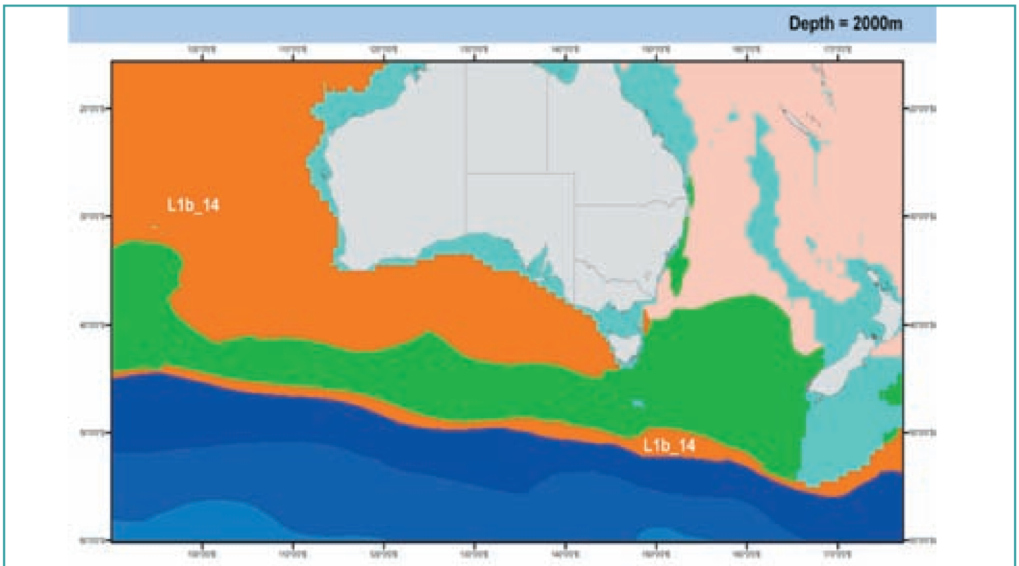
Water Mass 14

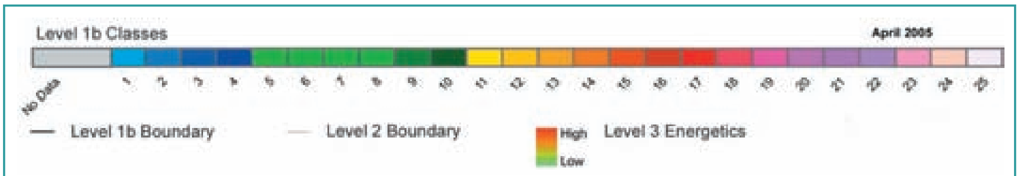


Description: A deep water mass that appears in the study region at about 1100 m depth from the north-eastern corner of the Indian Ocean. It subsequently expands with depth to fill the Indian Ocean at about 1750 m depth. At around 2000 m, it fills the Tasman Abyssal Plain basin in the Pacific and disappears in the north-west corner of the deep Pacific at about 4000 m.

Water Mass 14	Mean	Min.	Max.	Std Dev.
Temperature (ºC)	2.42	1.63	4.48	0.54
Salinity	34.72	34.67	34.85	0.03
Oxygen (mm/l)	3.65	1.96	4.45	0.63
Nitrate (mg/l)	34.03	25.34	41.21	2.05
Silicate (mg/l)	94.72	68.47	141.21	13.49

Depth (m):	2000	**Longitude (°E):**	112
Latitude (°S):	-31	**Volume (km³/106):**	9.08





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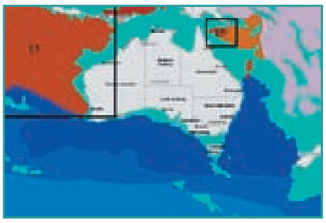
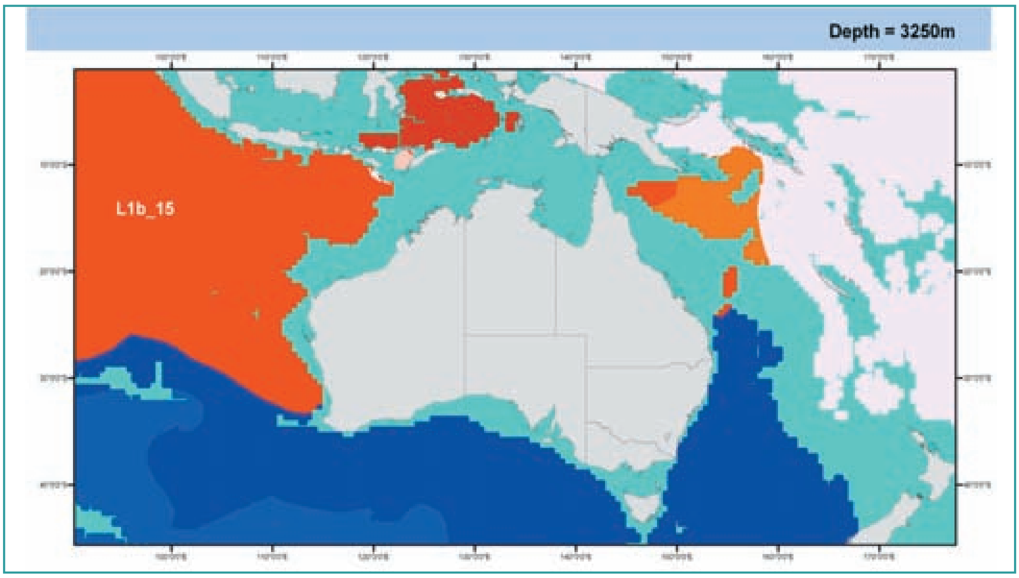
Water Mass 15

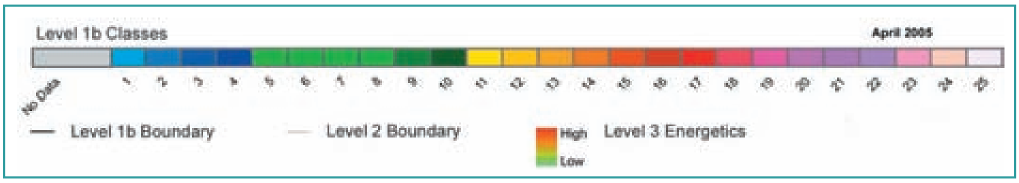


Description: A large body of deep water in the West Australian Basin. It appears in the central band of this basin at about 2000 m depth and extends no deeper than about 2250 m, at which depth it also intrudes into the northern portion of the South Australian Basin. With depth, it contracts to the north and is confined to the extreme north-east corner of the West Australian Basin at 5500 m, the deepest depth of the study area.

