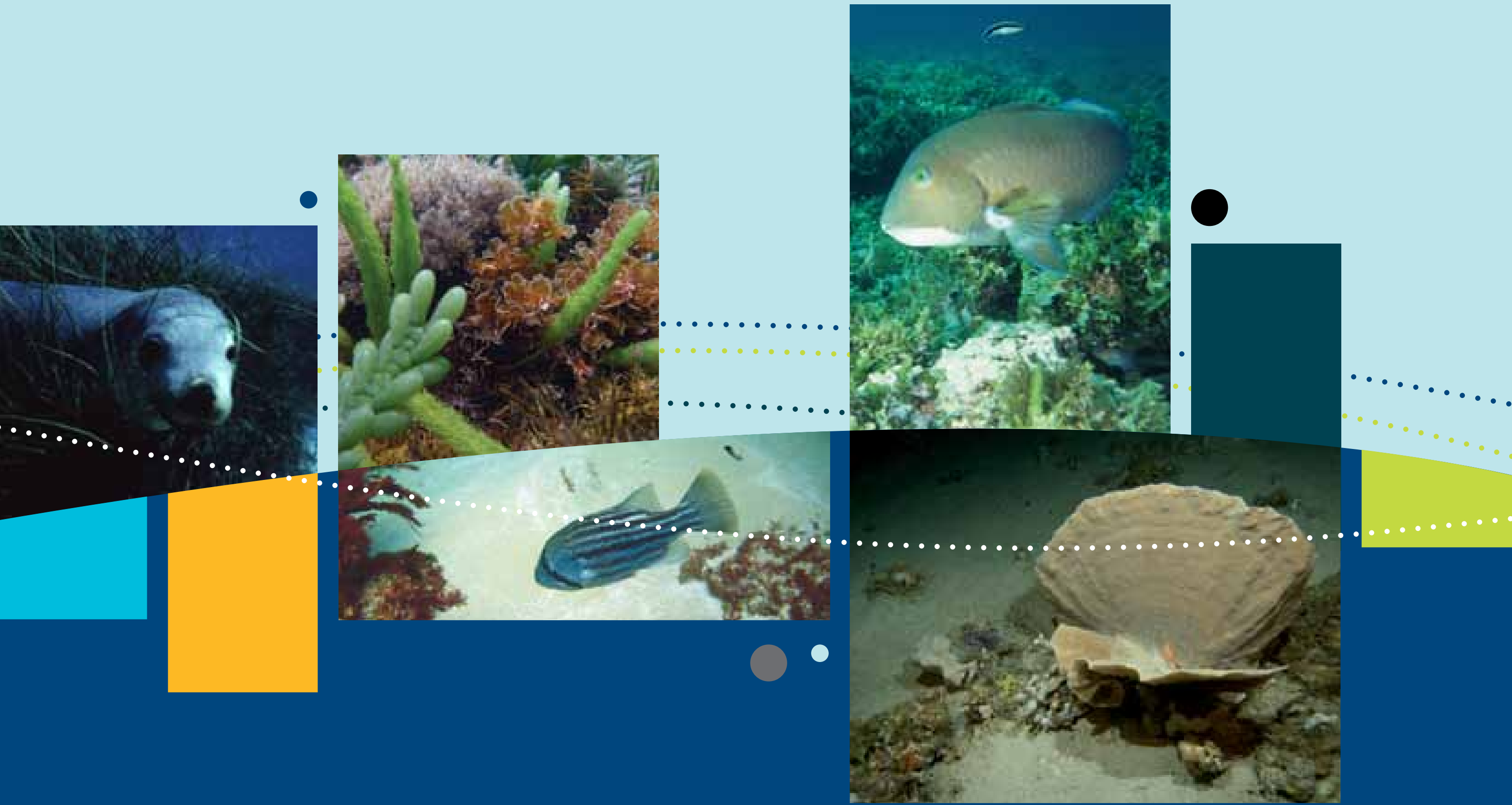
Australian Government

Department of Sustainability, Environment, Water, Population and Communities



Commonwealth marine environment report card

Supporting the draft marine bioregional plan for the South-west Marine Region

prepared under the *Environment Protection and Biodiversity Conservation Act 1999*

Disclaimer

Commonwealth marine environment report card—South-west Marine Region

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Report cards

The primary objective of the report cards is to provide accessible and up-to-date information on the conservation values found in Commonwealth marine regions. This information is maintained by the Department of Sustainability, Environment, Water, Population and Communities and is available online through the department's website (www.environment.gov.au).

Reflecting the categories of conservation values, there are three types of report cards:

- species group report cards

- marine environment report cards

- heritage places report cards.

Commonwealth marine environment report card

Commonwealth marine environment report cards describe features and ecological processes in marine regions and identify key ecological features as conservation values. Key ecological features are of regional importance for either biodiversity or ecosystem function and integrity within the Commonwealth marine environment and have been identified through the marine bioregional planning process.

The Commonwealth marine environment is a matter of national environmental significance under the *Environment Protection and Biodiversity Conservation Act 1999 (*EPBC Act). Actions requires approval from the environment minister if it has, will have or is likely to have a significant impact on a matter of national environmental significance. The identification of key ecological features therefore assists decision making about the Commonwealth marine environment under the EPBC Act.

While the focus of these report cards is the Commonwealth marine environment, in some instances features and ecological processes occurring in state waters are referred to where there is connectivity between features and ecological processes in state and Commonwealth waters.

Commonwealth marine environment report cards:

- describe the relevant marine region

- describe existing Commonwealth marine reserves

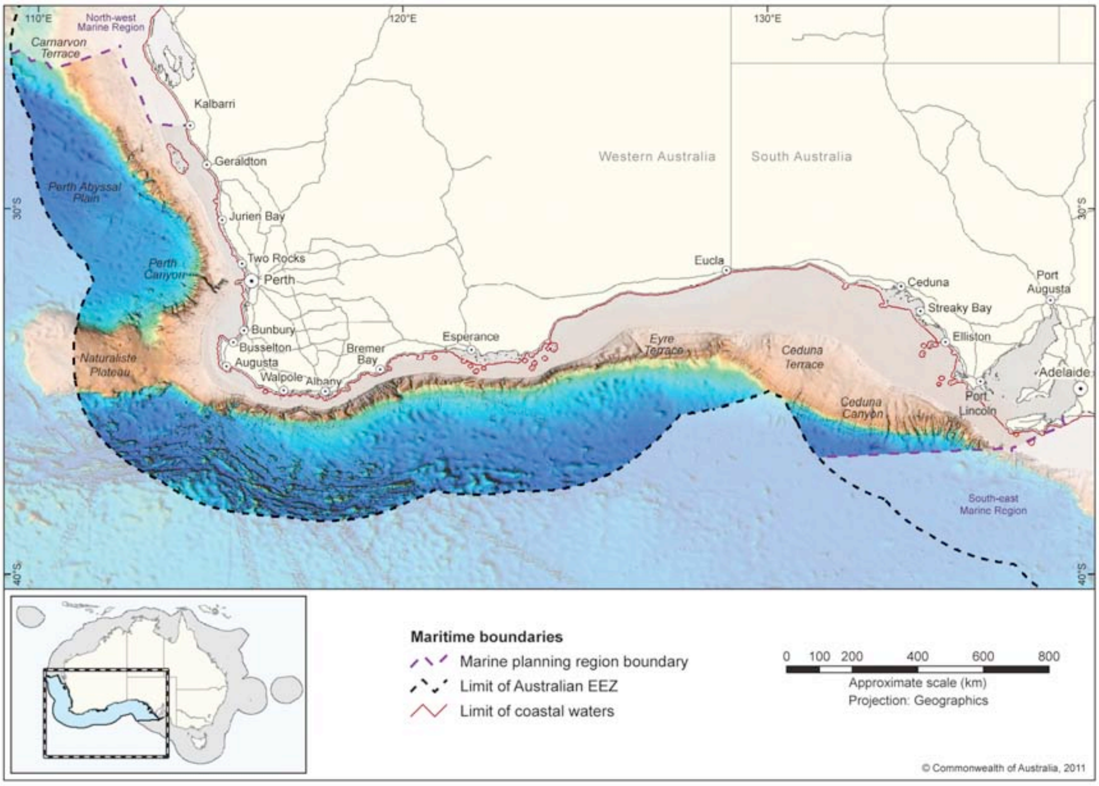
- describe each key ecological feature, outlines its conservation values and details the current state of knowledge on each feature

- assesses pressures to each of the key ecological features and identifies the level of concern the pressure places on the conservation of the feature.

1 The Commonwealth marine environment of the South-west Marine Region

The South-west Marine Region comprises Commonwealth waters and seabed from the eastern end of Kangaroo Island, South Australia, to 70 km offshore from Shark Bay, Western Australia. Inshore, the region is delineated by the outer jurisdictional boundary limit of the state waters of South Australia and Western Australia, while offshore it is delineated by the Australian exclusive economic zone boundary (Figure 1). The South-west Marine Region is adjacent to, but does not cover, the state waters of South Australia and Western Australia.

Figure 1 Map of the South-west Marine Region



The South-west Marine Region is generally characterised by low levels of nutrients and high species biodiversity, including a large number of endemic species. The flora and fauna of the region are a blend of tropical, subtropical and temperate species. Temperate species dominate the southern and eastern parts of the region, while tropical species become progressively more common towards the north of the region adjacent to Australia's west coast.

Physical structure of the region

The region encompasses waters over the continental shelf, the continental rise and the abyssal plains. The shallower waters of the continental shelf are approximately 10–200 m in depth. Large parts of the continental shelf are high energy environments with high exposure to waves. Inshore features include island groups and fringing coastal reefs that provide sheltered habitats.

More than anywhere else in Australia, the continental slope of the region is incised by a large number of submarine canyons (Potter, Southby & Heap 2006) comprising some of Australia's most complex canyon networks. The region also contains some of the largest areas of abyssal plains within Australia's exclusive economic zone and thus contains some of the most extensive deepwater benthic environments. The Naturaliste Plateau is Australia's deepest temperate-water marginal plateau and is separated from the shelf by the Naturaliste Trough. The plateau is an extensive area (the entire feature is approximately 90 000 km^2) of deepwater habitat around 2000–5000 m deep (Potter, Southby & Heap 2006). Similarly, the Diamantina Fracture Zone, a very deep area of complex topography featuring troughs with depths to 5900 m and ridges that rise up from the sea floor to approximately 4000 m deep, includes unique and varied deepwater habitats (Richardson, Mathews & Heap 2005).

Ecosystem drivers

From a global perspective, the South-west Marine Region is generally characterised by low levels of nutrients and high species biodiversity, including a large number of species found nowhere else in the world. The biological communities comprise species of temperate origin, which, in the north of the region, mix with tropical and subtropical species. Broadly, these characteristics reflect the influence of the Leeuwin Current, the low level of run-off from the land, and the relatively stable recent geological history (McClatchie et al. 2006).

The ocean currents in the region include the Leeuwin Current, the subsurface Leeuwin Undercurrent on the west coast, the Flinders Current on the south coast, and the seasonal, coastal Capes Current and Cresswell Current. The Leeuwin Current is the 'signature current' of the region because it extends the length of the region and has a significant impact on biological productivity of ecosystems and biodiversity in the region. The Leeuwin Current is a shallow and narrow current (less than 300 m deep and 100 km wide) that transports warm, nutrient-depleted water from the tropics southward along the shelf break and outer parts of the shelf of the entire region (McClatchie et al. 2006) and south-east to Cape Grim in Tasmania's north-west. Although the Leeuwin Current flows all year round, the strength of its flows show a marked seasonal variation with the strongest flows occurring during winter. During summer, the Leeuwin Current weakens to the point that its inflow to the Great Australian Bight is largely absent.

The Leeuwin Current strongly affects the ecology of the region in a number of ways. In the nutrient-poor waters of the region, production hinges on the import of nutrients from deeper waters into surface waters through upwelling and meso-scale cyclonic eddies (50–200 km diameter eddies that spin clockwise and in some cases lift deeper water toward the surface). The Leeuwin Current suppresses predictable large-scale upwellings on the west coast. In some areas, it interacts with seafloor features and other currents to generate relatively small, periodic upwellings that locally enhance nutrient levels. As a result, the Leeuwin Current plays an important role in maintaining low levels of productivity on the west coast (McClatchie et al. 2006). Consequently, Australia's west coast is an area that can only support relatively small fisheries compared with other areas with eastern boundary currents in the world, such as the Humboldt Current off Peru and the Benguela Current off Africa.

The interactions of the Leeuwin Current with seafloor features at the shelf break also lead to the formation of meso-scale eddies (McClatchie et al. 2006). Such eddies are known to occur in predictable locations: off Shark Bay, the western edge of the Houtman Abrolhos Islands, south-west of Jurien Bay, the Perth Canyon, south-west of Cape Naturaliste and Cape Leeuwin, and south of Albany, Esperance, and the Eyre Peninsula. Scientists believe that eddy systems may have a profound effect on pelagic production in the region, driving offshore production by transporting nutrients and entire pelagic communities offshore and also generating upwellings of deeper water that are higher in nutrients (McClatchie et al. 2006). However, these processes have not been studied in detail. A major challenge to understanding the importance of eddy systems in the region is their complexity and variability. For example, there are clockwise and anti-clockwise eddies that form on both the south and west coasts and they may have different physical characteristics—eddies can have cool water or warm water in their core or they may be associated with ascending or descending water.

