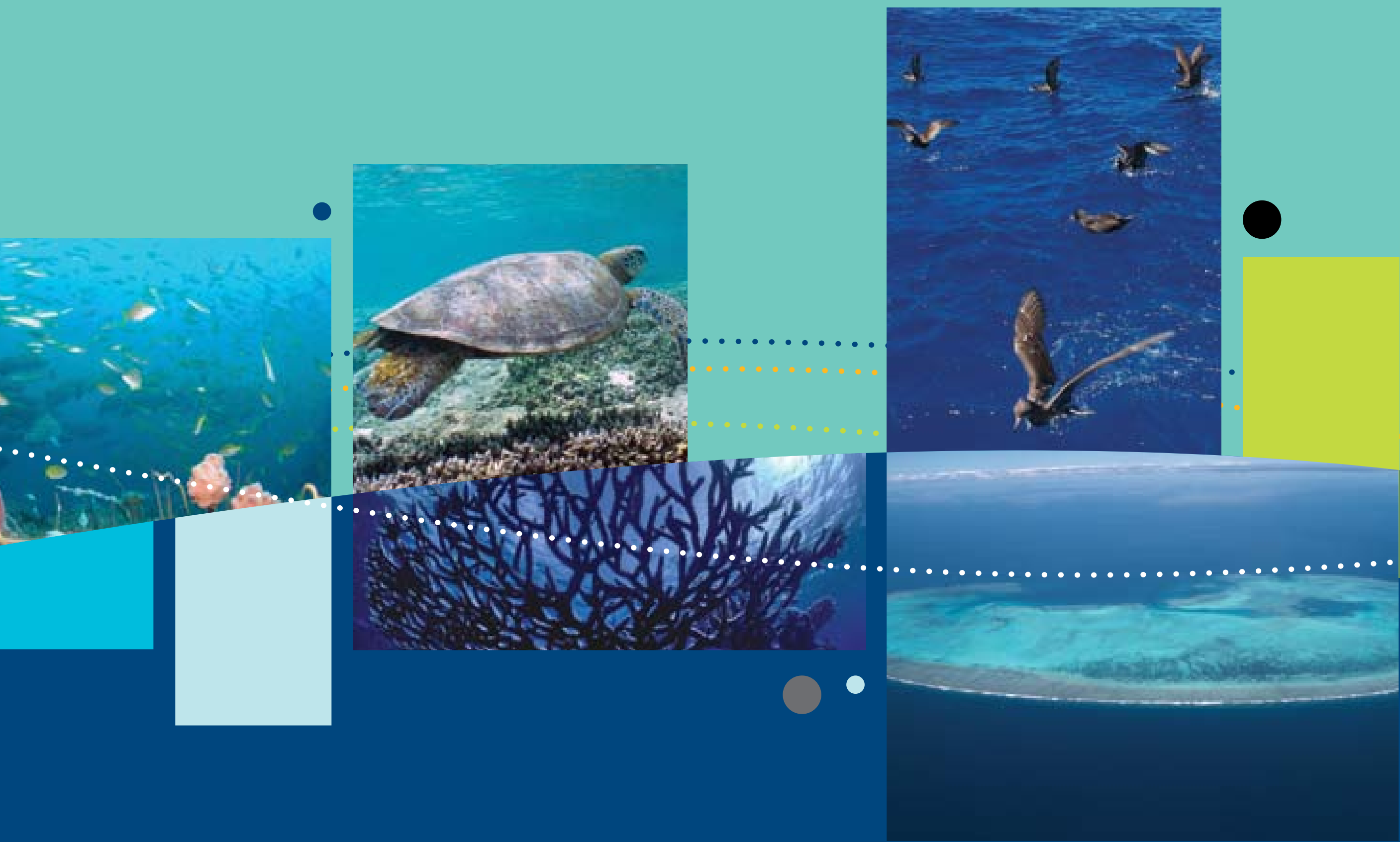
Australian Government

Department of Sustainability, Environment, Water, Population and Communities



# Commonwealth marine environment report card

## Supporting the marine bioregional plan for the Temperate East Marine Region

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

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Images:
Flesh-footed shearwater and Balls Pyramid – I.Hutton, Middleton Reef from air – Director of National Parks, Pimpernel Rock, Solitary Islands – D.Harasti, A Green turtle swims in shallows over reef top – GBRMPA, Acropora species – R.Chesher Ph.D, Runic wreck on Middleton Reef – Director of National Parks, Bottlenose Dolphins – M.Spencer, Olive Sea Snake – GBRMPA, Black-browed Albatross – M.Double, Olive Sea Snake – GBRMPA, Blue Devil – D.Harasti