Water Mass 15	Mean	Min	Max	Std. Dev.
Temperature (ºC)	1.60	1.09	2.34	0.32
Salinity	34.72	34.68	34.76	0.01
Oxygen (mm/l)	3.99	3.22	4.46	0.26
Nitrate (mg/l)	34.00	24.28	39.56	1.51
Silicate (mg/l)	117.75	71.99	147.96	13.09

Depth (m):	3250	**Longitude (°E):**	105.7
Latitude (°S):	-15.5	**Volume (km^3/106):**	18.76





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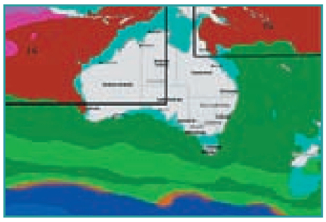
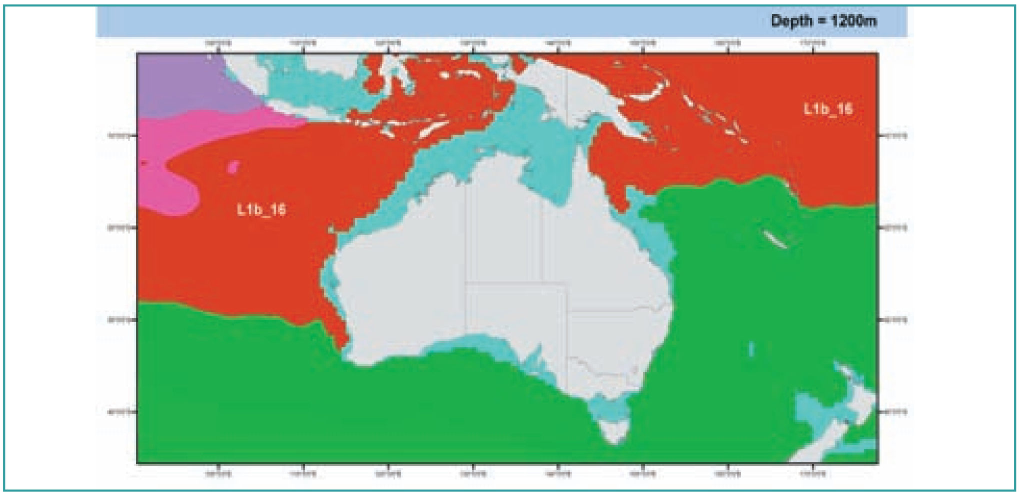
Water Mass 16

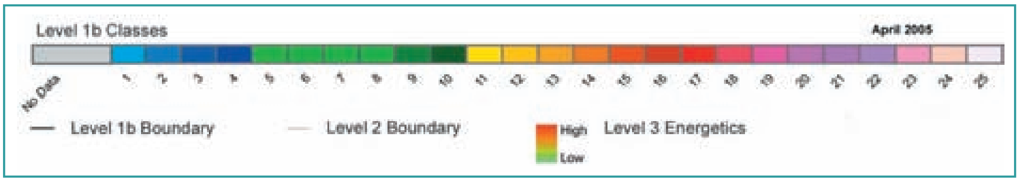
Description: A northern, deep, water mass that appears in the North Pacific and central part of the West Australian Basin at about 600 m. At greater depths, its Pacific distribution expands south. At 850 m this water occupies the eastern portion of the West Australian Basin. At about 1200 m depth, it fills the West Australian Basin except for the far north-western portion, from which it is separated by a strong front. At a depth of 1500 m the water mass is sparsely distributed in the Pacific. A remnant pool remains at the deepest depths in the South Banda Basin between the north-west Australian landmass and Sulawesi.



Water Mass 16	Mean	Min	Max	Std. Dev.
Temperature (ºC)	2.42	1.63	4.48	0.54
Salinity	34.72	34.67	34.85	0.03
Oxygen (mm/l)	3.65	1.96	4.45	0.63
Nitrate (mg/l)	34.03	25.34	41.21	2.05
Silicate (mg/l)	94.72	68.47	141.21	13.49

Depth (m):	1200	**Longitude (°E):**	145.1
Latitude (°S):	-8.9	**Volume (km³/106):**	14.54





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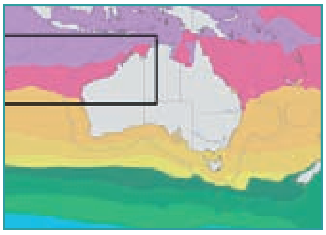
Water Mass I17

Indian Transition: Indian Central Tropical Transition Water Mass



Description: Water Mass I17 has the same water properties as the Coral Sea Region (1b_P17) but occurs as a narrow band extending out from a broad base that originates from about the offshore Kimberley region of Western Australia down to as far south as Shark Bay. The rapid narrowing of the water mass band to the west is an indication that it is entrapped as a transition zone between adjacent core regions. Energy levels increase offshore and to the south and there is an intensified band along the coast that may reflect strong tidal stirring.

Water Mass I17	Mean	Min	Max	Std. Dev.
Temperature (°C)	25.62	10.67	29.41	3.43
Salinity	35.12	34.66	36.04	0.25
Oxygen (mm/l)	4.62	4.07	5.35	0.13
Nitrate (mg/l)	0.92	0.00	17.38	2.08
Silicate (mg/l)	2.56	0.25	16.21	1.69

Depth (m):	50
Latitude (ºS):	-16.5
Longitude (ºE):	157.8
Volume (km^3/106):	1.00

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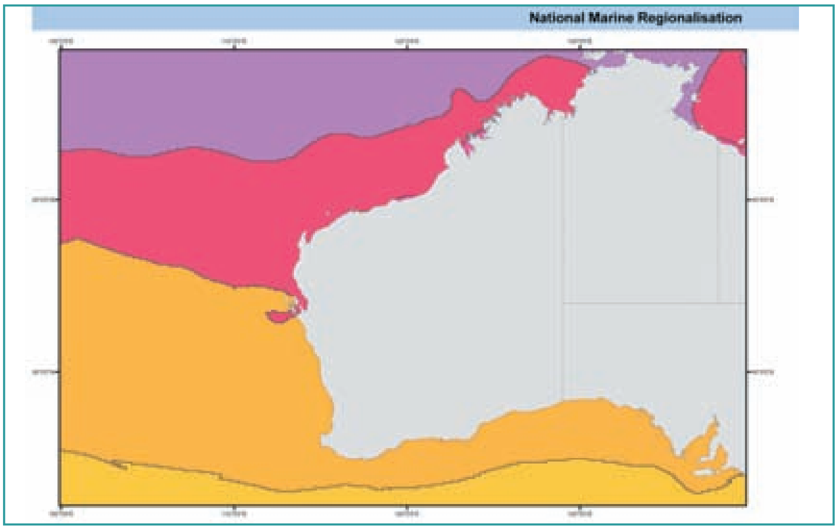