The Leeuwin Current plays a crucial role in the distribution of species in the region. Its warm water transports tropical and subtropical species, which become established in areas further south than they otherwise would. For instance, it is because of the Leeuwin Current that a number of tropical fish and hard coral species are found as far south as Rottnest Island (latitude 32° S) (McClatchie et al. 2006). The Leeuwin Current and the deeper Flinders Current are also likely to aid the large-scale movements of a number of migratory species.

The ecology of the region is also greatly influenced by a lack of river discharge (McClatchie et al. 2006). The few significant rivers adjacent to the region flow intermittently and their overall discharge is low. Consequently, there is a limited amount of terrigenous (originating from the land) nutrient inputs. When combined with the suppression of large-scale upwelling, discussed above, limited nutrient input from the land reinforces the region's relatively nutrient-poor status compared with many other marine environments.

The low discharge of rivers and the generally low rate of biological productivity also results in low turbidity (suspended sediments), making the waters of the region relatively clear. This means that light can penetrate to greater depths, allowing a number of light-dependent species and associated communities to be found in waters deeper than those in which they live in other parts of Australia. For instance, macroalgae can be found at depths of 120 m in some parts of the region, while seagrasses can be found at depths of 50 m.

Biological diversity

The flora and fauna of the region are a blend of tropical, subtropical and temperate species. Temperate species dominate the southern and eastern parts of the region, while tropical species become progressively more common in the north.

The South-west Marine Region is known for its high species diversity and high numbers of endemic species (species that are found nowhere else in the world) and there are many more species to be discovered. Of the known species, more than 1000 species of macroalgae, between 17 and 22 species of seagrass, 600 species of fish, 110 species of echinoderm and 189 species of ascidians have been recorded in the region (McClatchie et al. 2006). In the near shore area of southern parts of the region, approximately 85 per cent of fish species, 95 per cent of molluscs and 90 per cent of echinoderms are thought to be endemic. By comparison, it has been estimated that only 13 per cent of fish, 10 per cent of molluscs and 13 per cent of echinoderms are endemic to tropical regions of Australia. The region also contains a number of endemic species that are commercially fished, such as the western rock lobster and dhufish. A global study of coral reef biodiversity hotspots has also found that while the west coast of Western Australia from Ningaloo reef (outside the region) to Rottnest Island has moderate to high species richness, it is also one of the global hotspots for endemism. Similarly, recent studies of demersal fish communities on the continental slope of the west coast revealed high species richness compared with the North Atlantic and northern Pacific Oceans.

The high species diversity of the region is largely attributed to the lack of mass extinction events associated with unfavourable environmental conditions such as glaciations over the recent geological past and the moderating influence of the Leeuwin Current over about the past 50 million years (Richardson, Mathews & Heap 2005). The high species richness (for example, in hard corals, demersal fish, seagrasses and macroalgae) is also, in part, due to biogeographic overlap of the ranges of temperate and tropical species. The high endemism in the region is partly the product of the long period (the past 80 million years) during which the marine flora and fauna in the region have been isolated from species occurring around other landmasses.

The region's south coast has not been as well studied as the west coast. However, a growing body of research indicates that its waters support a rich diversity of organisms. The Great Australian Bight is known to have one of the world's most diverse soft sediment ecosystems: recent sampling studies have revealed assemblages that include 360 species of sponge, 138 species of ascidians and 93 species of bryozoans, many of which were newly discovered species (McClatchie et al. 2006).

The South-west Marine Region is an area of global significance for breeding or feeding grounds for a number of threatened marine animals, including Australian sea lions, southern right whales and white sharks. Scientists have identified the south-western corner of Australia as an important area for beaked whales, which are the least-known species group of whales (MacLeod & Mitchell 2006). The region also provides habitat for a large number of seabird species that nest on nearby islands and coastline.

Our understanding of species biodiversity and endemism in the deeper parts of the region, on the continental slope, continental rise and abyssal plain is poor when compared with our knowledge of shallower coastal and shelf communities. Of all the oceanic regions under Australia's jurisdiction, the South-west Marine Region includes the deepest areas and the largest expanse of continental rise. Species unknown to science are undoubtedly yet to be discovered in these unique environments. It is expected that the biodiversity values in the Diamantina Fracture Zone, the

Naturaliste Plateau, and the numerous submarine canyons that incise the continental slope are high compared with other parts of the world.

Bioregional framework

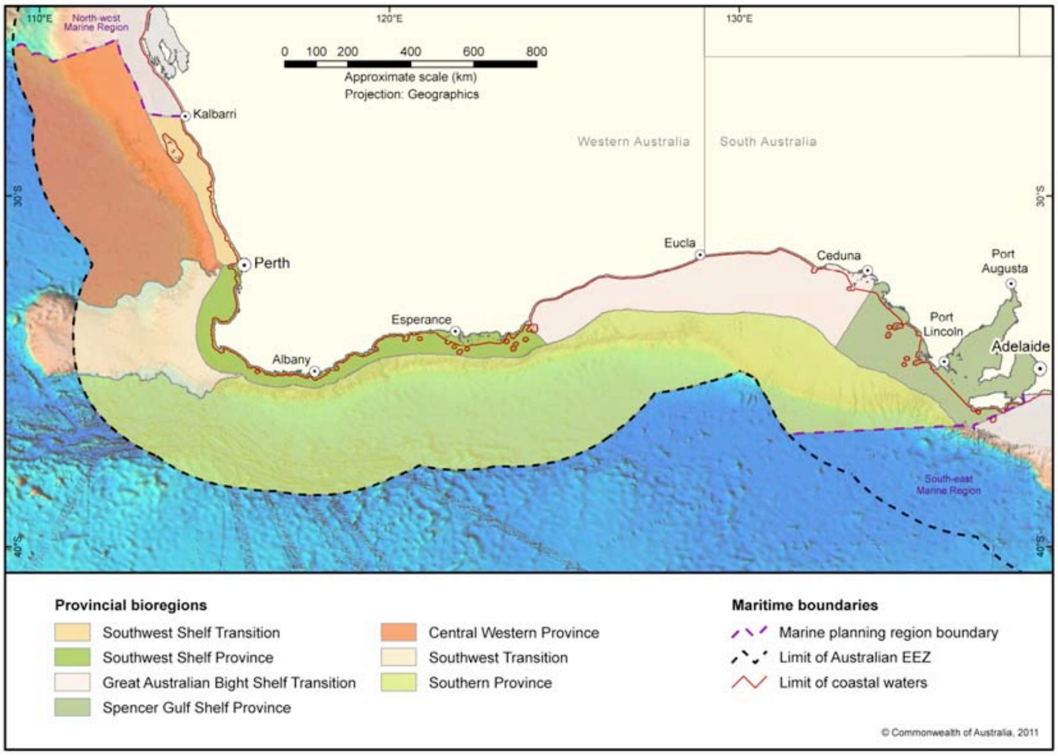
The Integrated Marine and Coastal Regionalisation of Australia Version 4.0 (IMCRA v.4.0) identifies seven bioregions[1] in the South-west Marine Region (Figure 2). The regionalisation provides a spatial framework to represent at a broad scale the distribution patterns of marine life in the region. IMCRA v.4.0 is the product of the combination of the 1996 Interim Marine and Coastal Regionalisation of Australia (for waters on the continental shelf) with the 2005 National Marine Bioregionalisation (for off-shelf waters). The nomenclature of the bioregions of IMCRA v.4.0 has used the term 'IMCRA' to identify those bioregions that lie over the continental shelf. For the purposes of this report card the term 'IMCRA' has been replaced with 'Shelf' to distinguish shelf bioregions from those offshore. The seven bioregions in the South-west Marine Region are the:

Southwest Shelf Transition
Central Western Province
Southwest Shelf Province
Southwest Transition
Great Australian Bight Shelf Transition
Spencer Gulf Shelf Province
Southern Province.

[1] For the purpose of this document, in dealing with the Commonwealth marine area, 'bioregion' means provincial bioregion as defined in the Integrated Marine and Coastal Regionalisation of Australia (Version 4.0).

These bioregions have been used in the development of a representative network of marine reserves in the South-west Marine Region.

Figure 2 Bioregions in the South-west Marine Region



2. Key ecological features

Key ecological features define areas and features of ecological importance in the Commonwealth marine environment. They are elements of the South-west Marine Region that, based on current scientific understanding, are considered to be of regional importance for either biodiversity or ecosystem function and integrity. Key ecological features of the South-west Marine Region have been identified by the Australian Government on the basis of advice from scientists about the ecological processes and characteristics of the area. Attachment 1 provides a detailed description of each feature, outlines its national and/or regional importance and describes potential ecological health indicators. It also reports on the assessment of environmental pressures on the key ecological features and outlines the relevant existing protection measures.

3. Protected places in the Commonwealth marine environment—South-west Marine Region

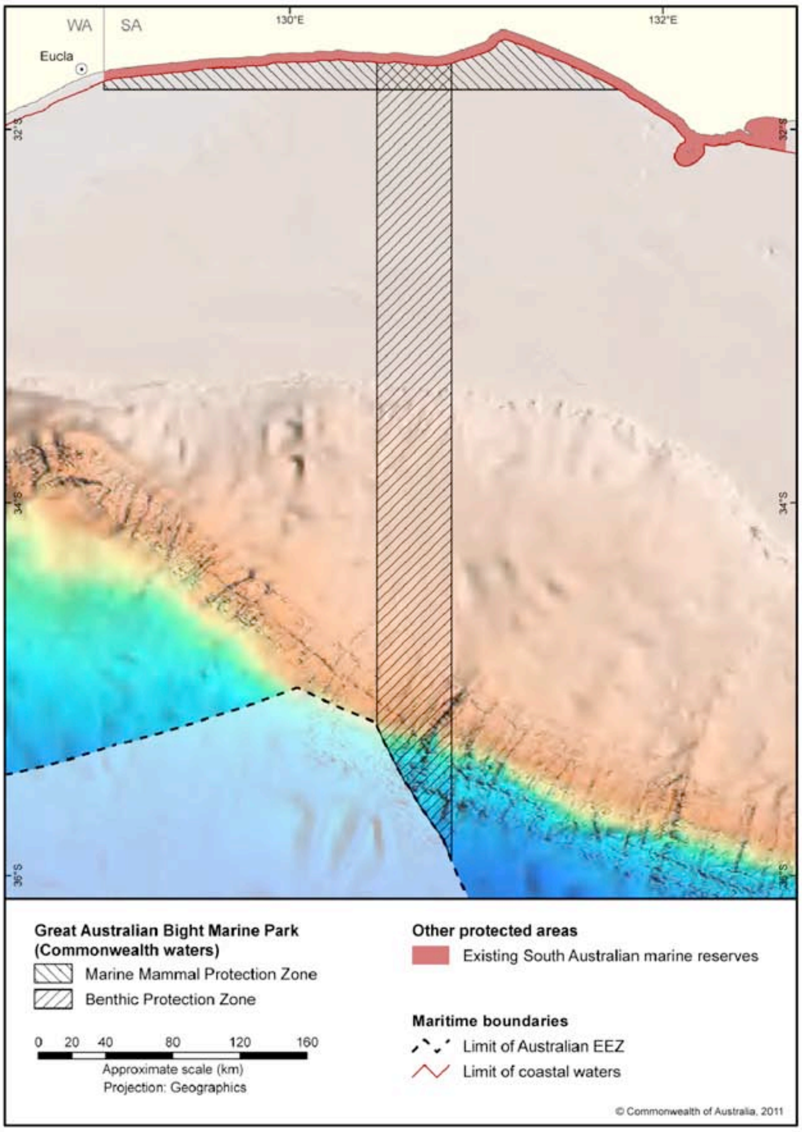
Protected places include marine reserves and heritage places. Heritage places are described in the heritage places report card which is available at **www.environment.gov.au/coasts/mbp/south-west/index.html**.

Within the South-west Marine Region there is currently one Commonwealth marine reserve—the Great Australian Bight Marine Park.

The Great Australian Bight Marine Park

The Great Australian Bight Marine Park stretches from 200 km west of Ceduna in South Australia and follows the coast to the Western Australian border. The park includes a strip 20 nautical miles wide extending 200 nautical miles offshore (Figure 3). The park comprises adjoining South Australian and Commonwealth protected areas. The Yalata Indigenous Protected Area also lies adjacent, creating one of the world's largest contiguous areas of land and sea managed for biodiversity conservation.

