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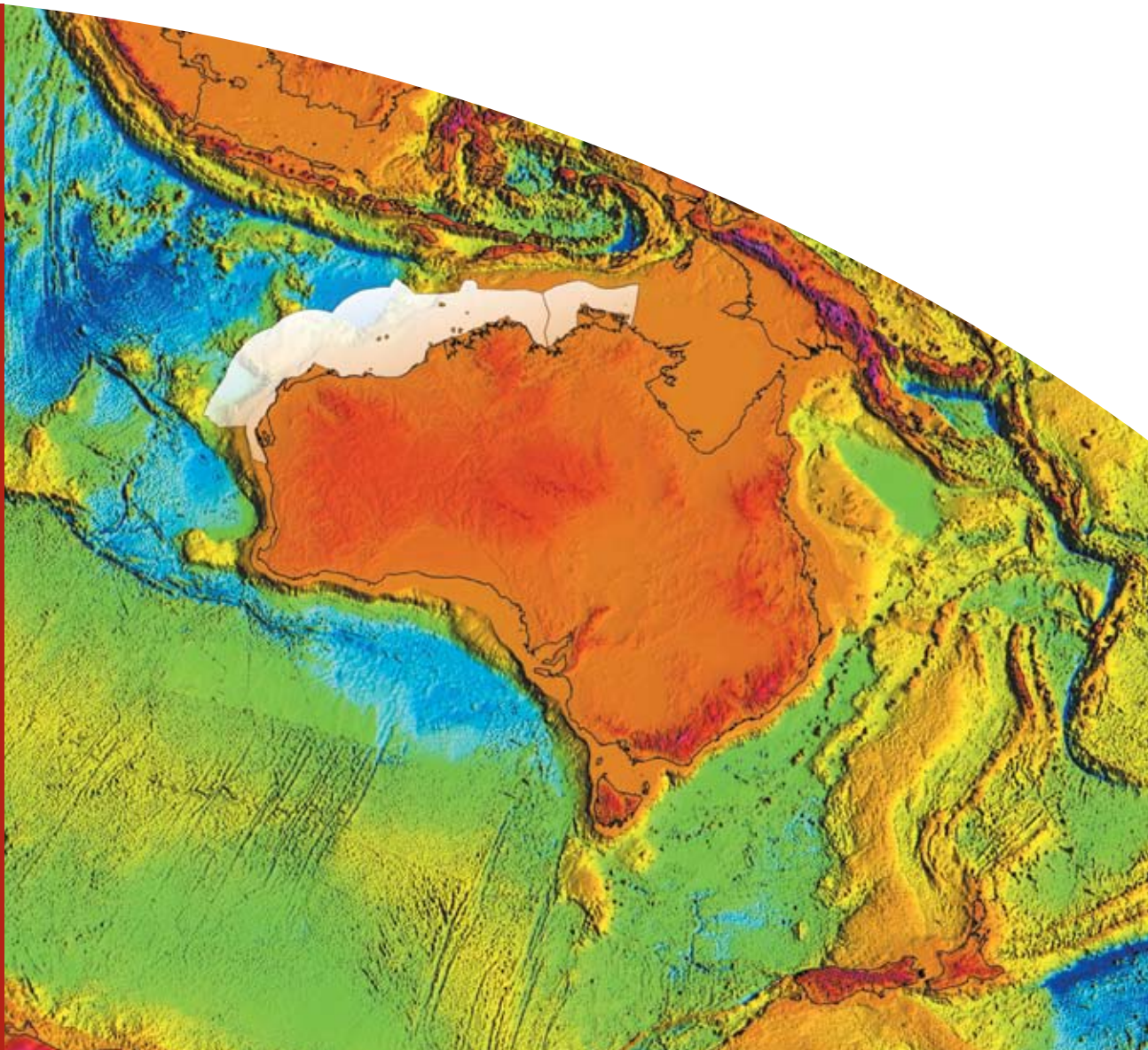
Sedimentology and Geomorphology of the Northwest Marine region