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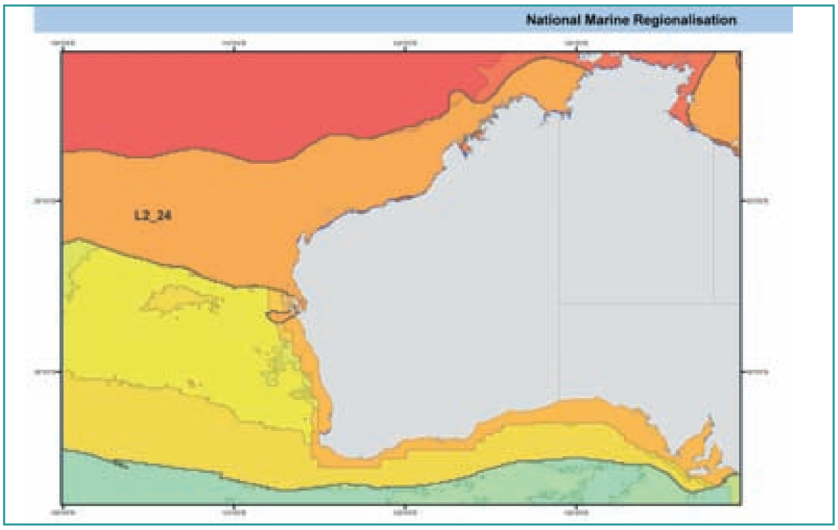

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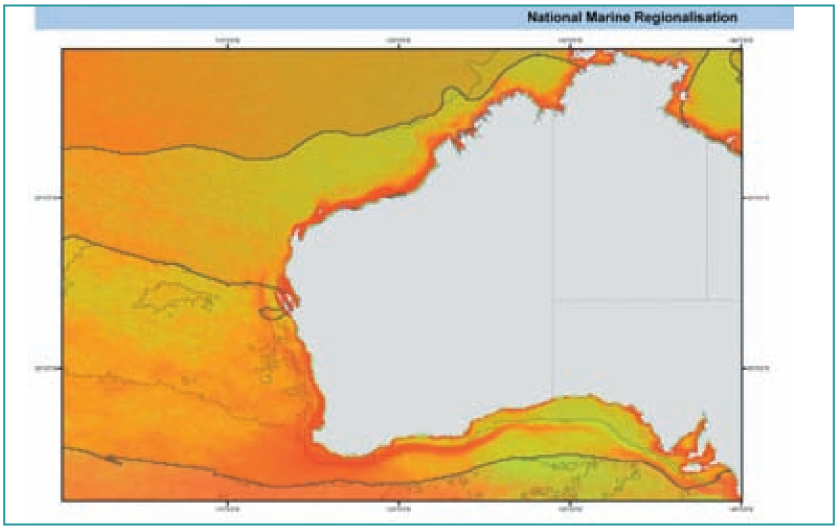

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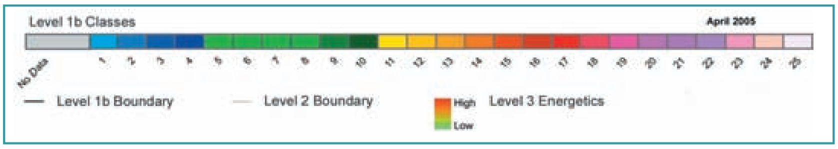
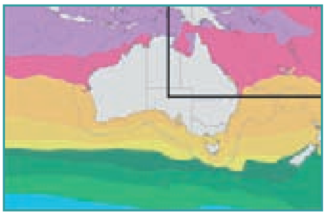


Water Mass P17

Coral Sea: Pacific North-West Tropical Warm Pool



Description: Water Mass P17 is a near-surface layer representing the core of the Coral Sea region in the tropical band of the north-west Pacific to the south of Papua New Guinea. The water here is warmer and more saline than water south of the Tasman Front. The higher salinity is due to convective evaporation when water is transported into the region by way of the Equatorial Current, which splits at the Australian coast. The northward arm feeds into the Solomon Sea and the southern arm becomes the East Australian Current, the western boundary current of the South Pacific Subtropical gyre. Increased energetics in this layer (Level 3 map) occur to the east of the island chain that extends from New Caledonia to Papua New Guinea. An energetic shelf-edge strip occurs offshore of the Great Barrier Reef, presumably associated with the splitting of the Equatorial Current system.

Water Mass 17	Mean	Min	Max	Std. Dev.
Temperature (°C)	25.62	10.67	29.41	3.43
Salinity	35.12	34.66	36.04	0.25
Oxygen (mm/l)	4.62	4.07	5.35	0.13
Nitrate (mg/l)	0.92	0.00	17.38	2.08
Silicate (mg/l)	2.56	0.25	16.21	1.69

Depth (m):	50
Latitude (ºS):	-16.5
Longitude (ºE):	157.8
Volume (km^3/106):	1.00

...continued page 2

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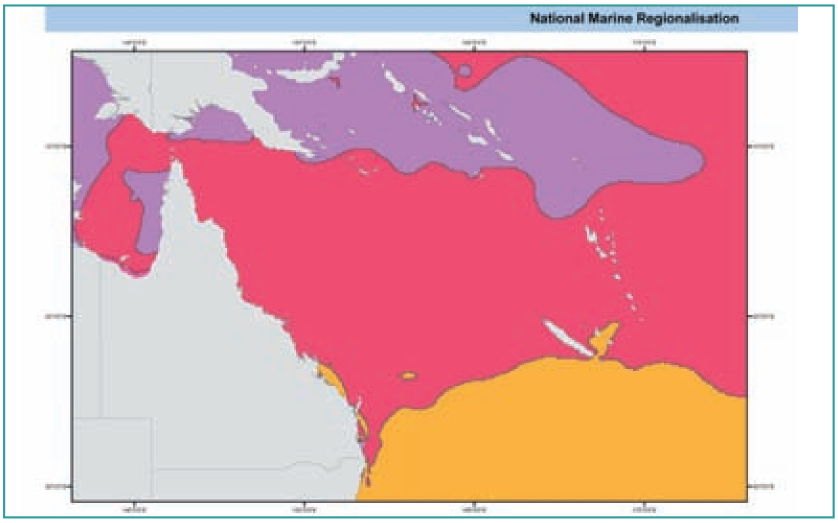