Figure 3 The Great Australian Bight Marine Park



The Great Australian Bight Marine Park (Commonwealth Waters) is a Commonwealth reserve under the EPBC Act. The Australian and South Australian governments manage the park cooperatively to protect conservation values (specifically, the southern right whale; the Australian sea lion; other species of conservation significance and a transect representative of the seabed on the continental shelf and slope of the Great Australian Bight). The Great Australian Bight Marine Park (Commonwealth Waters), declared in 1998, covers around 19 700 km² and extends to 1000 m below the seabed. Management plans regulate recreational, scientific and commercial uses of the park within four distinct management areas or zones: a Whale Sanctuary Zone and Conservation Zone in the South Australian Marine Park (in the state coastal waters of the Bight) and, in Commonwealth waters, a Marine Mammal Protection Zone (which abuts and complements the two zones of the South Australian Marine Park) and a Benthic Protection Zone. Each zone is assigned to IUCN category VI—managed resource protected area.

Several unique factors combine to contribute to the high level of biodiversity and endemism in the area of the park. These include a long period of geological isolation, a persistent high wind and wave energy environment, warm-water intrusion via the Leeuwin Current from Western Australia, and cold-water, nutrient-rich upwellings in the east. Taxonomic groups with exceptional diversity in this area include red algae (seaweed), ascidians (sea squirts), bryozoans (lace corals), molluscs (shellfish) and echinoderms (sea urchins and sea stars). The Benthic Protection Zone is within the region identified by James et al. (2001) as year-round downwelling and arrested carbonate production. Ward et al. (2006) and Currie, Sorokin and Ward (2009) assessed the effectiveness of this zone in representing regional biodiversity and found that it appears to effectively represent the epifaunal assemblages of the eastern Great Australian Bight (Dambacher, Rochester & Dutra 2009).

Although the Australian and South Australian governments manage the Great Australian Bight Marine Park cooperatively, each jurisdiction has its own management plan to manage the day-to-day uses of its respective components of the park. The EPBC Act (section 354) prohibits actions affecting native species inside the park unless authorised under the Great Australian Bight Marine Park (Commonwealth Waters) Management Plan 2005–2012. The plan currently allows a range of activities, including fishing and scientific research, to be carried out under permit from the Director of National Parks. Other provisions of the EPBC Act prevent activities that affect species of particular conservation interest (in the park or in other Commonwealth waters), and control actions that could have a significant impact on the Commonwealth marine environment, including the park's seabed. The park's management plan supplements this protection by minimising disturbances to areas of habitat important to these species, and prohibiting disturbances to the seabed by benthic trawling, while allowing for other ecologically sustainable activities in the park.

There are few pressures on the Commonwealth marine environment within the Great Australian Bight Marine Park. Pressures on the species for which the marine park is important are assessed in species report cards. The impact of fisheries on Australian sea lions has recently been assessed (Hamer et al. 2009). There are oil and gas exploration activities next to and in areas overlapping deeper waters of the marine park. All activities within the boundaries of the Commonwealth waters of the park must comply with the Great Australian Bight Marine Park (Commonwealth Waters) Management Plan 2005–2012. Further information on the Great Australian Bight Marine Park is available at www.environment.gov.au/coasts/mpa/gab.

Certain activities are prohibited within the park (Commonwealth waters). Some activities might be allowed subject to permit approval issued by the Director of National Parks. Mining operations—including exploration activities such as seismic testing—are prohibited in the park (Commonwealth waters) except with the approval of the Australian Governor General and carried out in accordance with the management plan. Alongside the requirements outlined above for undertaking activities in the Great Australian Bight Marine Park (Commonwealth waters), certain activities also require additional environmental approvals; for example, actions that will or are likely to have a significant impact on matters of national environmental significance will be subject to the assessment and approval provisions of chapters 2 to 4 of the EPBC Act.

References

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Attachment 1: Key ecological features of the South-west Marine Region

Key ecological features define areas and features of ecological importance in the Commonwealth marine environment. They are elements of the South-west Marine Region that, based on current scientific understanding, are considered to be of regional importance for either biodiversity or ecosystem function and integrity. As new data and knowledge about the ecology of the region become available, the role of these and other features in the biodiversity and ecosystem functioning of the region will become clearer.

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

- a species, group of species or community with a regionally important ecological role, where there is specific knowledge about why the species or group is important to the ecology of the region and the spatial and temporal occurrence of the species or group is known
- a species, group of species or community that is nationally or regionally important for biodiversity, where there is specific knowledge about why the species or group is regionally or nationally important for biodiversity and the spatial and temporal occurrence of the species or group is known
- an area or habitat that is nationally or regionally important for
  - enhanced or high biological productivity
  - aggregations of marine life
  - biodiversity and endemism
- a unique seafloor feature with ecological properties of regional significance.

Key ecological features of the South-west Marine Region have been identified by the Australian Government on the basis of scientific advice about the ecological processes and characteristics of the area. Sixteen key ecological features have been identified in the region (Figure 1). The following sections—from 1 to 16—provide a detailed description of each feature and outline their national or regional importance. A broad assessment of the pressures affecting the key ecological features in the South-west Marine Region is included in section 17. Section 18 outlines the environmental management and regulation measures currently in place to provide protection to the region’s ecosystems.

A glossary is provided at the end of the attachment, defining scientific terms and other terminology.

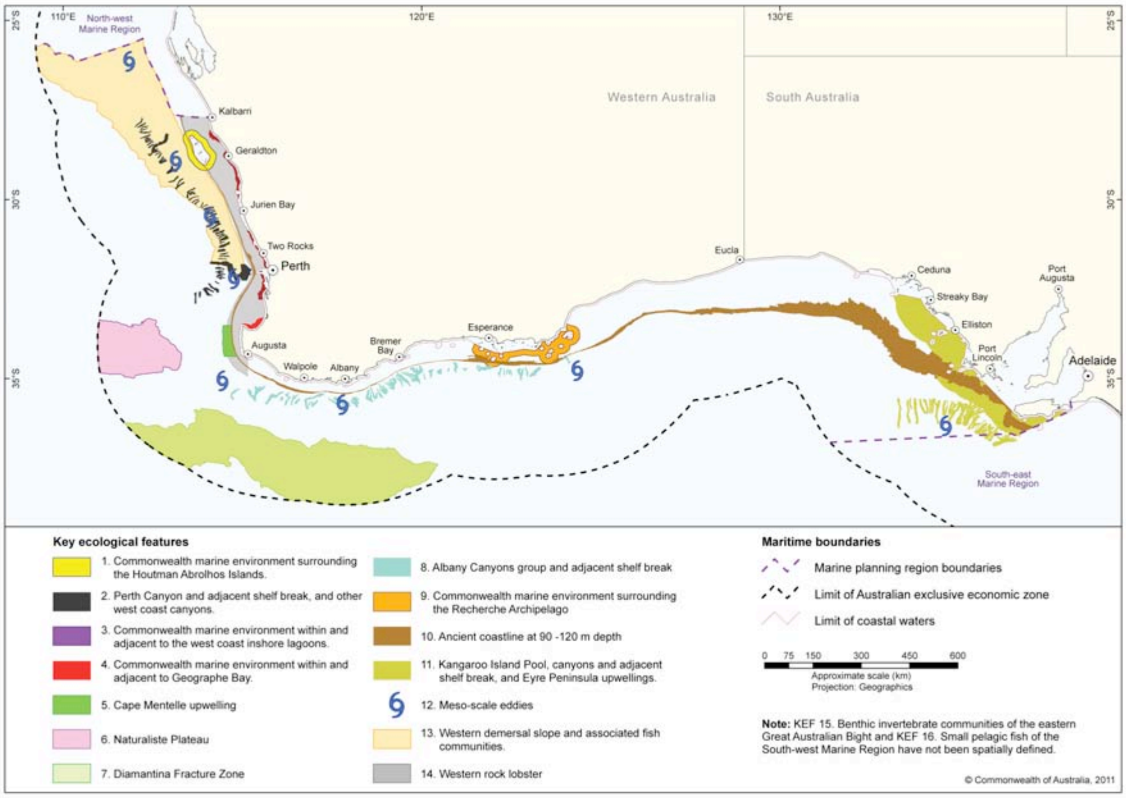

Figure 1: The key ecological features of the South-west marine region

1. Commonwealth marine environment surrounding the Houtman Abrolhos Islands

National and/or regional importance

The Commonwealth marine environment surrounding the Houtman Abrolhos Islands has conservation value as an area of high biodiversity and endemism in benthic and pelagic habitats. It provides important foraging habitats for globally important seabirds breeding colonies.

Values description

The Houtman Abrolhos Islands are a complex of 122 islands and reefs located at the edge of the continental shelf between 28°15' S and 29° S, approximately 60 km offshore from the mid-west coast of Western Australia. The Houtman Abrolhos waters and reefs have been relatively well studied and are noted for their high biodiversity and mix of temperate and tropical species, resulting from the southward transport of species by the Leeuwin Current over thousands of years. The islands lie in a transitional zone between major marine biogeographic provinces, caused by the juxtaposition of the warm, tropical water of the Leeuwin Current and colder water more typical of the islands' latitude (Hayes et al. 2008). The Leeuwin Current allows the tropical to subtropical transition to occur at 28–29.5° S, whereas on the east coast of Australia this transition occurs at 24° S (Collins et al. 1991, in Richardson, Mathews & Heap 2005). The Leeuwin Current allows the Houtman Abrolhos Islands to support the highest-latitude coral reefs in the Indian Ocean (Richardson, Mathews & Heap 2005). The islands also represent the southern limit in Western Australia of many widespread Indo-Pacific tropical fish.

The reefs are composed of 184 known species of coral that support approximately 400 species of demersal fish, 492 species of molluscs, 110 species of sponges, 172 species of echinoderms and 234 species of benthic algae. The area provides important habitat for rock lobsters (*Panulirus cygnus*). The Houtman Abrolhos Islands are the largest seabird breeding area in the eastern Indian Ocean (Hayes et al. 2008), supporting over one million pairs of breeding seabirds (predominantly terns), including sedentary and migratory species (Surman & Wooller 2003). Many of the islands' biodiversity features, most notably seabirds and rock lobster, rely on the benthic and pelagic ecosystems in the immediate surrounding Commonwealth marine environment. The area is also recognised as an important resting area for migrating humpback whales. The islands are the northernmost breeding site of the Australian sea lion (DEWHA 2007), although sea lions are not thought to be an important component of this ecosystem because of their low population numbers.

Calcium carbonate production and associated reef growth in the Houtman Abrolhos Islands is not significantly different from tropical reefs, and depends on the strength or occurrence of the Leeuwin Current over time (Collins et al. 1991, in Richardson, Mathews & Heap 2005). The islands and reefs may act as a refuge for corals when sea surface temperatures become too hot in more northern latitudes. As such, the Houtman Abrolhos Islands can provide insight into coral responses to climate change, which may be important for managing coral reefs in the face of rising global temperatures (Richardson, Mathews & Heap 2005).

2. Perth Canyon and adjacent shelf break, and other west coast canyons

National and/or regional importance

The continental slope of the South-west Marine Region is incised by a large number of submarine canyons, more than anywhere else in Australia, and includes some of the nation's most complex networks of marine canyons. The Perth Canyon is the largest canyon on the Australian margin and it forms a major biogeographical boundary. It is expected that the biodiversity values in these canyons are high. The Perth Canyon is defined as a key ecological feature because it is an area of higher productivity that attracts feeding aggregations of deep-diving mammals and large predatory fish. It is also recognised as a unique seafloor feature with ecological properties of regional significance.

Values description

The west coast system of canyons spans an extensive area (8744 km^2) of continental slope offshore from Kalbarri to south of Perth. It includes the Geographe, Busselton, Pelsaert, Geraldton, Wallaby, Houtman and Murchison canyons and, most notably, the Perth Canyon, which is Australia's largest ocean canyon. The Perth Canyon (offshore from Rottnest Island, at 32° S) is prominent among the west coast canyons because of its magnitude and ecological importance; however, the sheer abundance of canyons spread over a broad latitudinal range makes this feature important as a whole.

Canyons can be characterised by higher productivity and species diversity than surrounding slope areas of similar depth or distance offshore (Richardson, Mathews & Heap 2005). They are pathways for transporting sediments, nutrients and biota off the continental shelf and slope and onto the abyssal plain, either acting as a sink for this relatively organic-rich material or directing it into deeper water (Richardson, Mathews & Heap 2005). Canyons are also conduits for upwelling and downwelling, processes that influence environmental variables such as nutrient availability and water temperature. Upwelling of water from the deep ocean supplies nutrients to the continental shelf and slope, which is important for phytoplankton blooms and production in local fisheries (Richardson, Mathews & Heap 2005). The west-coast canyons are believed to be associated with small periodic upwellings that locally increase productivity and attract aggregations of marine life. In the Perth Canyon, interactions between the canyon topography and the Leeuwin Current induce clockwise-rotating eddies that transport nutrients from greater depths. Due to the canyon's depth and the Leeuwin Current's barrier effect, this remains a subsurface upwelling (depths less than 400 m), which confers ecological complexity that is typically absent from canyon systems (Pattiaratchi 2007).