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# COMMONWEALTH MARINE ENVIRONMENT REPORT CARD—TEMPERATE EAST MARINE REGION

Supporting the marine bioregional plan for the Temperate East Marine Region prepared under the *Environment Protection and Biodiversity Conservation Act 1999*

## Report cards

The primary objective of report cards is to provide accessible information on the conservation values found in 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**). A glossary of terms relevant to marine bioregional planning is located at **www.environment.gov.au/marineplans**.

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

- species group report cards
- marine environment report cards
- protected places report cards.

## Commonwealth marine environment report cards

Commonwealth marine environment report cards describe features and ecological processes and they identify key ecological features at a regional scale. Key ecological features are the parts of the marine ecosystem that are considered to be of regional importance for biodiversity or ecosystem function and integrity within the Commonwealth marine environment.

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

Commonwealth marine environment report cards:

- describe the relevant marine region
- describe each key ecological feature, outline its conservation values and detail the current state of knowledge on each feature
- assess pressures to each key ecological feature and identify the level of concern the pressure places on the conservation of each feature.

# 1. The Commonwealth marine environment of the Temperate East Marine Region

The Temperate East Marine Region comprises Commonwealth waters from the southern boundary of the Great Barrier Reef Marine Park to Bermagui in southern New South Wales, as well as the waters surrounding Lord Howe and Norfolk islands. The region covers approximately 1.47 million square kilometres of temperate and subtropical waters and abuts the coastal waters of southern Queensland and New South Wales. It extends from shallow waters on the continental shelf, 3 nautical miles (5.5 kilometres) from shore, to the deep ocean environments at the edge of Australia's exclusive economic zone, 200 nautical miles from shore (Figure 1).