A Spatial Analysis

Christina Baker, Anna Potter, Maggie Tran and Andrew D. Heap

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Sedimentology and Geomorphology of the North West Marine Region of Australia

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Executive Summary

This report contains a review of literature and the results of a study of the sedimentology and geomorphology of the North West Marine Region (NWMR) and nominated area of the North Marine Region (NNMR). The study is a collaboration between Geoscience Australia and the Department of the Environment, Water, Heritage and the Arts (DEWHA). Data generated by this study expands the national fundamental marine samples dataset for Australia's marine jurisdiction, with analyses consistent with those completed on samples from the rest of the margin. Information contained in this report will contribute to Geoscience Australia's national work program through the creation of seascapes (surrogates for seabed habitats) for the NWMR and will be used by the Department of the Environment, Water, Heritage and the Arts (DEWHA) as part of the Marine Bioregional Planning work program.

Geoscience Australia is the national repository and custodian of marine sediment data including a national marine samples database (MARS; <http://www.ga.gov.au/oracle/mars>) that is a fundamental marine dataset for the Australian margin. This study has significantly improved the distribution of quantitative textural and composition data stored in MARS for the NWMR and NNMR. To realise the principal aim of the study, the following three objectives were devised:

1. Analyse seabed sediment samples (nominally 200) for quantitative grain size distribution and carbonate content;
2. Identify sources of marine sediment samples and populate MARS with the data; and
3. Produce a report synthesizing and summarizing the oceanography, tectonic history, late Quaternary evolution, geomorphology and sedimentology of the NWMR and the NNMR based on this data and previous literature.

Results of the analyses are presented as a regional synthesis within the framework of the Integrated Marine and Coastal Regionalisation of Australia (IMCRA) and National Bioregionalisation of Australia 2005 and where possible within the constraints of geomorphic features identified in a recent study of the geomorphology of the Australian margin by Heap and Harris (in press). Reporting the results in this way provides both an updated and quantitative analysis of the regional sedimentology from previous works and characterises the broad-scale management zones designed to support bioregional marine planning. Characterising sedimentology by geomorphic feature allows the resolution of relationships between feature and sediment type.

The NWMR is a tropical carbonate margin that comprises an extensive area of shelf, slope and abyssal plain/deep ocean floor. The northern shelf (Northwest and Sahul Shelves) is broad and gentle with an indiscernible shelf break, and the southern shelf (Dirk Hartog Shelf) is narrow. The northwest margin is controlled by tectonic activity of the Triassic (250 Ma) to Jurassic (145 Ma) that occurred as a result of continental break-up. The margin is influenced by the Leeuwin Current and Indonesian Throughflow, as well as seasonal up-welling events, internal tides and cyclone-induced storms. A series of reefs are located on the outer shelf/slope. Eight bioregions occur within the NWMR, and these include four offshore (~65% of total NWMR area) and four shelf (~35% of total NWMR area) bioregions.

The regional sedimentology is dominated by marine carbonates. Sediments show a broad zoning and fining with water depth. Oceanography, tectonic history, late Quaternary evolution and geomorphology have established the sedimentary setting for the margin. Main sedimentary trends of the NWMR include:

- A tropical carbonate shelf that is dominated by sand and gravel to latitudes of around 15°.
- An outer shelf/slope zone that is dominated by mud; and
- A relatively homogenous rise and abyssal plain/deep ocean floor that is dominated by non-carbonate mud because it occurs below the carbonate compensation depth.

Significant outcomes of this study include:

- Production of the most up-to-date and comprehensive representation of the seabed sedimentology for the northwest and the northern Australian margin, building on existing regional sediment models;
- Production of a detailed synthesis and review of literature for the NWMR and the NNMR;
- Quantification of regional seabed sediment characteristics and distribution in the NWMR and NNMR and assessment of the sediment variability at a NWMR, bioregion and geomorphic feature level;
- Production of a robust, consistent quantitative dataset that permits defensible quantitative comparisons of the seabed sedimentology to be made between the northwest margin and the whole Australian margin; and
- Recognition and quantification of the spatial heterogeneity of seabed sedimentology within the NWMR and the NNMR that can be linked to seabed habitat complexity. Capturing the spatial heterogeneity of the seabed sedimentology will allow more accurate and precise mapping of seabed habitats (seascapes) and aid in more effective future sampling strategies.