The Perth Canyon is a major cutting canyon in the region, that is, it cuts into the continental shelf. Cutting canyons experience high sediment load from offshore transport and receive organic material from productive shelf waters. The Perth Canyon is long, deep, narrow and steep-sided, cutting 4 km into the continental shelf (Pattiaratchi 2007). The head of the canyon starts at the 200 m depth contour on the continental shelf and drops to a depth of 1000 m over a 6.5 km distance before doglegging down onto the abyssal plain (at about 4000 m) (Rennie, McCauley & Pattiaratchi 2006). The canyon head transports shelf material into the deep ocean and is an important link between continental shelf habitats and deepwater habitats (Richardson, Mathews & Heap 2005). The Perth Canyon marks the southern boundary for a number of tropical species groups on the shelf, including sponges, corals, decapods and xanthid crabs. Deep ocean currents upwelling in the canyon create a nutrient-rich, cold-water habitat that attracts deep-diving mammals and large predatory fish, which feed on small fish, krill and squid. A number of cetaceans, predominantly pygmy blue whales (*Balaenoptera musculus brevicauda*), aggregate in the canyon during summer to feed on the prey aggregations (Pattiaratchi 2007). Arriving from November onwards, their numbers peak in March to May. The topographical complexity of the canyon is also believed to provide more varied habitat that supports higher levels of epibenthic biodiversity than adjacent shelf areas (Hayes et al. 2008).

3. Commonwealth marine environment within and adjacent to the west coast inshore lagoons

National and/or regional importance

This feature is recognised as a habitat that is nationally or regionally important for high benthic productivity and for aggregations of marine life. Both benthic and pelagic habitats within the feature are of conservation value.

Values description

A chain of inshore lagoons extends along the Western Australian coast from south of Mandurah to Kalbarri. The lagoons are formed by distinct ridges of north–south oriented limestone reef with extensive beds of macroalgae (principally *Ecklonia* spp.), and extend between 0 m and 30 m deep. Although macroalgae and seagrass appear to be the primary source of production, scientists suggest that groundwater enrichment may supplement the supply of nutrients to the lagoons.

These lagoons are considered to be important for benthic productivity and recruitment for a range of marine species. The Leeuwin Current brings warm water and propagules from tropical and subtropical regions that recruit into these sheltered reefs and lagoons, creating an area of high productivity that significantly contributes to the ecological functioning and integrity of this area. The lagoons are dominated by seagrass and epiphytic algae (Dambacher, Rochester & Dutra 2009)—seagrass provides important habitat for many marine species, and epiphytes are the main food source in the lagoonal system.

The lagoons are associated with high biodiversity and endemism, containing a mix of tropical, subtropical and temperate flora and fauna. Emergent reefs and small islands create a diverse topography, and the mix of sheltered and exposed seabeds form a complex mosaic of habitats. The area includes ecosystems that are important for benthic productivity, including macroalgae and seagrass communities, and breeding and nursery aggregations for many temperate and tropical marine species. The inshore lagoons are important areas for the recruitment of the commercially and recreationally important western rock lobster, dhufish, pink snapper, breaksea cod, baldchin and blue gropers, abalone and many other reef species. Extensive schools of migratory fish visit the area annually, including herring, garfish, tailor and Australian salmon.

4. Commonwealth marine environment within and adjacent to Geographe Bay

National and/or regional importance

This feature has important conservation value for its high productivity, aggregations of marine life, biodiversity and endemism. Both benthic and pelagic habitats within the feature are of conservation value.

Values description

Geographe Bay is a large, shallow (less than 30 m deep), sheltered bay that encompasses a wide curve of the Western Australian coastline extending from Cape Naturaliste to Bunbury. It is an area of high productivity supported by extensive and diverse seagrass meadows that cover approximately 60 per cent of the bay (McMahon et al. 1997). The tropical and temperate seagrass beds account for approximately 80 per cent of benthic primary production in the area. The conditions of the bay, and the south-flowing warm waters of the Leeuwin Current, make this an area of high biodiversity and endemism, with a mix of tropical and temperate species. The Leeuwin Current exerts a strong influence on the bay, and brings warm and oligotrophic waters and tropical species along the temperate south coast of Western Australia (Dambacher, Rochester & Dutra 2009).

Similar to the inshore lagoons to the north, Geographe Bay provides important nursery habitat for many shelf species (e.g. juvenile dusky whaler sharks use the shallow seagrass habitat as nursery grounds for several years, before ranging out to adult feeding grounds along the shelf break). The seagrass provides valuable habitat for fish and invertebrates (Carruthers et al. 2007). Geographe Bay is also recognised as an important resting area for migrating humpback whales during the late winter–spring months (McCauley et al. 2000) that, along with shark and fish species, support the value of this feature for aggregations of marine life.

5. Cape Mentelle upwelling

National and/or regional importance

This feature has important conservation value for its high productivity. Nutrients from the upwelling support phytoplankton blooms in shallow waters, creating regions of high productivity that contribute to the ecological functioning and integrity of this area.

Values description

The Cape Mentelle upwelling occurs during summer months between Cape Leeuwin and Cape Naturaliste in the south-west corner of Australia. The Cape Mentelle upwelling draws relatively nutrient-rich water from the base of the Leeuwin Current (where nutrient levels are higher), up the continental slope and onto the inner continental shelf (at depths of less than 50 m), where it results in phytoplankton blooms at the surface (Pattiaratchi 2007). The phytoplankton blooms provide the basis of an extended food chain characterised by feeding aggregations of small pelagic fish, larger predatory fish, seabirds, dolphins and sharks (Pattiaratchi 2007), making the region rich in biodiversity.

6 Naturaliste Plateau

National and/or regional importance

The Naturaliste Plateau is a complex and unique seafloor feature in an area of convergence for numerous water bodies and currents. Both benthic and demersal habitats within the feature are of conservation value. It is the only seafloor feature in the region that interacts with the subtropical convergence front.

Values description

The Naturaliste Plateau lies west of Cape Leeuwin and Cape Naturaliste, and is Australia's deepest temperate marginal plateau. It extends approximately 400 km east–west and 250 km north–south, covering approximately 90 000 km^2 of deepwater habitat (depths of 2000–5000 m). It is relatively flat with a slight northward dip, and has steep southern and western sides and a more gently sloping northern side. It is bordered by the South Australian Abyssal Plain in the south and the Perth Abyssal Plain in the west and north, and is separated from continental Australia by the Naturaliste Trough to the east. A terrace feature is present on the steep southern side of the plateau between 4500 m and 5000 m, before the margin grades into the abyssal plain (Borissova 2002; Harris et al. 2005). The plateau marks the boundary between Australia's western and southern continental margin (Borissova 2002).

Although very little is known about the marine life of this plateau, the combination of its structural complexity, mixed-water dynamics and relative isolation indicate that it supports deepwater communities with high species diversity and endemism (DEWHA 2007). The plateau acts as an underwater 'biogeographical island' on the edge of the abyssal plain, providing habitat for fauna unique to these depths. The plateau is also within a deep eddy field that is thought to be associated with high productivity and aggregations of marine life. Proximity to the nearby subtropical convergence front is thought to have a significant influence on the biodiversity of the plateau (DEWHA 2007).

7. Diamantina Fracture Zone

National and/or regional importance

The Diamantina Fracture Zone is recognised as a unique seafloor feature with ecological properties of regional significance (biodiversity). Both benthic and demersal habitats within the feature are of conservation value. The area is expected to sustain habitats similar to those occurring on and around the Tasmanian Seamounts in the South-east Marine Region (Richardson, Mathews & Heap 2005). This area encompasses the deepest known points in Australia's exclusive economic zone, reaching depths over 6000 metres.

Values description

The Diamantina Fracture Zone is a structurally complex area of extremely rugged topography south of the Naturaliste Plateau. It is a deepwater environment composed of numerous closely spaced troughs and ridges, with a characteristic east–west orientation (Stow 2006). Covering more than 100 000 km^2, the zone extends from Broken Ridge (95° E) in the Indian Ocean to 120–125° E (Richardson, Mathews & Heap 2005). The ridges within the fracture zone can rise up to 4000 m from the sea floor which, together with seamounts, may affect water dynamics and flow and increase productivity. While research on the area is limited, the fracture zone's size, physical complexity and isolation indicate that it is likely to support deepwater communities characterised by high species diversity and endemism. The ridge and seamount features across the fracture zone may act as stepping stones for species dispersal and migration across the zone and the wider abyssal plain. The Diamantina Fracture Zone is up to 200 km wide, and provides unique and varied deepwater habitats (Richardson, Mathews & Heap 2005).

Such complex topography results in highly variable environmental conditions, such as depth, temperature, trophic conditions and ocean current systems (Heinz et al. 2004 in Richardson, Mathews & Heap 2005). This range of environmental conditions may create distinctive community structures, and has the potential to support a variety of unique habitat types. Previous work in the South-east Marine Region and other regions show that seamounts and pinnacles support highly productive biological communities with diverse species composition. They can create obstacles to current flow, causing eddies and circular currents, turbulent mixing and localised upwelling and downwelling. These physical processes may result in increased local primary and secondary productivity and the trapping of particles, nutrients or organisms (Richardson, Mathews & Heap 2005). This accumulation of particles and nutrients promotes phytoplankton growth, which in turn encourages a variety of marine life, such as whales and dolphins, fish species and benthic biota. As with the Naturaliste Plateau, seamounts may act as isolated 'biological islands' on the abyssal plain, or 'stepping stones' for species dispersal and migration (Wilson & Kaufman 1987 in Richardson, Mathews & Heap 2005).

8. Albany canyon group and adjacent shelf break

National and/or regional importance

This feature has important conservation value for its high productivity, aggregations of marine life, and as a unique seafloor feature with ecological properties of regional significance. Both benthic and demersal habitats within the feature are of conservation value.

Values description

The Albany canyon group extends 700 km from Cape Leeuwin to east of Esperance, Western Australia (from 115° E to 124° E). The group consists of 32 canyons that cut deeply into steep continental slope. The canyon system extends from Broke Canyon in the west, to the Albany, Vancouver, Wilyunup, Bremer and Malcolm canyons to the east. These submarine canyons start on the uppermost continental slope and extend up to 90 km offshore, reaching the lowermost slope and extending onto the abyssal plain (Exon et al. 2005). Sonar surveys have shown individual canyons up to 90 km long and to depths of 2000 m.

In contrast to other canyon systems in the region, the Albany canyon group is immediately adjacent to, and interacts with, a large section of continental shelf break. The area is thought to be associated with small, periodic subsurface upwelling events (Pattiaratchi 2007) that may drive localised regions of high productivity, contributing to the ecological functioning and integrity of this area. The canyons are known to be a feeding area for the sperm whale (Bannister, Kemper & Warneke 1996) and sites of orange roughy aggregations (Caton & McLoughlin 2004). Anecdotal evidence also indicates that this area supports fish aggregations that attract large predatory fish and sharks.

Canyons in the Albany canyon group are numerous and closely spaced, and connect a wide range of depth-related habitat types. Some canyons may be interconnected. The majority of canyons in the group cut into the shelf or occur just off the shelf edge—these cutting canyons experience high sediment load from offshore transport and receive organic material from productive shelf waters (Richardson, Mathews & Heap 2005). Areas with numerous, closely spaced canyons, such as the Albany canyon group, may allow high amounts of organic matter to reach the abyssal plain. Therefore, biodiversity may be higher on the abyssal plain in regions of closely spaced canyons (Richardson, Mathews & Heap 2005).

9. Commonwealth marine environment surrounding the Recherche Archipelago

National and/or regional importance

The Commonwealth marine environment surrounding the Recherche Archipelago is an area of important conservation value for its aggregations of marine life, biodiversity and endemism. Both benthic and demersal communities within the feature are of conservation value. The Recherche Archipelago on the shelf is the most extensive area of reef in the Commonwealth marine environment of the south-west region (35 203 km^2 of reef habitat). The reef and seagrass habitats support a high species diversity of fish, molluscs, sponges and macroalgae.

Values description

The Recherche Archipelago is a chain of approximately 105 islands and 1500 islets extending over 470 km of coastline near Esperance, Western Australia. The archipelago is a region of high biodiversity, endemism and aggregations of marine life that can be attributed to the mosaic of macroalgae-dominated rocky reef, seagrass, sand and rhodolith habitats (Dambacher, Rochester & Dutra 2009; DEWHA 2007; Kendrick et al. 2005). Its reef and seagrass habitats support a high diversity of warm temperate species, including 263 known species of fish, 347 species of molluscs, 300 species of sponges and 242 species of macroalgae. Demersal fish and invertebrates represent important components of these communities, and are thought to be tightly coupled with the pelagic fish community (Dambacher, Rochester & Dutra 2009; Kendrick et al. 2005). High levels of endemism span multiple trophic spectrums (Kendrick et al. 2005). The islands also provide resting areas and breeding sites for Australian sea lions and New Zealand fur seals. The archipelago forms a protected setting with sediment accumulation on the leeward (north-eastern) side of islands. This sheltered environment is important for commercial fisheries such as abalone, pilchard, shark and southern rock lobster (Baxter 2003).