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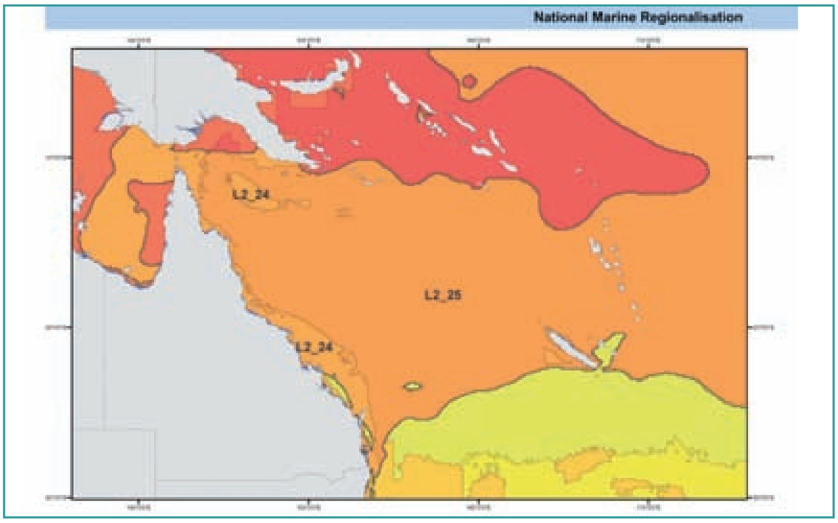
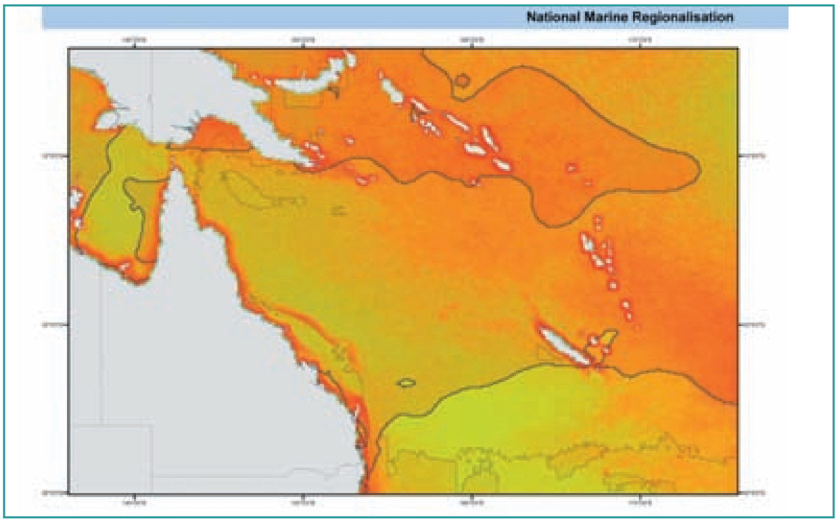


Level 2



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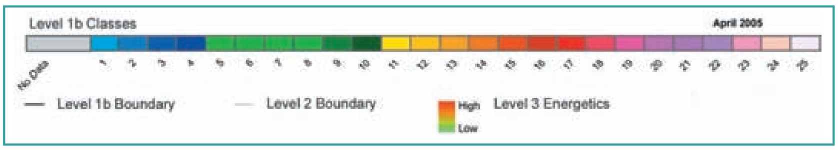
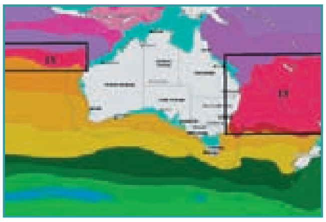


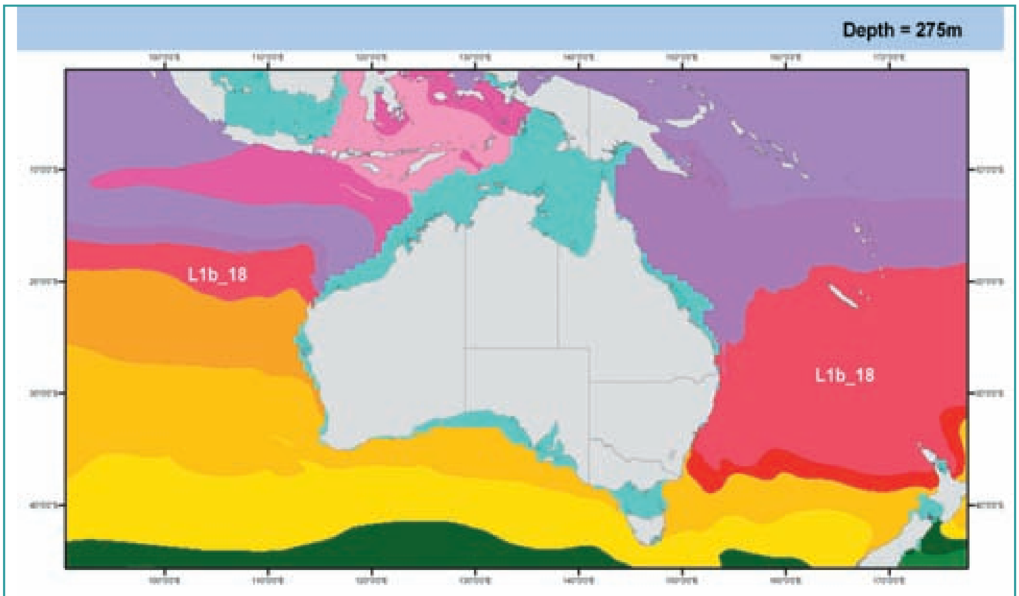
Water Mass 18

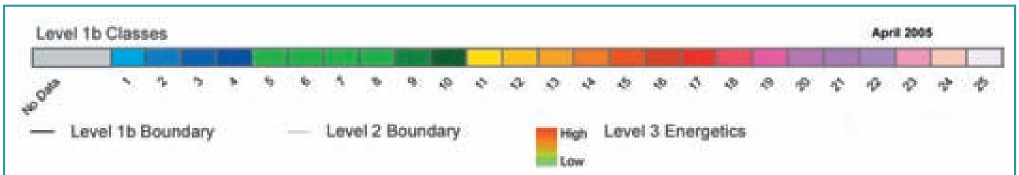
Description: This is an upper-layer frontal water mass that extends westward from the North West Cape of Western Australia into the Indian Ocean. It is first detectable at about 70 m depth, but extends to a maximum depth of about 450 m. A water layer with similar properties occurs as an extensive band in the southern portion of the Pacific Ocean.



Water Mass 18	Mean	Min	Max	Std. Dev.
Temperature (ºC)	3.94	2.43	6.75	0.90
Salinity	34.59	34.47	34.68	0.04
Oxygen (mm/l)	2.71	1.90	3.75	0.45
Nitrate (mg/l)	36.53	25.13	46.11	2.45
Silicate (mg/l)	91.33	37.66	148.00	21.03

Depth (m):	275	**Longitude (°E):**	163
Latitude (°S):	-23.9	**Volume (km^3/106):**	2.66