A principal application of the study is to support research into the associations between physical seabed properties such as sediment texture and composition and the distribution of benthic marine habitats and biota. This research contributes to Geoscience Australia's work on the spatial representation of benthic marine habitats and biota for Australia's vast marine jurisdiction. This work is crucial for developing robust, defensible methods of mapping habitats over thousands of kilometres using spatially abundant physical data combined with site-specific biological data.

1. Introduction

1.1. BACKGROUND

This report presents the geomorphology and sedimentology of the North West Marine Region (NWMR) and a section of the Northern Marine Region (NMR) termed the nominated area of the (NNMR). The three main outputs of the report include: 1) a review of previous geological research undertaken in the NWMR and NNMR; 2) the results of a quantitative study of seabed sediment texture and composition for these regions; and 3) a synthesis of this information characterising regional trends in sedimentology, geomorphology and bathymetry. The study is a collaboration between Geoscience Australia and the Department of the Environment, Water, Heritage and the Arts (DEWHA) and is a continuation of similar work conducted for the South West Marine Region (Potter et al., 2006; Richardson et al., 2005).

Previous sediment studies in the NWMR have predominantly produced qualitative results at local scales. Existing quantitative textural and compositional data available for the region prior to this task was relatively sparse. The study has improved the coverage of quantitative data for the NWMR by procuring and generating quantitative texture and composition data for 200 nominal seabed samples. This data expands the national marine sediment dataset for Australia's marine jurisdiction, with analyses consistent with those completed on samples from the rest of the margin. By combining results of previous qualitative work and quantitative information generated from existing and new data, this report provides an improved understanding of sedimentology for the NWMR and the NNMR. Information contained within this report will contribute to the Department of the Environment, Water, Heritage and the Arts Marine Bioregional Planning work program and will be one information input used for the selection of candidate marine protected areas for the North West and nominated area of the Northern Marine Region.

Geomorphic, sedimentary and biological information has previously been utilised to develop a National Bioregionalisation of Australia's Exclusive Economic Zone (EEZ) (Department of the Environment and Heritage (National Oceans Office), 2005; now the Department of the Environment, Water, Heritage and the Arts) and substantive geomorphic features of the west, north west and northern continental margins have already been identified and mapped (Heap and Harris, in press). This report adds significantly to these previous studies by incorporating the information in a sedimentological synthesis that includes a discussion of the implications for marine conservation in the NWMR and nominated area of the NMR.

The physical characteristics of the seabed, as described by sediment texture and composition data, can assist in determining the diversity of benthic marine habitats. These data represent "enduring features" which are elements of the physical environment that do not change considerably (in human lifespans), and they are known to influence the diversity of biological systems. This is important for marine conservation due to the better definition and characterisation of benthic habitats. Seabed texture and composition are easily measurable parameters that, when combined with other physical features can be used to create "seascapes" that serve as broad surrogates for benthic habitats and biota (Whiteway et al., 2007). Seascapes have the potential to be used in informing the marine bioregional planning process and the

design of a national system of representative Marine Protected Area's (MPA). This data increases the sediment coverage of the NWMR and NNMR to be used in the generation of seascapes.

1.2. SCOPE

1.2.1. Generation and Synthesis of Seabed Information for the NWMR and the NNMR

In April 2007, Geoscience Australia and the DEWHA agreed to undertake a collaborative project to identify, analyse and collate existing information on the texture and composition of the seabed in the NWMR and the NNMR. The main objectives of this project were to:

- Identify and summarise all previous geological information for the NWMR and the NNMR;
- Procure and analyse sediment samples (nominally 200) from the NWMR, currently held by Geoscience Australia and other marine science institutions, for grain size and carbonate concentrations;
- Provide data on the texture and composition of the seabed for the NWMR to populate Geoscience Australia's national marine samples database (MARS; www.ga.gov.au/oracle/mars) with the data; and
- Produce a report synthesising and summarising the sedimentology and geomorphology of the seabed for the NWMR and the NNMR in support of marine bioregional planning and creation of a national system of representative marine protected areas.