The archipelago is influenced by large, deeply abrading ocean swells that erode the shelf to depths of approximately 100 m, with greatest abrasion between 50 m and 90 m depths. This makes the region one of the highest energy sites in Australia (Kendrick et al. 2009). The influence of the Leeuwin Current as far east as the archipelago is evident from the occurrence of warm-water foraminifera and algae (Richardson, Mathews & Heap 2005). The east-moving Leeuwin Current maintains a nutrient-poor water column, where primary productivity is limited by nitrogen (Condie & Dunn 2006; Kendrick et al. 2009). Consequently, there is deep light penetration and primary production to depths of 50 m from seagrass and macroalgae.

10. Ancient coastline between 90 m and 120 m depth

National and/or regional importance

This area has important conservation value for its high productivity, aggregations of marine life, biodiversity and endemism. Both benthic habitats and associated demersal communities are of conservation value.

Values description

The continental shelf of the South-west Marine Region contains several terraces and steps, reflecting the gradual increase in sea level across the shelf that occurred during the Holocene. Some of these features are escarpments, with their elevation and distinctness varying throughout the region. Where they are prominent, they create topographic complexity that may facilitate benthic biodiversity; create small, localised upwellings due to local acceleration of water movements; and increase biological productivity.

While the ancient coastline is present throughout the region, it is particularly evident in the Great Australian Bight, where it provides complex habitat for a number of species. A prominent escarpment occurs close to the middle of the continental shelf off the Great Australian Bight at a depth of approximately 90–120 m. Experts suggest that parts of this ancient coastline may support some demersal fish species travelling across the continental shelf to the upper continental slope, thereby supporting ecological connectivity. Benthic biodiversity and productivity occur where the ancient coastline forms a prominent escarpment, such as in the western Great Australian Bight, where it is dominated by sponge communities of significant biodiversity and structural complexity. Large sponges up to 1 m across have been recorded from this area—large individuals at these depths are likely to be many decades old.

11. Kangaroo Island Pool, canyons and adjacent shelf break, and Eyre Peninsula upwellings

National and/or regional importance

These features have conservation value for high or increased productivity, and for aggregations of marine life. The Kangaroo Island canyons are a unique seafloor feature with ecological properties of regional significance. Stretching from Kangaroo Island to the west of the Eyre Peninsula, seasonally predictable local upwellings of nutrient-rich water make this area of regional ecological importance. Values apply to the benthic and pelagic habitats of these features.

Values description

The Kangaroo Island canyons include a small group of steep-sided, narrow canyons that begin at the eastern end of the Ceduna Terrace and continue to the Murray Canyons in the adjoining South-east Marine Region. Seasonal undersea currents interact with the canyons to bring food from the deep ocean to the surface,
creating the Kangaroo Island Pool. Very little is known about the connectivity between this extensive canyon system on the deep slope and the shelf. It is thought that blind canyons (those that do not encroach onto the shelf) on the Eyre and Ceduna terraces may act as conduits for deepwater upwelling, which may be important for whale feeding.

The Kangaroo Island canyons and Eyre Peninsula upwellings are associated with high productivity that attracts seasonal aggregations of marine life. Seasonal upwellings are believed to be an important factor that increases production of plankton communities. These upwellings support aggregations of krill, small pelagic fish and squid, which in turn attract marine mammals (e.g. pygmy blue whales, fin whales, sperm whales, dolphins and New Zealand fur seals), sharks, large predatory fish and seabirds. Anecdotal evidence indicates that orange roughy, blue grenadier and western gemfish aggregate here, and are also thought to spawn in this area—empirical evidence shows that orange roughy eggs occur in high densities. The canyons are also thought to be an important pupping area for school shark (Pattiaratchi 2007) and the adjacent shelf break is known for high yields of giant crab and southern rock lobster.

The main area of upwelling is the Kangaroo Island Pool along the 100 m depth contour (offshore and to the west of Kangaroo Island). During summer (November to April), periods of south-easterly winds cause a cold tongue of water to propagate from this pool and extend past the mouth of the Spencer Gulf towards the coast of the western Eyre Peninsula, where it reaches the surface around several rocky headlands. These summer upwellings are mainly wind driven and occur as relatively predictable, seasonal pulses.

Collectively, these features support high productivity during the summer and autumn months, which contributes to the ecological functioning and integrity of these systems (Dambacher, Rochester & Dutra 2009). During these months, coastal upwelling of cold, nutrient-rich water from the Flinders Current (a boundary current that flows westward along the shelf slope) supports high phytoplankton productivity. This in turn leads to high zooplankton production, which attracts feeding aggregations of small pelagic fish (especially sardines and anchovies) and higher trophic groups including southern bluefin tuna, seabirds and marine mammals (e.g. pygmy blue whales and sperm whales) (Dambacher, Rochester & Dutra 2009; Hayes et al. 2008; Ward et al. 2006). Primary and secondary production, and fish production, are relatively high for Australian waters.

12. Meso-scale eddies (several locations)

National and/or regional importance

These features are recognised as pelagic habitats that have important conservation value for their high productivity and for aggregations of marine life. These sites are important food sources, particularly for mesozooplankton, given the broader region’s nutrient-poor conditions, and they become prey hotspots for a complex range of higher trophic-level species. Meso-scale eddies and seasonal upwellings play a critical role in species distribution, allowing tropical and subtropical species to become established in areas further south than they otherwise would (Hayes et al. 2008).

Values description

Driven by interactions between currents and bathymetry, persistent meso-scale eddies form regularly (three to nine eddies per year) within the meanders of the Leeuwin Current. These features range between 50 km and 200 km in diameter and typically last more than five months. They form in predictable locations, particularly in the western and south-western shelf break regions (e.g. south-west of Shark Bay, the western edge of the Houtman Abrolhos Islands, south-west of Jurien Bay, Perth Canyon, south-west of Cape Naturaliste and Cape Leeuwin, and south of Albany, Esperance and the Eyre Peninsula). The eddies are important transporters of nutrients and plankton communities, taking them far offshore into the Indian Ocean where they are consumed by oceanic communities.

Meso-scale eddies form within unstable meanders of the Leeuwin Current as it flows south along the west Australian shelf break, and may be triggered by interactions between the north-flowing Leeuwin Undercurrent, local bathymetric features (e.g. the Perth Canyon) and the Leeuwin Current (Rennie, Pattiaratchi & McCauley 2007; Waite et al. 2007).

Meso-scale eddies are observed in surface ocean currents as bodies of water that typically occur in counter-rotating pairs or triplets. Eddies are identified through satellite altimeter data. Cyclonic (clockwise-rotating) eddies and anticyclonic (anticlockwise-rotating) eddies have cold and warm core surface signatures, respectively (Feng et al. 2007). Mesoscale eddies with cold and warm core surface signatures are important regions of high productivity that contribute to the ecological functioning and integrity of the broader region. Cyclonic eddies are thought to play an important role in lifting deep water (which can be relatively cooler and richer in nutrients) toward the surface, where it can increase production of plankton communities that attract aggregations of marine life. Anticyclonic eddies support production at their centre (through entrainment) and perimeters (through advection and mixing of nutrient-rich waters) (Feng et al. 2007). Anticyclonic meso-scale eddies are important features of the South-west Marine Region because they are consistently associated with high phytoplankton biomass; transport coastal phytoplankton communities offshore; and support much larger communities of phytoplankton than the surrounding waters (Moore et al. 2007; Thompson, Pesant & Waite 2007). They therefore provide an important food source for mesozooplankton in otherwise oligotrophic waters (Waite et al. 2007).

It is highly probable that these features attract a range of organisms from the higher trophic levels, such as marine mammals, seabirds, tuna and billfish (DEWHA 2007), although further research is required to confirm this. These eddies play a critical role in determining species distribution, as they influence the southerly range boundaries of tropical and subtropical species, the transport of coastal phytoplankton communities offshore and recruitment to fisheries (Feng et al. 2007; Hayes et al. 2008). Eddy systems may have a profound effect on pelagic production in the region, driving offshore production by transporting nutrients and entire pelagic communities offshore, and also generating upwellings of nutrient-rich deeper water. However, these processes have not yet been studied in detail. A major challenge to understanding their importance in the region is the complexity and variability of eddy systems.

13 Demersal slope and associated fish communities of the Central Western Province

National and/or regional importance

This species assemblage has important conservation value for its biodiversity and endemism. Demersal fish on the slope in this bioregion have high species diversity compared with other, more intensively sampled, oceanic regions of the world. Its diversity is attributed to the overlap of ancient and extensive Indo-west Pacific and temperate Australasian fauna (Williams, Koslow & Last 2001).

Values description

The western demersal slope provides important habitat for demersal fish communities. In particular, the continental slope of the Central Western provincial bioregion (which extends from the edge of the shelf to the limit of the exclusive economic zone, between Perth and the northern boundary of the South-west Marine Region) supports demersal fish communities characterised by high diversity and endemism (Williams, Koslow & Last 2001). Scientists have described 480 species of demersal fish that inhabit the slope of this bioregion, and 31 of these are considered endemic to the bioregion. A diverse assemblage of demersal fish species below a depth of 400 m is dominated by relatively small benthic species such as grenadiers, dogfish and cucumber fish.

Unlike other slope fish communities in Australia, many of these species display unique physical adaptations to feed on the seafloor (such as a mouth position adapted to bottom feeding), and many do not appear to migrate vertically in their daily feeding habits.

14. Western rock lobster

National and/or regional importance

The western rock lobster has conservation value because of its presumed ecological role on the west coast continental shelf. This species is the dominant large benthic invertebrate in this bioregion. The lobster plays an important trophic role in many of the inshore ecosystems of the South-west Marine Region. Western rock lobsters are an important part of the food web on the inner shelf, particularly as juveniles.

Values description

Within the South-west Marine Region, western rock lobsters (*Panulirus cygnus*) can be found north of Cape Leeuwin to a depth of 150 m. As an abundant and wide-ranging consumer, the western rock lobster is likely to play an important role in ecosystem processes on the shelf waters in the region (MacArthur, Hyndes & Babcock 2007).

The ecological role of western rock lobster is best understood in shallow waters (less than 10 m) where it can significantly reduce the densities of invertebrate prey, such as epifaunal gastropods, through its varied and highly adaptable diet (MacArthur, Hyndes & Babcock 2007). However, there is a lack of similar studies in deep water (greater than 20 m) in the region. The little information available for deepwater populations suggests that, in contrast to shallow water, lobsters forage primarily on animal prey, which is dominated by crustaceans such as decapod crabs and amphipods (MacArthur, Hyndes & Babcock 2007). However, there are no quantitative data to indicate the significance of their foraging behaviour on deepwater ecosystems in the region.

Despite the limited information currently available about the ecological role of western rock lobster, the presumption that it has a significant ecological role is supported by research elsewhere (e.g. Tasmania, New Zealand, South Africa and North America), where marine reserves have helped identify significant interactions between lobster and prey species (MacArthur, Hyndes & Babcock 2007).

The species plays an important trophic role in many of the inshore ecosystems on the inner shelf, particularly during the post-larval puerulus phase. The life-cycle of the western rock lobster is complex. Spawning and egg hatching occur in late spring to summer, typically in water depths of 40 m or more. The summer hatching and night-time aggregation of phyllosoma in surface water coincides with maximal wind-generated offshore surface transport vectors, resulting in offshore larval dispersal into the Indian Ocean and beyond the influence of the Leeuwin Current. The phyllosoma life stage lasts 9–11 months during which time the larvae become widely distributed throughout the south-eastern Indian Ocean, at distances greater than 1500 km from the Western Australian coast. Late larval stages are known to aggregate at depths of 50–120 m, particularly during the day, and are therefore subject to subsurface circulation features resulting in a net transport of late phyllosoma larvae back to the Australian coast. Late phyllosoma larvae metamorphose into a post-larval puerulus beyond or just on the edge of the continental shelf. During this life stage, the puerulus, or juvenile lobsters, swim across the shelf waters to settle in shallow inshore reefs where they remain for three to four years, before migrating to deeper waters in summer to spawn and complete the lifecycle. While on the inshore reefs, they become important prey for a range of species, including octopus, cuttlefish, baldchin groper, blue groper, dhufish, pink snapper, wirrah cod, breaksea cod and Australian sea lions (Hayes et al. 2008). The high biomass of rock lobster, combined with its vulnerability to predation, suggests it is an important trophic pathway for a range of inshore species, many of which also inhabit the Commonwealth marine environment. These large invertebrates figure prominently in food webs of other key ecological features, such as the Commonwealth marine environment surrounding the Houtman Abrolhos Islands. Western rock lobsters are particularly vulnerable to predation during seasonal moults from November to December and, to a lesser extent, during April and May.

Puerulus settlement peaks between September and January and strongly correlates with the strength of the Leeuwin Current (Caputi et al. 1996 in Hayes et al. 2008). The strength of the Leeuwin Current therefore has a strong influence on the commercial catch of western rock lobster, and is used as an indicator of the likely state of the fishery in three to four years' time. Recent environmental conditions have not been conducive to high puerulus settlement, with water temperature and westerly winds both below average. The past two years have seen the lowest catches on record (WA DF 2010).