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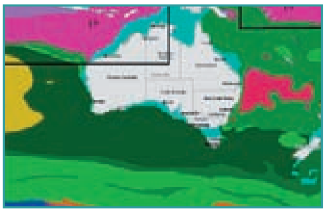
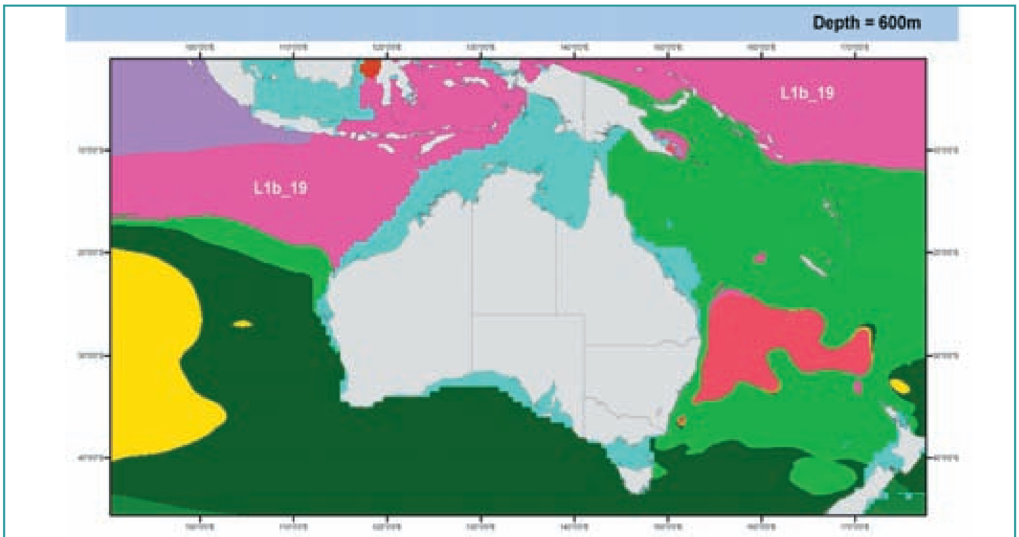
Water Mass 19

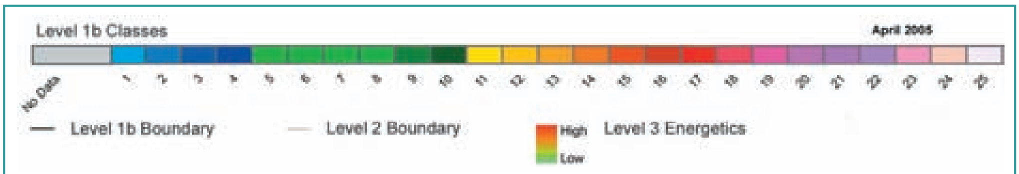


Description: An intermediate-sized water body that is associated with the Indo-Pacific Throughflow. It appears at about 125 m depth in the northern Indian Ocean as a front extending out from the north-west of Western Australia. A northern front is seen off western Papua New Guinea at about 450 m depth. It is at its maximum extent between about 450 and 600 m and disappears at about 1200 m, at which depth it is part of the intermediate-depth front in the north-west portion of the West Australian Basin.

Water Mass 19	Mean	Min	Max	Std. Dev.
Temperature (ºC)	7.42	3.51	19.08	2.00
Salinity	34.61	34.46	34.74	0.06
Oxygen (mm/l)	2.49	1.52	4.38	0.53
Nitrate (mg/l)	31.79	8.95	40.90	4.26
Silicate (mg/l)	52.45	7.98	116.91	20.04

Depth (m):	600	**Longitude (°E):**	122.9
Latitude (°S):	-8.9	**Volume (km^3/106):**	5.44





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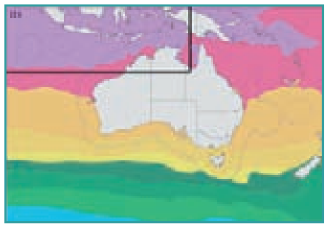
Water Mass I20

Indonesian Throughflow: Indian North-East Equatorial Water Mass



Description: *Indonesian Throughflow Water* derives from Pacific Ocean Central Water and is formed during transit through the Indonesian archipelago, where the high precipitation rates reduce salinity levels (water masses 1b_20 and 1b_23). The water enters the Indian Ocean between Timor and the North West Shelf and through the various passages between the islands east of Bali. It spreads across the central Indian Ocean as a latitudinal tongue of high-temperature, low-nutrient, low-salinity water.

This outflow occurs throughout the upper 1000 m of the water column (but at depth is classed as a different water mass – 1b_23) and has a major influence on the climate of the entire ocean basin and the Western Australian region in particular. Substructure at Level 2 appears to be related to regional influences of freshwater runoff affecting salinity levels. Energy levels are elevated around the numerous islands and coastline irregularities, and there is a general increase to the west, presumably associated with the westward tongue of the outflow waters.

Water Mass I20	Mean	Min	Max	Std. Dev.
Temperature (°C)	27.69	21.61	30.34	1.16
Salinity	34.21	29.32	34.72	0.50
Oxygen (mm/l)	4.42	3.63	5.33	0.17
Nitrate (mg/l)	0.66	0.00	10.65	0.78
Silicate (mg/l)	3.76	0.00	56.33	2.25

Depth (m):	20
Latitude (ºS):	-8.3
Longitude (ºE):	116.4
Volume (km^3/106):	0.62

...continued page 2

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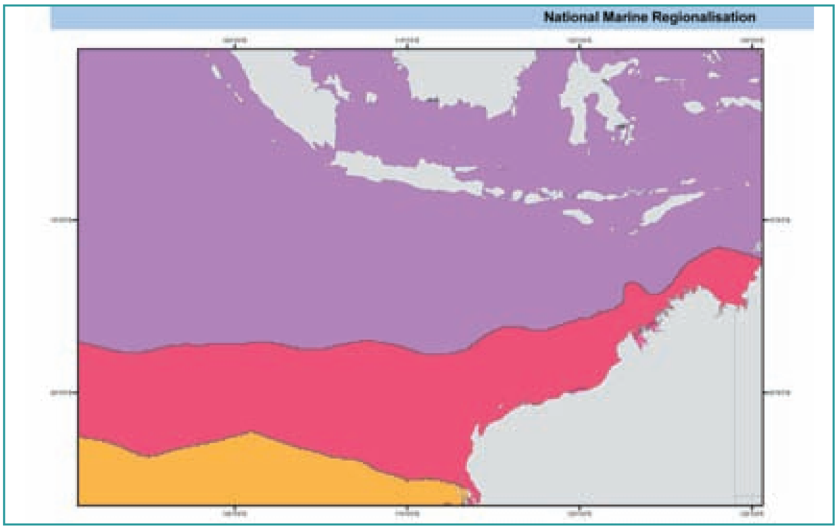
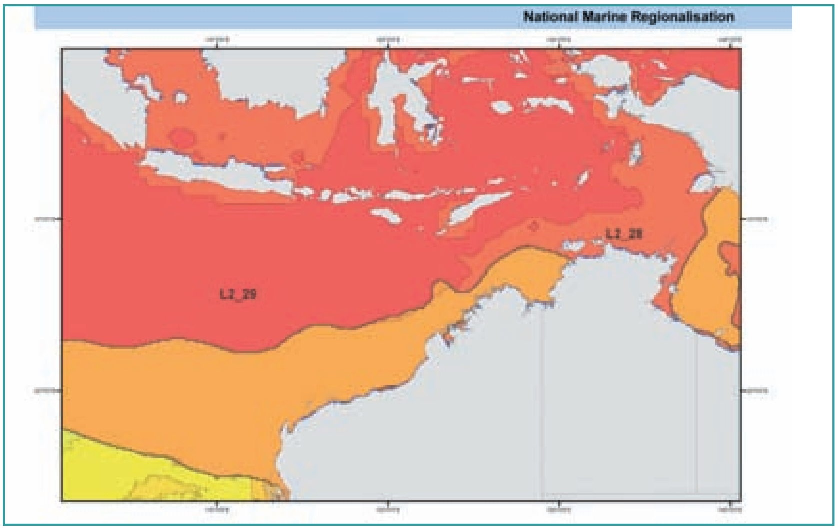
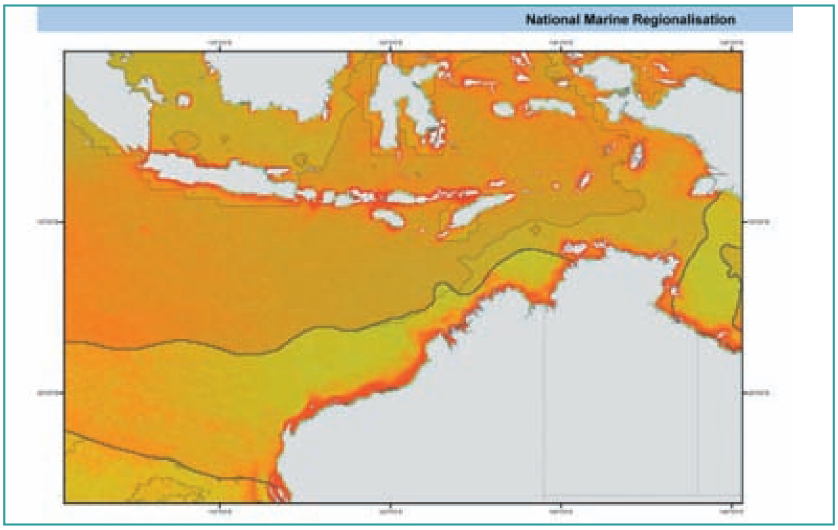