1.2.2. Expected Project Outcomes

The expected outcomes of this project are:

- To obtain a better understanding of the nature of the seabed for the west, northwest and northern margins of Australia;
- To improve the available information on the sedimentology of the NWMR for the scientific and planning communities, leading to the development of Marine Bioregional Plans;
- To improve access to data on the nature of the seabed through continued population of the MARS database as a national fundamental marine dataset and
- To provide texture and composition data for future projects; for example, the data may be combined with other physical data on the seabed (i.e. depth, geomorphology, sediment mobility etc) to create 'seascapes' that represent major ecological units based on measurable, recurrent and predictable features of the marine environment.

1.2.3. Products and Outputs

Key outputs of this project will be:

- 200 quantitative textural and compositional data points for the NWMR and associated metadata available in the MARS database;
- A review and synthesis of previous geological information for the NWMR and nominated area of the NMR (Chapter 3);
- Quantitative analyses of the sedimentology and geomorphology of the NWMR and nominated area of the NMR (Chapters 4, 5 and 6);
- A synthesis of all previous and new sediment information for the NWMR and nominated area of the NMR at planning region and bioregion scales (as defined by DEWHA) (Chapters 4, 5 and 6);
- An interpretation of sediment information and discussion of the significant findings and their implications for Marine Bioregional Planning (Chapter 6); and
- A series of web-accessible digital maps to standards appropriate for data coverage and sediment properties in the NWMR and nominated area of the NMR (Appendix G).

1.3. DESCRIPTION OF GEOMORPHOLOGY

In 2004, a collaborative agreement between Geoscience Australia, CSIRO – Marine and Atmospheric Research, and the former Department of the Environment and Heritage (National Oceans Office) created a National Marine Bioregionalisation (NMB 2005) of Australia (Department of Environment, Water, Heritage and the Arts, 2005). The NMB 2005 provides an over-arching management framework for a large part of Australia’s marine jurisdiction and is based on the most up-to-date knowledge of the biophysical properties of Australia’s marine environment, including seabed geomorphology and sedimentology. Definitions of geomorphic provinces and features included in the NMB 2005 and used in the spatial analyses in this study are listed in Table 2.1.

1.4. MARINE REGIONS

The five marine regions of Australia’s Exclusive Economic Zone (EEZ) include the East Marine Region, Northern Marine Region, North West Marine Region and South East Marine Region. Marine bioregional plans will be developed for each of these marine regions including the NWMR outlined in this report.

1.4.1. NWMR and Nominated Area of the NMR

The NWMR encompasses Commonwealth Waters between Kalbarri in Western Australia to the Western Australia and Northern Territory border in the Bonaparte Gulf (Fig. 1.1; Fig.1.2). This region comprises 1.1 million km² of ocean and seabed and is bounded inshore by the outer limit of state waters of northern Western Australia (which generally extends out to three nautical miles from the territorial sea baseline), and bounded offshore by the edge of the Australian EEZ (200 nautical miles from the low water mark) except between Cape Leveque and Cape Londonderry, where the NWMR does not extend to the EEZ boundary.

Changes to the location of the marine planning region boundaries have resulted in a portion of the Northern Marine Region (NMR) being excluded from previous geomorphology and sedimentology assessments by Geoscience Australia (Heap and Harris, in press). This area, the nominated area of the Northern Marine Region herein referred to as the NNMR, has been included in the present study. The NNMR covers an area of nearly 200,000 km² and includes the seabed and water column from the boundary of the NWMR in the west to the Aurari Bay in the east (Fig 1.1).