15. Benthic invertebrate communities of the eastern Great Australian Bight

National and/or regional importance

This species group has conservation value in its biodiversity. The carbonate province is an iconic feature, both on the Australian margin and in the world. This region has been recognised for its global significance for cool-water carbonate habitats, and has been used as a type-case example for shallow cool-water environments seen in the rock record (Richardson, Mathews & Heap 2005).

Values description

Benthic invertebrate communities of the eastern Great Australian Bight shelf are highly biodiverse, soft sediment ecosystems. A 2002 survey of benthic marine life sampled 797 species, including 360 species of sponge, 138 ascidians and 93 bryozoans, many of which were new to science (Ward et al. 2006). The shelf is part of the world's largest cool-water carbonate province (i.e. an area characterised by calcareous communities such as bryozoans, molluscs and foraminifera). It is an iconic feature that has had little or no terrestrial input (fresh water or sediments), and does not experience the seasonal oceanic upwelling that occurs in other temperate latitude-parallel shelves. Geomorphology, sedimentology and hydrodynamics interact to create ideal conditions for cool-water carbonate production. As a result, carbonate sediments make up more than 80 per cent of shelf sediments (James et al. 2001). Hydrodynamically, seasonal upwelling across the Great Australian Bight brings nutrients from the deep ocean onto the shelf. This upwelling is proportional to the amount of carbonate production, and therefore regulates the carbonate factory (James et al. 1994, 2001 in Richardson, Mathews & Heap 2005).

The high biodiversity has been attributed to the unusual width of the continental shelf, geographic isolation from similar habitats, and opportunities for incursions by tropical species in the Leeuwin Current (which reaches as far as the eastern Great Australian Bight). The benthic invertebrate communities found on the shelf, particularly sponges, ascidians and bryozoans, have been described as among the world's most diverse soft sediment ecosystems.

The shelf of the Great Australian Bight constitutes one of the world's largest temperate carbonate platforms, covering approximately 260 000 km^2 (James et al. 2001). Surface sediments are dominated by heterozoan carbonate fragments comprising bryozoans, molluscs, porifera, rhodoliths and other invertebrates (Richardson, Mathews & Heap 2005). Unimpeded south-westerly waves and swells create a high-energy environment that can create wave abrasion at depths of up to 60 m. In deeper environments, sediments are moved intermittently during winter storms, transporting fine-grained sediments off-shelf—this is the major physical process down to approximately 120 m (James et al. 2001). Epifaunal assemblages of macroinvertebrates are dominated by filter feeders (primarily porifera, but also ascidians and bryozoans), which provide habitat and resources for a diverse community of crustaceans and molluscs (Ward et al. 2006). The relative abundance of these filter-feeding communities is largely determined by the availability of deepwater nutrients, which is controlled by processes of upwelling and downwelling across the shelf (James et al. 2001). There is a significant positive relationship between species richness and biomass, both of which decline with increasing depth and increasing percentage of fines (mud) in sediment (Ward et al. 2006).

This feature includes the Great Australian Bight Marine Park, with its Benthic Protection Zone that is within a region that experiences year-round downwelling and arrested carbonate production (James et al. 2001). Ward et al. (2006) and Currie, Sorokin and Ward (2009) found that the Benthic Protection Zone effectively represents the regional biodiversity and epifaunal assemblages of the eastern Great Australian Bight (Dambacher, Rochester & Dutra 2009).

16. Small pelagic fish of the South-west Marine Region

National and/or regional importance

This species group has conservation value for its ecological role. Small pelagic fish are an extremely important component of pelagic ecosystems, providing a link between primary production and higher predators, such as other fish, sharks, seabirds, seals and cetaceans. Small pelagic fish are known to occur in a number of bioregions within the South-west Marine Region, but particular interest lies in their occurrence and ecological role in the Great Australian Bight and the fisheries off Gulf St Vincent and Spencer Gulf (Hayes et al. 2008).

Values description
'Small pelagic fish' refers to shoaling, epipelagic fish that are supported by summer upwelling events in the Bonney and Eyre pelagic ecosystems. This species group is considered important for ecological functioning and integrity, providing critical links between primary production and higher predators (Freon et al. 2005). In the South-west Marine Region, the small pelagic fish include ten species: sardine, scaly mackerel, Australian anchovy, round herring, sandy sprat, blue sprat, jack mackerel, blue or slimy mackerel, red bait and saury. Collectively, they are an important prey item for a diverse range of species including tuna, whales, dolphins, seals, sea lions and numerous seabirds (Hayes et al. 2008). Fluctuations in abundance of small pelagic fish have serious implications for the functioning of pelagic ecosystems. Some predatory species (such as southern bluefin tuna, pygmy blue whale, southern right whale, short-tailed shearwater and petrel) migrate annually during the upwelling season to take advantage of the increased prey opportunities, while others (e.g. New Zealand fur seal and crested tern) establish colonies next to these regions. This group of fish also supports Australia's largest fishery (by weight), the South Australian Sardine Fishery. This fishery suffered mass mortality events in 1995 and 1998, when more than 70 per cent of the adult stock was thought to have perished. The distribution and abundance of anchovy expanded during these events, but this has since decreased as stocks of sardine recovered (Ward et al. 2008).

During winter, the surface waters of the Eyre and Bonney coastal systems are dominated by the Leeuwin Current, the east-flowing South Australian Current and wind-driven coastal currents. These currents create downwelling throughout the system. In summer, the Leeuwin Current weakens and the coastal currents flow in the opposite direction, encouraging episodic upwelling of nutrient-rich water off Kangaroo Island and the Bonney coast. Summer upwelling in the Eyre and Bonney coastal systems, together with nutrient-rich water within the euphotic zone, supports a herbivorous food web; a large and important group of small pelagic fish; and a range of predatory fish, mammals and seabirds (Hayes et al. 2008).

17. Vulnerabilities and pressures

Key ecological features are large and complex ecological systems made up of diverse habitats and ecological communities and supporting ecosystem processes that are important for the region's marine environment and its biodiversity. The assessment of the level of concern associated with pressures on the key ecological features has taken into account been undertaken in circumstances where, while it is possible to clearly identify key ecological features based on our knowledge of large scale ecosystem function, there is comparatively limited knowledge about how ecosystem function and structure will respond to pressures. Data of the current distribution of human activities and their future patterns of development have also been taken into account (see Clifton 2007). In the context of the complexity that characterises key ecological features, there is uncertainty about the implications of environmental pressure at different spatial, temporal and ecological scales. Because of this, the pressure assessment presented below must by necessity be viewed as a 'broad-brush' assessment aimed at guiding further consideration and research (see also section 18).

The findings of the pressure assessment are summarised in Figure 2.

Key ecological feature	Pressure																			
	Sea level rise	Changes in sea temperature	Change in oceanography	Ocean acidification	Chemical pollution / contaminants	Nutrient pollution	Changes in turbidity	Marine debris	Noise pollution	Light pollution	Physical habitat modification	Human presence at sensitive sites	Nuisance species	Extraction of living resources	Bycatch	Oil pollution	Collisions with vessels	Collision/entanglement with infrastructure	Disease	Invasive species
1. Commonwealth marine environment surrounding the Houtman Abrolhos Islands	of concern	of concern	of concern	of potential concern	of potential concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of potential concern	of less or no concern	of less or no concern	of potential concern	of potential concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern
2. Perth Canyon and adjacent shelf break, and other west coast canyons	of less or no concern	of concern	of concern	of potential concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of potential concern	of potential concern	of potential concern	of potential concern	of less or no concern	of less or no concern	of less or no concern
3. Commonwealth marine environment within and adjacent to the west coast inshore lagoons	of potential concern	of concern	of concern	of potential concern	of potential concern	of potential concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of potential concern	of less or no concern	of less or no concern	of potential concern	of potential concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of potential concern
4. Commonwealth marine environment within and adjacent to Geographe Bay	of potential concern	of concern	of concern	of potential concern	of potential concern	of potential concern	of potential concern	of less or no concern	of potential concern	of less or no concern	of potential concern	of less or no concern	of less or no concern	of potential concern	of less or no concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of potential concern
5. Cape Mentelle upwelling	of less or no concern	of concern	of concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of potential concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern
6. Naturaliste Plateau	of less or no concern	of potential concern	of potential concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern
7. Diamantina Fracture Zone	of less or no concern	of potential concern	of potential concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern
8. Albany Canyon group and adjacent shelf break	of less or no concern	of potential concern	of potential concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern
9. Commonwealth marine environment surrounding the Recherche Archipelago	of potential concern	of concern	of concern	of potential concern	of potential concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of potential concern	of potential concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of potential concern
10. Ancient coastline between 90 and 120 m depth	of less or no concern	of potential concern	of potential concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of potential concern	of less or no concern	of less or no concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern
11. Kangaroo Island Pool, canyons and adjacent shelf break, and Eyre Peninsula upwellings	of less or no concern	of concern	of concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of potential concern	of potential concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern
12. Meso-scale eddies (several locations)	of less or no concern	of concern	of concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern
13. Demersal slope and associated fish communities of the Central Western Province	of less or no concern	of potential concern	of potential concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of potential concern	of less or no concern	of potential concern	of less or no concern	of less or no concern	of potential concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern
14. Western rock lobster	of potential concern	of concern	of concern	of potential concern	of less or no concern	of less or no concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of potential concern	of less or no concern	of less or no concern	of potential concern	of less or no concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern
15. Benthic invertebrate communities of the eastern Great Australian Bight	of less or no concern	of potential concern	of potential concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern
16. Small pelagic fish of the south-west marine region	of less or no concern	of concern	of concern	of potential concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of less or no concern	of potential concern	of less or no concern

Figure S1.2 Assessment of the level of concern associated with the effects of pressures on key ecological features of the South-west marine region

(red)	of concern	(yellow)	of potential concern
(blue)	of less or no concern		

Sea level rise

Global sea levels rose about 20 cm between 1870 and 2008. The Intergovernmental Panel on Climate Change projections are for a rise of 18–79 cm above 1990 levels by 2095. Sea levels are currently rising at near the upper end of current projections and will continue to rise in response to increasing concentrations of greenhouse gases. Higher sea level rises could occur (Church et al. 2009).

Sea level rise is *of concern* in relation to the Commonwealth marine areas surrounding the Houtman-Abrolhos Islands because of the implications for the globally important seabird populations breeding on the islands and foraging in the surrounding waters. The Houtman Abrolhos Islands (particularly the leeward islands, including Pelsaert Island) are low-lying, averaging 3 m above sea level. As many seabirds are ground-nesting species, the loss of habitat and the increased effects of storms (compounded by the predicted increase in frequency and intensity of storms) associated with sea level rise, have the potential to reduce reproductive success, as well as displace populations from their breeding areas.

Sea level rise is also *of potential concern* in relation to the Commonwealth marine areas within and adjacent to the west coast inshore lagoons and Geographe Bay; the Commonwealth marine environment surrounding the Recherche Archipelago and the western rock lobster. One of the anticipated effects of sea level rise is the increase in coastal erosion processes, which might be accompanied by an increase in sediment loads in the water column, particularly in inshore environments, and a possible loss of seagrass beds (Hobday et al. 2006). Depth ranges for macroalgae and other rocky reef species in the Commonwealth waters of the Recherche Archipelago may be affected by sea level rise. The western rock lobster is susceptible to sea level rise because it has an ecological reliance on seagrass beds, which may be affected by increased turbidity in the event that sea level rise increases the extent of coastal erosion.

Changes in sea temperature and oceanographic processes

Changes in sea temperature and oceanography are either *of potential concern* or *of concern* with respect to all key ecological features. In particular, these pressures are *of concern for* those key ecological features important for the region's productivity and for which the Leeuwin Current is considered a primary ecological driver.

Sea surface temperatures around Australia are expected to increase by 1–2 °C by 2030 and 2–3 °C by 2070 (Hobday et al. 2006). Modelling studies predict that the temperature of Australia's oceans at a depth of 500 m will also increase by up to 1 °C by 2070 (Hobday et al. 2006). The south-west of Western Australia is one of three hotspots in the Indian Ocean where rising temperature trends exceed the Indian Ocean basin average (Feng, Weller & Hill 2009). While the effects of increased sea temperature are likely to vary greatly across communities and ecosystems, there is a high level of agreement from different data sets that warming is affecting distributional ranges and growth of temperate marine fishes (Booth et al. 2009). Changes in sea surface temperature are also believed likely to result in changes to zooplankton communities, with implications for trophic dynamics (Richardson, McKinnon & Swadling 2009).

Alongside increases in temperature, changes in oceanographic processes are also anticipated in response to climate change. The strength of the Leeuwin Current has decreased slightly since the 1970s. This weakening is expected to continue, although this prediction currently has low confidence (Feng, Weller & Hill 2009). The Leeuwin Current is the basis of much of the region's biological productivity, and its strength and seasonal/climatic variability are a primary driver for the intensity, timing and locations of productivity events in the region, from the waters off Geraldton to the Great Australian Bight (Pattiaratchi 2007). The long-term implications for the region's ecosystems and its key ecological features are uncertain.