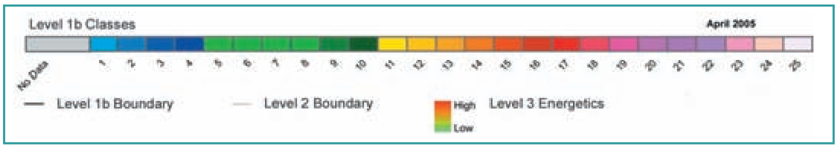
Level 1B



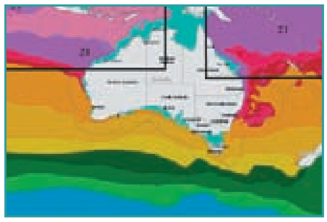
Level 2



Level 3



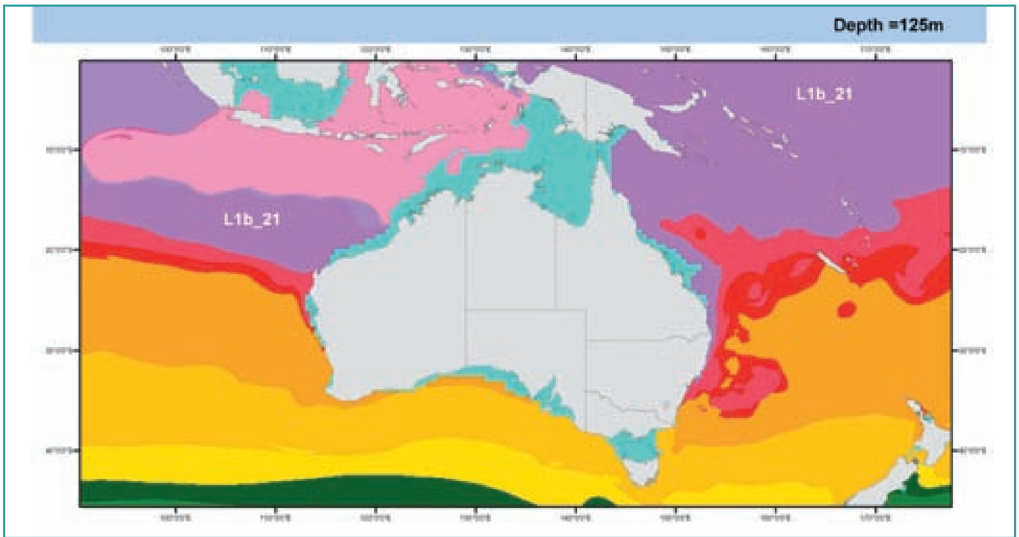
Water Mass 21

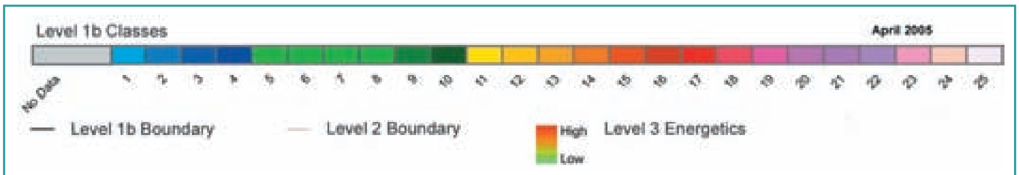


Description: The interface between the jet-like flow of Indonesian Throughflow Water and the eastward penetration of the South Indian Central Water produces a massive frontal region between 10 and 15ºS (water masses 1b_22, 1b_21 and 1b_18). An extensive band with similar water properties occurs in the northern Pacific off north-eastern Australia and Papua New Guinea, with a narrow southern intrusion down the coast to New South Wales.

Water Mass 21	Mean	Min	Max	Std. Dev.
Temperature (ºC)	22.89	12.26	29.07	3.96
Salinity	35.43	34.71	36.11	0.27
Oxygen (mm/l)	3.83	2.95	4.39	0.29
Nitrate (mg/l)	5.46	0.01	21.84	3.00
Silicate (mg/l)	3.68	0.76	20.25	2.73

Depth (m):	125	**Longitude (°E):**	156.3
Latitude (°S):	-11.6	**Volume (km^3/106):**	1.71