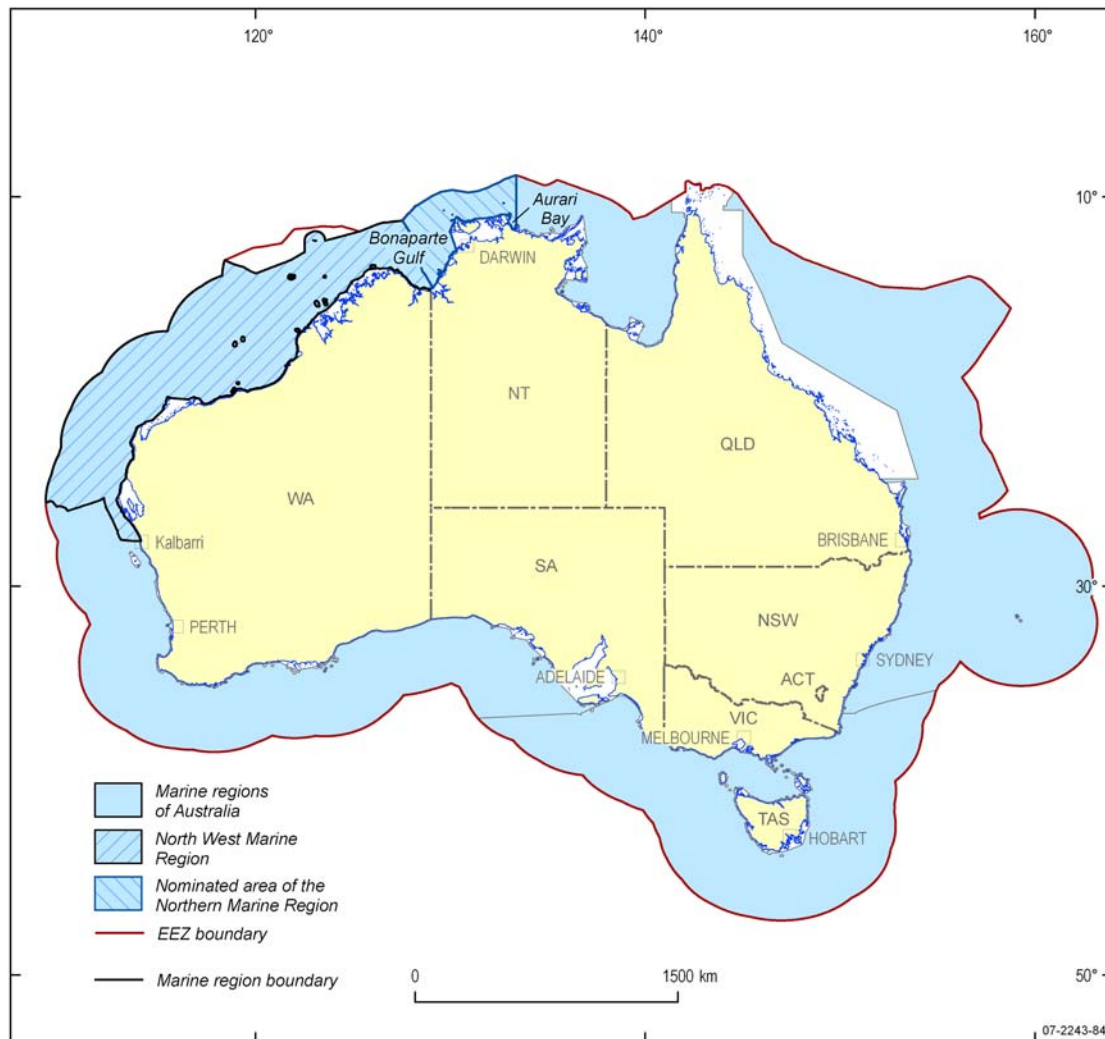


Figure 1.1. Location and extent of the North West Marine Region (NWMR) and nominated area of the North Marine Region (NNMR) relative to other Marine Regions in the Australian EEZ.

1.5. BIOREGIONS

The benthic component of the NMB 2005 management framework consists of a hierarchical set of geographic management units. Below the scale of the major ocean basins that comprise Australia's marine jurisdiction (i.e., the Indian, Southern and Pacific Oceans), the shelf, slope, rise and abyssal plain/deep ocean floor are designated as Primary Bathymetric Units that represent the broadest-scale planning unit and have areas of several million km².