In the region, changes in sea temperature and oceanographic processes have been implicated in shifts in the distribution of marine species, changes to prey variability (including positive changes for some species, such as bridled tern) and effects on reproductive time and success (Dunlop 2009; Gaughan et al. 2002; Surman & Nicholson 2009). The structure of ecological communities of the continental shelf might be affected by climate related changes: kelps in the central and southern Houtman Abrolhos Islands are at the northern limit of their distribution—and an increase in sea surface temperature could have a direct negative affect on their distribution in the region. Seagrass habitat is particularly susceptible to climate change pressures, and projected altered oceanic circulation due to climate change is likely to affect seagrass community species composition.

Increasing sea temperatures may affect the western rock lobster lifecycle. Water temperature affects the length of time that females retain their eggs, and larval growth rates have also been linked to temperature changes (Hobday, Poloczanska & Matear 2007). The influence of ocean temperatures along the west coast of Australia is expressed through changes in the Leeuwin Current, which could reduce puerulus settlement. Puerulus settlement is poor during El Niño years, when the Leeuwin Current tends to be weak. In La Niña years, the current tends to flow more strongly and settlement is much greater. The *Western Rock Lobster Fishery ecological risk assessment* (WA DF 2005) concludes that increases in sea surface temperature, changes in the Leeuwin Current and increased storm events could alter predator and prey relationships, and influence the abundance and spatial distribution of puerulus.

Key ecological features that are driven by oceanographic processes (such as meso-scale eddies) are particularly vulnerable to changes in physical parameters (e.g. sea surface temperature, intensity and direction of currents) arising from climate change. It is likely that these changes will affect various aspects of the biology of top pelagic predators and small pelagic species, such as metabolic functions, genetic modifications, growth, concentration and retention of early life stages, recruitment, reproductive strategies and overall distribution. The Cape Mentelle upwelling is strongly associated with the Capes Current, and both the upwelling and the Capes Current depend on summer southerly winds. Southerly winds overcome the along-shore pressure gradient, moving surface water offshore, upwelling colder water onto the continental shelf and moving the Leeuwin Current offshore. Coastal winds interact with the Leeuwin Current to produce this seasonal upwelling. Changes to the Leeuwin Current, the summer winds and ocean circulation are likely to affect the presence and intensity of the upwelling, and therefore the productivity and aggregations of marine life that it supports. The Perth Canyon feature is also strongly influenced by the Leeuwin Current. In the Perth Canyon, interactions between the canyon topography and the Leeuwin Current induce clockwise-rotating eddies that transport nutrients from greater depths. Upwelling off Kangaroo Island is enhanced by El Niño events, in part due to the increased frequency of upwelling-favourable winds (Middleton et al. 2007), which is expected to further increase as a result of climate change (Hobday et al. 2006). This upwelling supports Australia's largest population of sardines which, in turn, supports large aggregations of predators. Changes to this productivity could have significant impacts on community structure and function (Hobday et al. 2009). Climate change may also cause substantially increased summer upwelling (and decreased downwelling in winter) in the Eyre and Bonney coastal systems if it leads to increased El Niño conditions in these systems (Hayes et al. 2008).

Ocean acidification

Ocean acidification is *of potential concern* for all key ecological features in the region. Carbon dioxide dissolving in the oceans has lowered pH by 0.1 units since 1750, representing a 30% increase in hydrogen ion (acid) concentration (pH of open ocean waters has decreased from 8.2 to 8.1). The rate of this increase is estimated to be 100 times greater than any change in acidity experienced by marine organisms in the past 20 million years (Orr et al. 2009). Projected changes in Australian waters by 2070 include a decline in pH of 0.2 units (Lawrence , Ridley & Lunty 2007).

There is a high level of uncertainty about the effects of ocean acidification on marine life. While some organisms might be able to adapt (Orr et al. 2009), anticipated changes to phytoplankton and zooplankton have the potential to detrimentally affect ecosystem processes and the structure of ecological communities. Increasing carbon dioxide levels will increase acidity, affecting many organisms that use calcium carbonate for their structures (molluscs and some phytoplankton) (Lawrence, Ridley & Lunty 2007).

Research on the impact of ocean acidification on Antarctic krill has found that increased levels of carbon dioxide kill their embryos (Kawaguchi et al. 2010). Krill are an important part of the food chain because they feed on phytoplankton and zooplankton, and are a key food source for many species that occur in Australian waters. Consequently, acidification impacts have the potential to affect species further up the food chain.

The potential effects of increased acidity on the region's biodiversity also include changes to growth and population dynamics of some shell-forming organisms, impacts on the reproductive and metabolic functions of a number of fish and invertebrate species, and sensitivity of some early-life stages to acidification (Orr et al. 2009). Ocean acidification will also reduce coral growth rates (Anthony & Marshall 2009), making reefs, including those occurring in waters surrounding the Abrolhos Islands, more susceptible to erosion and disturbance from storms.

Chemical pollution/contaminants - **nutrient pollution** and **changes to water turbidity**

Chemical and nutrient pollution and changes in turbidity are *of potential concern* for key ecological features that are close to coastal areas experiencing industrial developments, intense land use and/or large ports, or within which aquaculture development is anticipated. Chemical pollution is also *of potential concern* for the marine environment of the Perth Canyon, because of its history of dumping at sea of chemical substances[2].

The Commonwealth marine areas adjacent to the west coast inshore lagoon and to Geographe Bay are close to large ports and to coastal areas experiencing high rates of urban and industrial development. Both these key ecological features include habitats—such as seagrass beds and limestone reefs—that are important breeding and nursing areas for a range of fish and shark species, and for the western rock lobster and that might be adversely affected by changes in water quality and turbidity. In particular, the region's waters are generally low in nutrients and have low levels of turbidity (McClatchie et al. 2006); any significant increase in nutrient or sediment loads as a result of increased agricultural

[2] **http://www.hydro.gov.au/n2m/dumping/dumping.htm**

production, urban and commercial run-off and desalination plants, has potential detrimental effects for biodiversity. Geographe Bay in particular is surrounded by agricultural lands on nutrient-poor, sandy soils, which have limited capacity for nutrient retention. The widespread application of synthetic fertilisers on this farmland is a likely source of the high nitrogen concentrations measured in the drainage networks entering the bay (McMahon & Walker 1998, in Dambacher, Rochester & Dutra 2009). This key ecological feature is also vulnerable to changes in turbidity, which might adversely affect the local extent and distribution of seagrass habitats. Increased run-off (the cause of turbidity changes in other parts of Australia) is not likely to be a significant source of pressure in this area due to the absence of large rivers and the anticipated dramatic decrease in rainfall predicted for the south-west corner of Australia (Hennessy, Macadam & Whetton 2006). Historically (around the 1950s), decreases in seagrass cover in Geographe Bay coincided with land clearing and drain construction, which are thought to have caused increased sediment loads (Dambacher, Rochester & Dutra 2009). High sediment loads can suppress photosynthesis in seagrass through turbidity in the water column or covering of seagrass leaves (Walker & McComb 1992 in Dambacher, Rochester & Dutra 2009). The western rock lobster is susceptible to impacts from increased turbidity because it has an ecological reliance on seagrass beds.

Future expansion of aquaculture operations in the region also has the potential to result in increased nutrients and detritus in the surrounding environment (Hayes et al. 2008), in localised eutrophication and algal blooms and in the introduction of potentially toxic chemicals (therapeutics, antifoulants). Development of finfish aquaculture in the area is being considered for a number of locations, including the Abrolhos Islands[3], off Two Rocks—north of Perth (ADC, 2007), and around Esperance and the Recherche Archipelago (WA DF 2000;).

Noise pollution

Noise pollution is *of potential concern* with respect to five key ecological features, because of their conservation significance for species known to be affected by noise disturbance and because of their location in areas where noise-generating activities are expected to increase.

Many marine animals use sound for a number of biological functions, including navigation, social communication and location of prey. There is growing concern that man-made noise impacts marine life, particularly cetaceans, because it may result in physical and/or behavioural effects on these species (DEWHA 2008). Many human activities that generate noise in the marine environment—including shipping, boating, seismic surveys—are expected to increase in the region (Clifton et al. 2007). Construction of coastal or marine infrastructure involving underwater blasting and pile driving is also increasing.

The Perth Canyon's communities and ecosystems might be detrimentally affected by multiple sources of noise, particularly in light of the significance of this feature for a number of protected large whales. Sources of noise in the marine environment of the Perth Canyon include defence activities within the Royal Australian Navy's West Australian Exercise Area (WAXA), shipping and boating traffic and seismic surveys. The marine environment surrounding the Albany Canyon group also experiences relatively high commercial shipping activity (more than five vessels per day), with expected increases in line with population growth and onshore development. Most ports in the region have or are expected to expand to accommodate larger Panamax and Capesize vessels (Clifton et al. 2007).

[3] **http://www.fish.wa.gov.au/docs/mp/mp137/summary.php?0305;** accessed March 2011

Future oil and gas exploration, construction and development in this area also have the potential to affect important areas for species that might be affected adversely by noise. The effects of seismic surveys on large whales have received the most attention in the region; however, there have also been experimental studies into the effects of seismic surveys on demersal fish (Popper, McCauley & Fewtrell 2002). As an area of high prospectivity for the oil and gas industry (and with recent acreage releases west of Kangaroo Island), there is potential for seismic exploration to affect whales that feed and nurse in the canyon. There are currently two large petroleum exploration permits in the Bremer sub-basin that overlay several canyons in the group. There has recently been a large and rapid growth in coastal development in South Australia, particularly on the Eyre and Yorke peninsulas. Increasing mining interests (such as iron ore and manganese) around Eyre Peninsula add to increased development and shipping out of Spencer Gulf.

Physical habitat modification

Physical habitat modification is *of potential concern* for those key ecological features that are either subject to bottom trawl activities, located in proximity of areas experiencing urban and industrial development, and/or inherently vulnerable to habitat modification.

Demersal trawl fishing is one activity in the region that results in physical habitat modification. On the west-coast shelf edge and slope 20 out of 48 habitat types occurring within the trawl fishery area are classified as at risk from the effects of trawling (Wayte et al. 2007). In the Great Australian Bight, trawling covers limited ground relative to the fishery area, but it is concentrated on the habitats of the shelf edge and upper slope (Williams et al 2010). The rich benthic communities of the Great Australian Bight shelf are characterised by fragile, slow-recruiting and slow-growing species (such as sponges, bryozoans and ascidians) and are particularly vulnerable to habitat disturbances (Currie, Sorokin & Ward 2008). The negative effects of demersal trawling are likely to be higher for bryozoans (which are brittle and easily broken by trawling gear) than for ascidians and porifera. In Gulf St Vincent, bryozoans suffered greater damage than porifera and ascidians after a prawn trawling event, and recruitment following trawling was lower for bryozoans than for porifera and ascidians (Tanner 2003 in Dambacher, Rochester & Dutra 2009). The habitats associated with the ancient coastline of the Great Australian Bight at depths of 80–100 m, although generally not suited to trawling, might also be subject to habitat loss and modification through the impacts of fishing gear. Recent research has identified and mapped habitat types of the Great Australian Bight, including the identification of habitat vulnerability, to inform further ecologically sustainable development of the industry (Williams et al 2010).

Other sources of benthic habitat loss or modification at more localised scales are dredging, construction of infrastructure, and laying of underwater pipelines and cables. Some inshore habitats in the region vulnerable to physical modification, such as the seagrass beds and limestone reefs of the west coast and Geographe Bay, provide important breeding and nursing areas for a number of endemic and important species, including the western rock lobster.

Extraction of living resources and **bycatch**

Extraction of living resources and bycatch have been assessed as *of potential concern* with respect to those key ecological features within which fishing activities and bycatch of non-target species occur. In the context of active fisheries management and the steady move towards ecosystem-based management of fisheries by all jurisdictions in Australia, this is a conservative assessment. However, the assessment is consistent with the pressure assessment criteria (as outlined in the *Overview of marine bioregional plans*) and it highlights the current limited understanding of both the ecosystem effects of individual fisheries and the cumulative effects of diverse fisheries on protected species, marine communities, habitats and ecosystems. For example, in relation to bycatch, a recent review of all Commonwealth fisheries found that current levels of independent observers preclude a cumulative assessment of the catch of non-target species, but recommend that such assessment is important to understand more broadly the environmental performance of fisheries and to underpin an holistic approach to the management of ecosystem impacts (Phillips et al 2010). Generally, there is also the need to increase our understanding of the effectiveness of bycatch mitigation measures (Bensley et al. 2010).

Oil pollution

Oil spills are unpredictable events and their likelihood is low—particularly in the context of the international and domestic regulatory mitigation measures that apply in Australia. Their consequences however can be severe, particularly in areas and at times of biological significance for important and/or threatened species.