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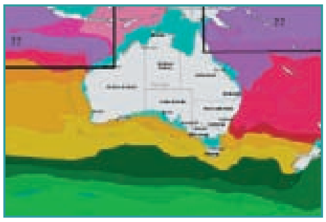
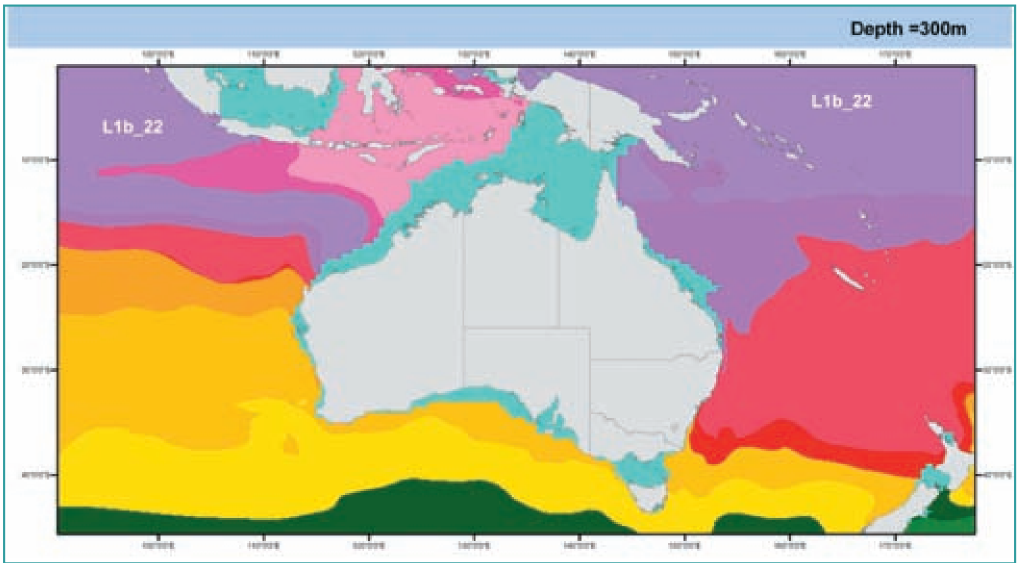
Water Mass 22

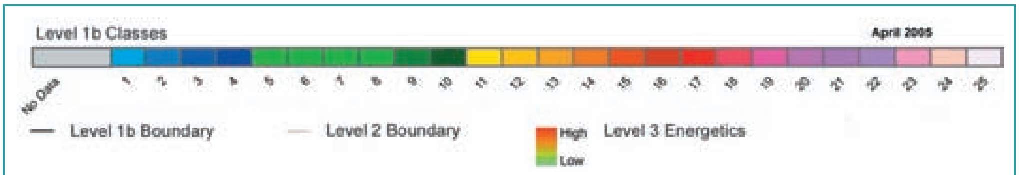


Description: This layer is, like Level 1b-21, part of the interface between the jet-like flow of Indonesian Throughflow Water and the eastward penetration of the South Indian Central Water. It also has a companion band of similar water properties in the northern Pacific off Papua New Guinea.

Water Mass 22	Mean	Min	Max	Std. Dev.
Temperature (ºC)	12.93	4.30	28.29	4.62
Salinity	34.96	34.69	35.84	0.22
Oxygen (mm/l)	2.53	1.23	4.38	0.78
Nitrate (mg/l)	22.69	0.54	40.25	8.97
Silicate (mg/l)	26.44	1.94	105.42	21.09

Depth (m):	300	**Longitude (°E):**	106.8
Latitude (°S):	-6.3	**Volume (km³/106):**	3.70





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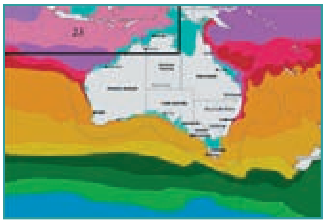
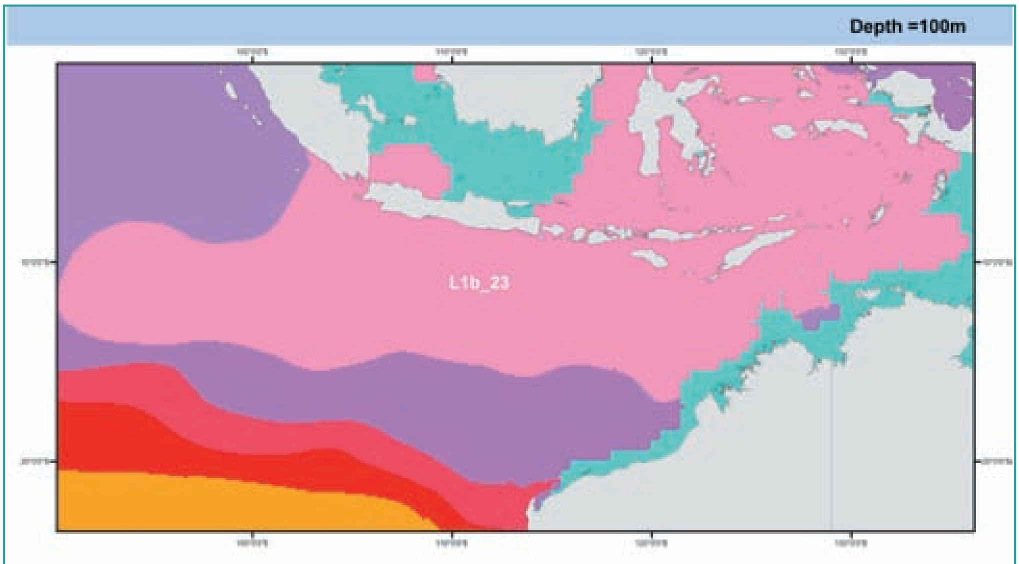
Water Mass 23

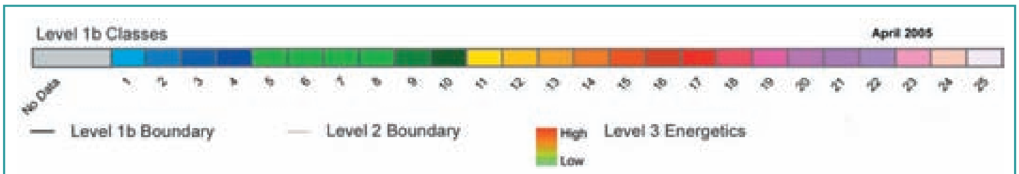
Description: This upper-surface layer starts in the northern portion of the Indo-Pacific region. By about 80 m depth it is distributed as a tongue of water penetrating westward into the Indian Ocean to a southern limit of about 20ºS. It is distributed largely to the west of Papua New Guinea and descends to a depth of about 350 m.