Within each of the Primary Bathymetric Units are Provincial Bioregions, which have been defined mainly by the distribution of demersal fish, bathymetry, and geomorphology, and have areas of hundreds of thousands of km² (IMCRA 4.0 2005). The Provincial Bioregions are the principal planning unit for Marine Bioregional Planning. Marine bioregional plans will be developed for each of these marine regions including the NWMR.

1.5.1. Bioregions of the NWMR

The NWMR comprises eight bioregions. (Fig, 1.2 & Table 1.2). Only three of these bioregions are contained entirely within the NNMR boundary. The remainder either occupy areas with water depths <30 m or extend into adjacent marine regions (i.e. the South West Marine Region or NNMR).

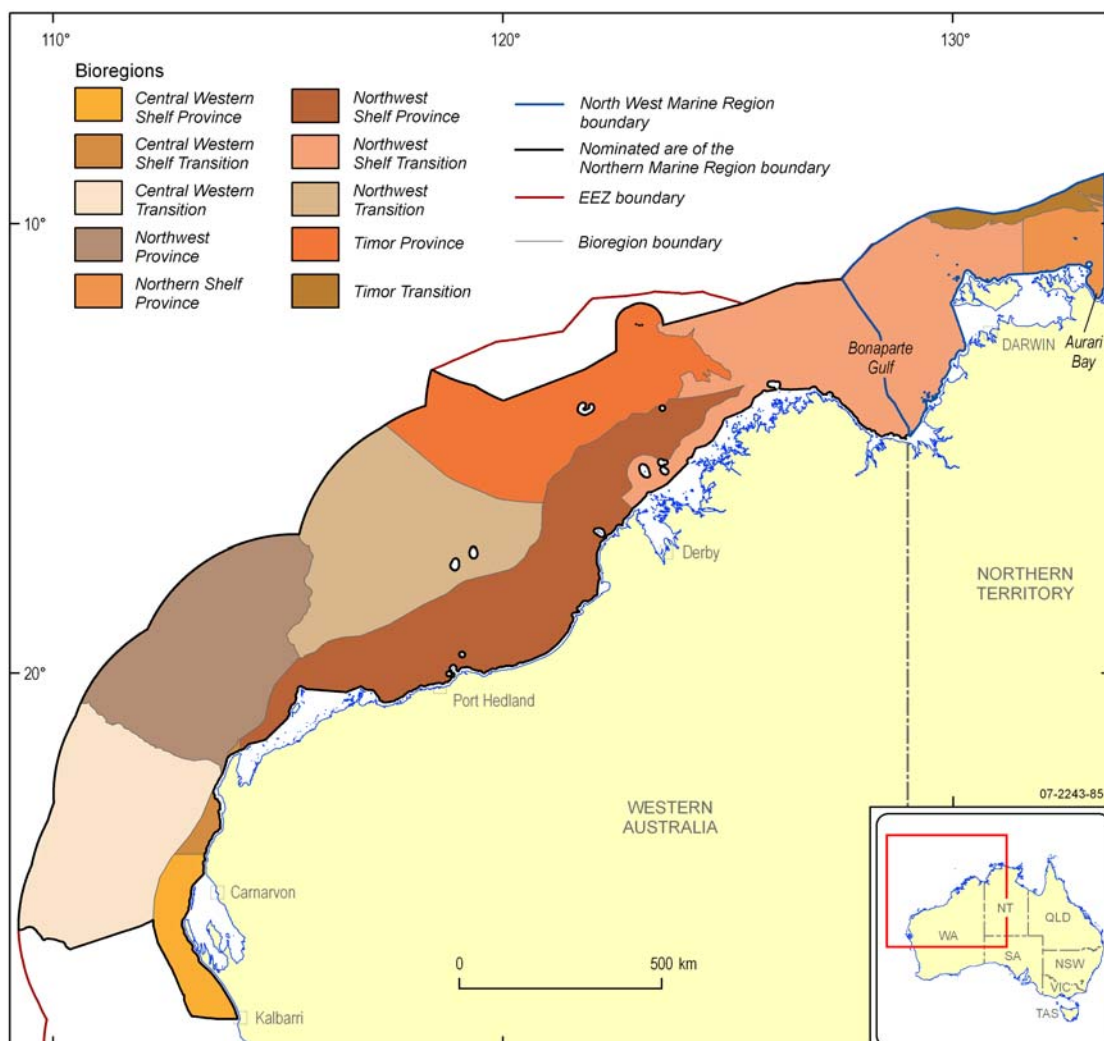


Figure 1.2. Bioregions of the North West Marine Region and nominated area of the Northern Marine Region.

Table 1.2. Summary details of the provincial bioregions contained in the NWMR.

Bioregion	% of bioregion included in NWMR	Water type	% of total NWMR area
Northwest Shelf Transition	44	Transitional Waters	13
Northwest Shelf Province	88	Tropical Waters	20
Central Western Shelf Transition	76	Transitional Waters	1
Central Western Shelf Province	65	Subtropical Waters	3
Central Western Transition	100	Transitional Waters	15
Timor Province	72	Tropical Waters	15
Northwest Transition	100	Transitional Waters	17
Northwest Province	100	Tropical Waters	17

The NWMR contains the Northwest Shelf Province, Central Western Shelf Transition, Central Western Shelf Province, and part of the Northwest Shelf Transition (Table 1.2). These provinces and transitions are located on the shelf. Water depths in the shelf bioregions are between 10 m and 350 m but are generally <150 m.

The NWMR also contains the Timor Province, Northwest Province, Northwest Transition and Central Western Transition (Table 1.2). These provinces and transitions mostly cover the slope and smaller area of the rise and abyssal plain/deep ocean floor. They are bounded by the shelf break, and water depths vary from 150 m to almost 6,000 m.

Full details of the bioregions are presented in Chapter 5. To support regional marine planning in the NWMR, the results of this study are discussed in the context of the provincial bioregions, and data are presented for individual bioregions.