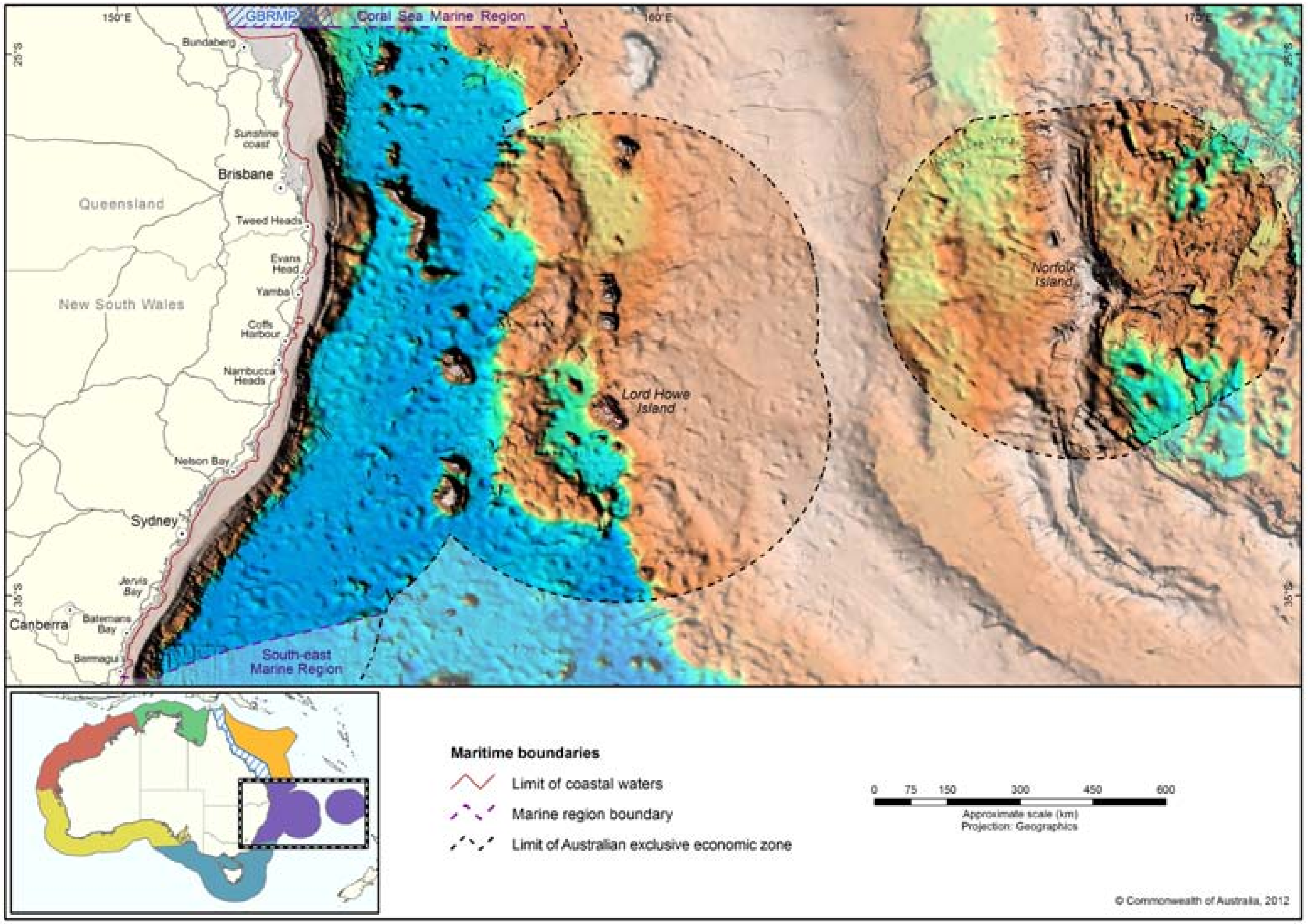


**Figure 1: Map of the Temperate East Marine Region**

The Temperate East Marine Region is physically characterised by a narrow continental shelf, significant variation in sea-floor features (including seamount chains and canyons), dynamic oceanography and a unique mix of tropical and cold water reef systems. Temperate species dominate the southern parts of the region and tropical species become progressively more common towards the north of the region.

## Physical structure of the region

The Temperate East Marine Region covers an extensive area of the shelf, slope and abyssal plain/deep ocean floor (DEWHA 2009a) and includes a range of significant geomorphic features including reefs, seamounts and canyons.

Three seamount chains extend north–south across the region: the Tasmantid seamount chain, Lord Howe seamount chain and Norfolk Ridge. These chains of submerged volcanoes and guyots support deep water coral communities and are known to aggregate a range of benthic and pelagic fish (DEWHA 2009a). Deep water reefs and densely populated sponge gardens of ascidians, bryozoans and soft corals communities are also found along the continental shelf edge and eastern continental slope (Dambacher et al. 2011). Reef features are defined by harder substrate that is usually elevated from the surrounding topography (Kloser & Keith 2010). Rocky reef habitats on Australia's east coast support a diverse assemblage of demersal fish, which show distinct patterns of association with shelf-reef habitats (Dambacher et al. 2011).

The eastern continental slope also features a large number of canyons (DEWHA 2009a). Canyons differ from other slope habitat because they have steep or rugged topography and mosaics of hard and soft substrate (Kloser & Keith 2010). Benthic megafauna such as attached sponges and crinoids are found in abundance, with high diversity at upper slope canyon depths from 150 to 700 metres (Kloser & Keith 2010).

## Ecosystem drivers

The Temperate East Marine Region spans subtropical and temperate waters that include pelagic, abyssal, seamount, canyon, reef and shelf habitats (Zann 2000, in Dambacher et al. 2011). Linking these habitats are strong ocean currents that greatly influence and structure the region's productivity and biological diversity. The East Australian Current is the dominant oceanographic influence on ecosystems in the region, bringing warm Coral Sea waters down the outer edge of the continental shelf, extending the range of tropical species into subtropical and temperate waters (Dambacher et al. 2011). Surface waters are generally of low to moderate productivity (Dambacher et al. 2011) and nutrient availability is strongly regulated by vertical mixing of the water column (Condie & Dunn 2006). Primary production in the southernmost waters of the region is generally higher due to greater vertical mixing associated with the Tasman Front and its eddies (Tilburg et al. 2002, in Dambacher et al. 2011), especially in winter and spring.