Oil pollution is *of potential concern* with respect to key ecological features whose values make them particularly vulnerable to the impacts of an oil spill. For example, key ecological features associated with important aggregations of marine life at or in proximity of the sea surface, for example, the Commonwealth waters surrounding the Houtman-Abrolhos Islands, where protected seabirds forage; the Perth Canyon, where relatively large numbers of the endangered pigmy blue whale aggregate seasonally; and the cape Mentelle upwelling, which seasonally attracts feeding aggregation of pelagic invertebrates, fish and mammals.

Both the intensity and distribution of activities that might lead to oil spills – such as oil production and transport – are expected to increase in the region.

Collision with vessels

Collision with vessels is *of potential concern* for the Perth Canyon key ecological feature. The Perth Canyon is an important habitat for a number of large whale species—including the pygmy blue whale, sperm whale and beaked whales, is in close proximity to the Fremantle and Kwinana ports and it overlaps with the Royal Australian Navy's West Australian Exercise Area. The potential for ship strikes is *of potential concern* in light of anticipated increases in shipping traffic (Clifton et al. 2007). Fatal ship strikes of blue whale have been reported in the South-west Marine Region (Kemper et al. 2008). It is not known the extent to which events that occur well offshore are not detected (Kemper 2008) or ship-related deaths go unrecognised (Laist et al. 2001).

Invasive species

Invasive species are *of potential concern* with respect to key ecological features that include inner and mid shelf environments and are close to potential sources of introduced species. No marine pests[4] have been recorded in the South-west Marine Region. Four marine pest species occur in the environment of four ports adjacent to the region (Fremantle, Bunbury, Albany and Port Adelaide).

Inshore areas—particularly port areas and sites where infrastructure development and maintenance takes place—have the highest risk of marine pests becoming established. Invasive species can be introduced into marine environments through ballast water

[4] Marine pests are marine plants or animals that have the potential to significantly impact marine industries and the marine environment.

exchange or biofouling. High-risk vessels for the introduction of marine pests include those that are slow moving, have spaces where marine species can settle, or come in close contact with the sea bottom and remain in a single area for extended periods (increasing the likelihood that a species that has settled at the source locality will be introduced to new regions). Vessels in this category include dredges, supply boats, drilling rigs and some fishing boats. Other high-risk ships include some of the 'flag of convenience' carriers that are low-cost operators with poorly maintained vessels, as well as small, private recreational vessels from other parts of the world. Pest species established in the neighbouring South-east Marine Region and capable of spreading into the deeper environments of the Commonwealth marine area include Northern Pacific seastar, New Zealand screw shell and Japanese kelp.

Temperate southern Australian habitats are considered to be at great risk from introduced marine species, because of their biogeographic isolation from other temperate marine habitats of the world. Species native to the east coast of Australia present a risk, as they have evolved independently of those on the west coast and may become invasive if introduced in favourable conditions in the South-west Marine Region. McClatchie et al. (2006) identified the dispersal of non-indigenous phytoplankton via ships' ballast water as a potential pressure to phytoplankton communities in the South-west Marine Region.

Disease

Disease is *of potential concern* with respect to small pelagic fish. Two mortality events substantially reduced pilchard stocks off South Australia and Western Australia in 1995 and 1998 (Ward et al. 2001). The two events resulted in the loss of 10–15% of the stock over an extensive area, stretching from the Great Australian Bight to the tropical coast of Western Australia. The mortality was attributed to a herpes virus, which might have been introduced, although this was not conclusively demonstrated. One possibility is that the virus was introduced to the region by imported sardines fed to farmed tuna (Whittington et al. 2008), and this commercial activity is projected to increase in the near future (Dambacher, Rochester & Dutra 2009). The disease outbreaks in 1995 and 1998 caused temporary closures of the fishery, and were also thought to have had wider ecosystem impacts although the ecosystem implications were not specifically assessed. Anchovies, normally restricted to coastal embayments, expanded into the habitat vacated by sardines (Ward et al. 2001) and there were reports of changes to gannet diets and increased mortality in little penguins (Hayes et al. 2008).

18. Relevant protection measures

Alongside the EPBC Act, a broad range of sector-specific management measures to address environmental issues and mitigate impacts apply to activities that take place in Commonwealth marine areas. These measures give effect to regulatory and administrative requirements under Commonwealth and state legislation for activities such as commercial and recreational fishing, oil and gas exploration and production, ports activities and maritime transport. In some instances, as in the case of shipping, these measures also fulfil Australia's obligations under a number of international conventions for the protection of the marine environment from pollution and environmental harm.

Details about protection measures under the EPBC Act (e.g. Recovery Plans) or threatening processes (e.g. Threat Abatement Plans) which are relevant to species that are components of the key ecological features can be found in the *Species Groups Report Cards*.

Under the EPBC Act, all fisheries managed under Commonwealth legislation, and state-managed fisheries that have an export component, must be assessed to ensure that they are managed in an ecologically sustainable way over time. Fishery assessments are conducted using the *Guidelines for the ecologically sustainable management of fisheries*. In particular, Principle 2 of the Guidelines requires that fishing operations should be managed to minimise their impact on the structure, productivity, function and biological diversity of the ecosystem.

Glossary

abyssal plain
The flat, relatively featureless bottom of the deep ocean at a depth greater than 2000 m. The average depth of the abyssal plain is about 4000 m.

aggregating behaviour
The concentration of fish for direct causes (such as the concentration of food organisms or for spawning) or unknown reasons.

algae
A major group of plants without a vascular or 'vein' system, living in fresh or marine water. *See also* macroalgae, microalgae.

anticyclonic
Rotation about a vertical axis that is clockwise in the northern hemisphere and counter-clockwise in the southern hemisphere. Anticyclonic mesoscale eddies in the South-west Marine Region have a warm core surface signature.

aquaculture
Farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants with some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc.

assemblage
A collection of plants or animals characteristically associated with a particular environment, which can be used as an indicator of the health of that environment.

Australian margin
The Australian continental margin (the offshore zone), consisting of the continental shelf, slope and rise that separates the dryland portion of a continent from the deep ocean floor.

ballast water
Water carried in tanks to maintain stability when a ship is lightly loaded. It is normally discharged to the sea when the ship is loaded with cargo.

bathymetry
The measurement of ocean depths to determine the seafloor topography.

benthic
Living on or in the bottom of the sea.

biodiversity

Variability among living organisms from all sources (including terrestrial, marine and other ecosystems and ecological complexes they are part of). This includes diversity within species and between species, and diversity of ecosystems.

biofouling
Undesirable growth of marine organisms on underwater surfaces such as ship hulls and man-made infrastructure.

biogeographic
Relating to large regions with distinct fauna and flora.

biomass
The quantity of organic matter within an ecosystem (usually expressed as dry weight per unit area or volume).

bioregion
A large area that has similar types of plants, animals and ocean conditions, compared to other similarly sized areas. In this document, 'bioregion' means provincial bioregion as defined in the Integrated Marine and Coastal Regionalisation of Australia Version 4.0.

biota
All the organisms at a particular locality.

bryozoans
Marine animals commonly known as moss animals, sea mats or (for some forms) lace coral. The majority of living bryozoans are encrusting (forming flat sheets that spread out over the substrate), but others grow upwards into the water column.

bycatch
All non-targeted catch, including by-product, discards and gear interactions. By-product refers to the unintended catch that may be kept or sold by the fisher. Discards refer to the product that is returned to the sea. Gear interactions refer to all species and habitat affected by the fishing gear.

calcareous
Mostly or partly composed of calcium carbonate.

carbonate organisms
Life forms that incorporate calcium and carbon from sea water into their skeletons or shells. They include algae, corals and bivalves. Carbonate organisms can be microscopic.

cetaceans
Members of the mammalian group Cetacea, including whales, dolphins and porpoises.

continental rise
The gently sloping surface located at the base of a continental slope.

continental shelf
The section of the seabed from the shore to the edge of the continental slope.

continental slope
The region of the outer edge of a continent between the relatively shallow continental shelf and the deep ocean.

convergence front
An interface or zone of transition between two dissimilar water masses.

crustacean
A type of arthropod that has gills and body covered by a hard shell (includes crabs, lobsters and shrimps).

cutting canyon
A canyon that incises the continental shelf.

cyclonic
Rotation about a vertical axis that is counter-clockwise in the northern hemisphere and clockwise in the southern hemisphere. Cyclonic mesoscale eddies in the South-west Marine Region have a cool core surface signature.

decapod
An order of Crustacea comprising lobsters, crabs and shrimps. Decapods have a fused head and thorax covered by a dorsal exoskeleton (carapace) made from chitin, and five pairs of legs.

demersal
Living on or near the bottom of the sea.

detritus
Any loose debris, such as finely divided rock or the remains of animal or plant tissue.

downwelling
A downward current of surface water in the ocean.

echinoderms
Marine animals with an internal skeleton of calcite plates and a water-vascular system that allows movement, breathing, nutrition or perception. Echinoderms include starfishes, sea cucumbers, sand dollars, brittle-stars, basket stars, sea lilies, feather stars and sea urchins.

ecological community
According to the *Environment Protection and Biodiversity Conservation Act 1999*, an ecological community is an assemblage of native species that: (a) inhabits a particular area in nature; and (b) meets the additional criteria specified in the regulations (if any) made for the purposes of this definition. More broadly, an ecological community is a group of species that commonly occur together in a way that is recognisably different from other groups.

ecosystem
A dynamic complex of plant, animal and microorganism communities and their non-living environment that interacts as a functional unit.

eddy (pl. eddies)
Circular movements of water formed on the side of a main current.

El Niño
Warming of the surface of the tropical east Pacific Ocean accompanied by high air surface pressure in the western Pacific. El Niño is often associated with drier conditions in eastern Australia.

endemic
Native to a particular area and found nowhere else.

epifauna
Animals living attached to rocky reefs or on the seafloor. They include hydroids, sea-pens, small bryozoans and sponges (compare to infauna).

epiphyte
A plant that grows on another plant.

exclusive economic zone
The sovereign waters of a nation, recognised internationally under the United Nations Convention on the Law of the Sea as extending out 200 nautical miles from shore.

fauna
The entire group of animals found in an area.

flora
The entire group of plants found in an area.

gastropod
A marine snail.

geomorphology
The study of landforms and the processes that shape them.

infauna
Animals living in the sandy or muddy surface layers of the ocean bottom, that either bury themselves or dig into the substrate (compare to epifauna).

invasive species
A species occurring, as a result of human activities, beyond its accepted normal distribution and which threatens valued environmental, agricultural or other social resources by the damage it causes.

invertebrate
An animal without a backbone (includes insects, worms, snails, mussels, prawns and cuttlefish).

invertivore
An animal that eats invertebrates.

krill
Shrimp-like marine crustaceans (also known as euphasiids) that occur in dense swarms. They feed on diatoms (a group of algae) and are the main food of filter-feeding whales. Krill are up to 5 cm long and are found in both surface and bottom waters.

La Niña
Warming of the western equatorial Pacific warm pool, north of New Guinea, accompanied by cooling in the equatorial eastern Pacific Ocean. La Niña is often associated with above-average rainfall in eastern Australia.

macroalgae
Large, visible algae, such as kelp.

meso-scale
Of intermediate size (e.g. hundreds of kilometres).

microalgae
Microscopic algae that form phytoplankton.

oligotrophic
Characterised by low levels of nutrients and plant life.

pelagic
Associated with the surface or middle depths of the water column (e.g. fish swimming freely in the open sea).

phytoplankton
Small plants, mostly microscopic, that are suspended in water and free-drifting.

piscivore
An animal that eats fish.

productivity
The ability of an ecosystem to produce, grow or yield products, whether trees, fish or other organisms. Productivity can be biological or ecological.

propagule
A dispersive structure such as a seed, fruit, eggs or sperm, released from a parent organism for reproductive purposes.

prospective
The likelihood of finding commercial mineral deposits.

province
A large-scale biogeographic unit derived from evolutionary processes in which suites of endemic species coexist.

recruitment
The influx of new members into a population by reproduction or immigration.

sediment
Naturally occurring material that is broken down by processes of weathering and erosion, and is subsequently transported by the action of fluids such as wind, water, or ice, and/or by the force of gravity acting on the particle itself.

shelf break
The area of the seabed where the continental shelf meets the steeper slope; commonly around depths of
200 m.

spawning
A reproductive strategy where eggs and sperm are released into water.

stock
A group of individuals of a species, usually occupying a particular spatial range. Stocks are a unit for managing and assessing fisheries.

subtropical
Relating to or occurring in a region intermediate between tropical and temperate.

temperate
The regions in which the climate undergoes seasonal changes in temperature and moisture. Temperate regions of the earth lie primarily between 30 and 60 degrees latitude in both hemispheres.

trophic level
The position an organism occupies in a food chain. Levels include primary producers; herbivores; primary, secondary and tertiary carnivores; and decomposers.

turbidity
The cloudiness in water that is caused by particles, usually of fine sediment or microscopic particles of biological material.

upwelling
The phenomenon of deep ocean water rising to the surface, usually bringing nutrients that can increase biological productivity.

zooplankton
The animal component of the plankton community.

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