1.5.2. Bioregions of the Nominated Area of the NMR (NNMR)

The NNMR addressed in this report is comprised of three bioregions (Table 1.3; Fig. 1.2). None of these bioregions are contained entirely within the NNMR boundary because they either occupy areas with water depths <30 m or extend into adjacent marine regions (i.e. the NWMR or NMR).

Table 1.3. Summary details of the provincial bioregions contained in the nominated area of the NMR.

Bioregion	% bioregion included in nominated area of NMR	Water type	% total nominated area of NMR area
Northwest Shelf Transition	42	Transition	66
Northern Shelf Province	9	Tropical Waters	25
Timor Transition	74	Transition	9

The nominated area of the NMR contains part of the Northwest Shelf Transition, Northern Shelf Province and the Timor Transition (Table 1.3). Full details of the bioregions are presented in

Chapter 5. As for the NWMR, results of this study are discussed in the context of the Provincial Bioregions, and data are presented for individual bioregions.

The entire area (179,200 km²) of the two shelf provinces and transitions are located on the shelf. A small area of slope is present in the Timor Transition in the northeast of the nominated area of the NMR.

Water depths in the nominated area of the NMR vary between 10 and 350 m. Deepest areas occur on the slope along the outer boundary of the EEZ. Sample coverage in the nominated area of the NMR is relatively even, with minor data gaps existing locally at several location on the inner shelf and one location on the mid- outer shelf in the west of the region.

1.6. REPORT STRUCTURE

The report provides a regional assessment of the sedimentology and geomorphology of the NWMR and NNMR. The report provides a synthesis of the existing sedimentology and geomorphology of the NWMR and NNMR (Chapter 3) which provides a framework in which the new data can be understood. This is followed by a regional scale spatial analysis of the sedimentology and geomorphology for the NWMR and NNMR (Chapter 4) and for each provincial bioregion occurring in the NWMR (Chapter 5), putting the new data into the context of the planning zones used by DEWHA. Lastly, results of this study and previous work in the NWMR and NNMR are summarised and discussed in terms of their implications for marine planning (Chapter 6).