Water Mass 23	Mean	Min	Max	Std. Dev.
Temperature (ºC)	20.99	9.22	28.84	4.94
Salinity	34.50	32.85	34.73	0.15
Oxygen (mm/l)	3.21	2.04	4.32	0.55
Nitrate (mg/l)	10.96	0.28	32.18	7.60
Silicate (mg/l)	15.00	1.54	49.80	10.17

Depth (m):	100	**Longitude (°E):**	119.5
Latitude (°S):	-8.5	**Volume (km^3/106):**	0.91





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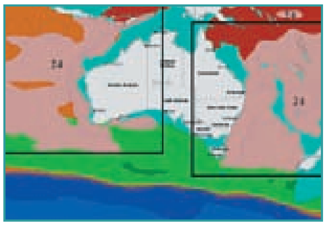
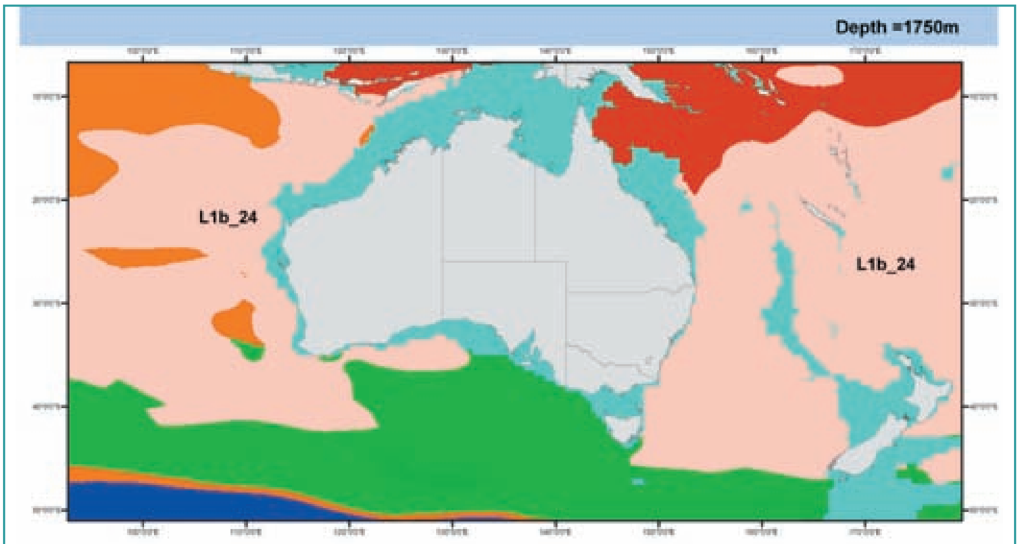
Water Mass 24

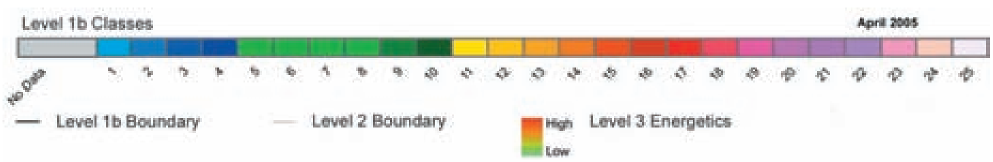
Description: A deep water mass that appears at about 1300 m depth in the central Indian Ocean. With increasing depth it expands to the east. At 1500 m it encircles Australia, but bifurcates to flow into the Indian and Pacific oceans. By 1750 m depth it is confined to the Pacific Ocean and disappears to the north. Its maximum depth is about 2250 m.



Water Mass 24	Mean	Min	Max	Std. Dev.
Temperature (ºC)	2.71	1.90	4.44	0.45
Salinity	34.64	34.56	34.72	0.03
Oxygen (mm/l)	3.30	2.05	3.98	0.40
Nitrate (mg/l)	35.99	27.46	42.37	1.86
Silicate (mg/l)	102.63	61.57	149.93	16.86

Depth (m):	1750	**Longitude (°E):**	154.7
Latitude (°S):	-22.2	**Volume (km^3/106):**	11.06





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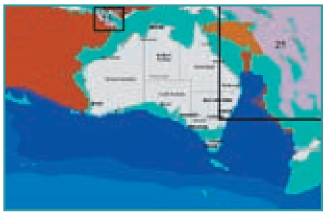
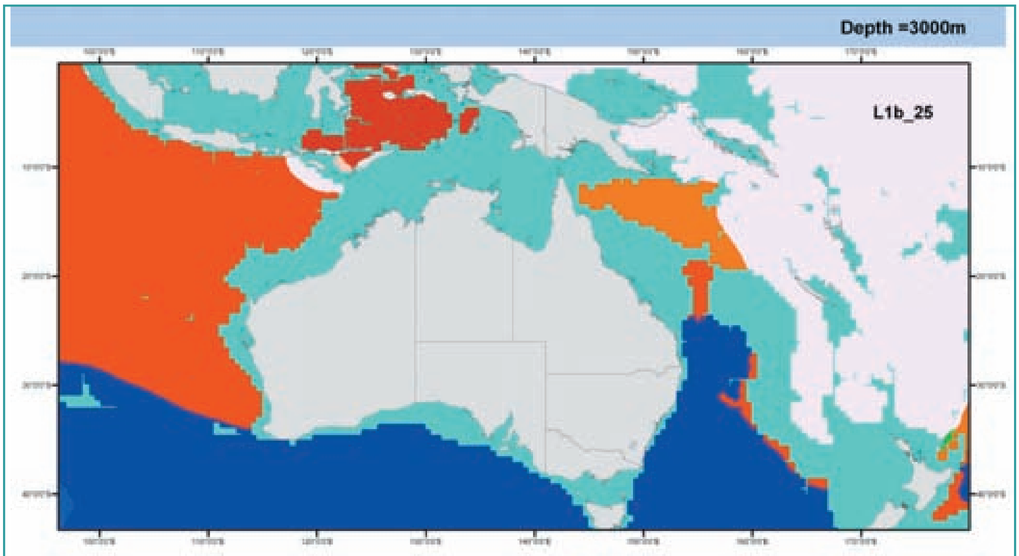
Water Mass 25

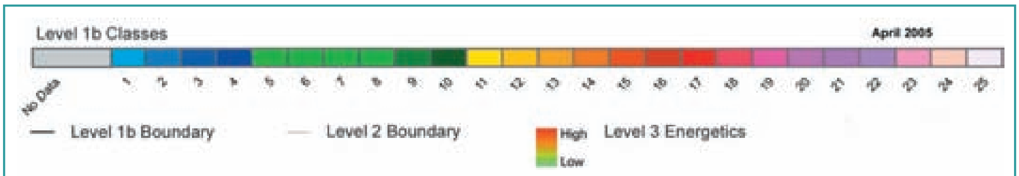


Description: A deep water mass largely confined to the north-east Pacific. At its shallower depth of about 2000 m it is found in the Coral Sea Basin and the Lord Howe Trough (located to the east of the Lord Howe Rise). At about 2750 m depth, it is no longer found in the Coral Sea Basin but is restricted to the other deep basins in the north-east Pacific. It is sporadically distributed throughout that region at deeper depths.

Water Mass 25	Mean	Min	Max	Std. Dev.
Temperature (ºC)	1.81	1.15	2.21	0.18
Salinity	34.68	34.65	34.72	0.01
Oxygen (mm/l)	3.49	2.31	4.15	0.23
Nitrate (mg/l)	36.02	27.41	42.42	1.71
Silicate (mg/l)	126.53	82.55	152.92	11.47

Depth (m):	3000	**Longitude (°E):**	167.9
Latitude (°S):	-13.1	**Volume (km^3/106):**	14.74





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