At around 33° S, the orientation of the coast changes and the East Australian Current begins to separate away from the continental shelf (Ridgway & Dunn 2003). This flow forms the Tasman Front, which plays a significant role in water mass transport through the Tasman Sea and out into the broader Pacific Ocean. A remnant portion of the East Australian Current remains close to the coast, continues southward along to Tasmania (Wyrtki 1962, in Dambacher et al. 2011). The Tasman Front marks an important meeting point between two differing water masses, the subtropical Coral and temperate Tasman Seas, representing a transition zone for the dispersal of tropical and temperate species (DEWHA 2009a). Along the front's edge, a series of large, warm-core, quasi-permanent eddies (Ridgway & Dunn 2003). These features also strongly influence community structure, even at depth. For example, tropical species are found within deep water communities on seamounts, ridges and guyots up to 700 kilometres offshore, at depths of greater than 500 metres (Cairns 2004). A similar tropical–temperate boundary also exists along the coast, between the northern tip of Fraser Island and Coffs Harbour.

## Biological diversity

The Temperate East Marine Region supports a richly diverse range of both tropical and temperate biological communities that are closely associated with the physical and oceanographic features of the region (Dambacher et al. 2011; DEWHA 2009a). Broadly, these are the:

- Tasman Sea seamounts/guyots/islands
- continental shelf
- abyssal plains and troughs
- cold-core and warm-core gyres and eddies.

The seamount chains are a dominant feature of the physical environment and have dynamic impacts on the biology of the region. Isolation and complex oceanography have given rise to distinct assemblages that have highly localised distributions (DEWHA 2009a). Communities associated with these features are typically characterised by slow-growing species (e.g. orange roughy) and exceptionally high levels of endemism (as high as 34 per cent) (de Forges et al. 2000). The isolation of these features also makes them refuges for otherwise rare species such as the black cod (DEWHA 2009a).

Against the relatively nutrient-poor waters of the region, productivity hotspots such as those associated with seamounts, upwellings, eddies and fronts are aggregation sites for marine species (Dambacher et al. 2011). Squid, tuna, billfish, gemfish, turtles and cetaceans are all known to be attracted to these regions (Dambacher et al. 2011; DEWHA 2009a). Above the water, seabirds including albatrosses, petrels and shearwaters also congregate at these sites (DEWHA 2009a). Foraging seabirds and turtles are also common along the continental shelf, and significant breeding sites for both species groups are found along the mainland coast. The shelf region is also a major tropical–temperate transition zone for benthic communities in the region. Due to the tropical influences of the southward flowing East Australian Current, tropical corals are found as far south as the Solitary Islands in New South Wales. The region supports particular diversity in crustaceans, syngnathids, sponges and molluscs (Dambacher et al. 2011; DEWHA 2009a; Tzioumis & Keable 2007).

The deeper reaches of region (e.g. the abyssal plain) remain largely unexplored. Nonetheless, projects such as the Census of Diversity of Abyssal Marine Life (CeDAMar) indicate that these areas are likely to be as biologically diverse as shallower communities.

## Bioregional framework

The Temperate East Marine Region covers all or part of 10 provincial bioregions[1] (Figure 2):

- Kenn Transition
- Central Eastern Transition
- Central Eastern Shelf Transition
- Central Eastern Shelf Province
- Central Eastern Province
- Tasman Basin Province
- Lord Howe Province
- Norfolk Island Province
- South-east Shelf Transition
- South-east Transition.

These provincial bioregions were identified as part of the Integrated Marine and Coastal Regionalisation of Australia version 4.0 (IMCRA v4.0), which classifies Australia's entire marine environment into broadly similar ecological regions. The purpose of regionalisation is to assist in simplifying the complex relationships between the environment and species distributions, and to characterise the distribution of species and habitats at differing scales.

Provincial bioregions represent regional classifications at the largest scale and they largely reflect biogeographic patterns in the distribution of bottom-dwelling fish (DEH 2006). Meso-scale bioregions are a finer scale regional classification of the continental shelf. They were defined using biological and physical information and geographic distance along the coast.

IMCRA v.4.0 provides a useful framework for regional planning and is the basis for establishing a national representative network of marine reserves across all Australian waters.

Further information about each bioregion is available in the East Marine Bioregional Profile at (**www.environment.gov.au/marineplans/temperate-east**).

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).

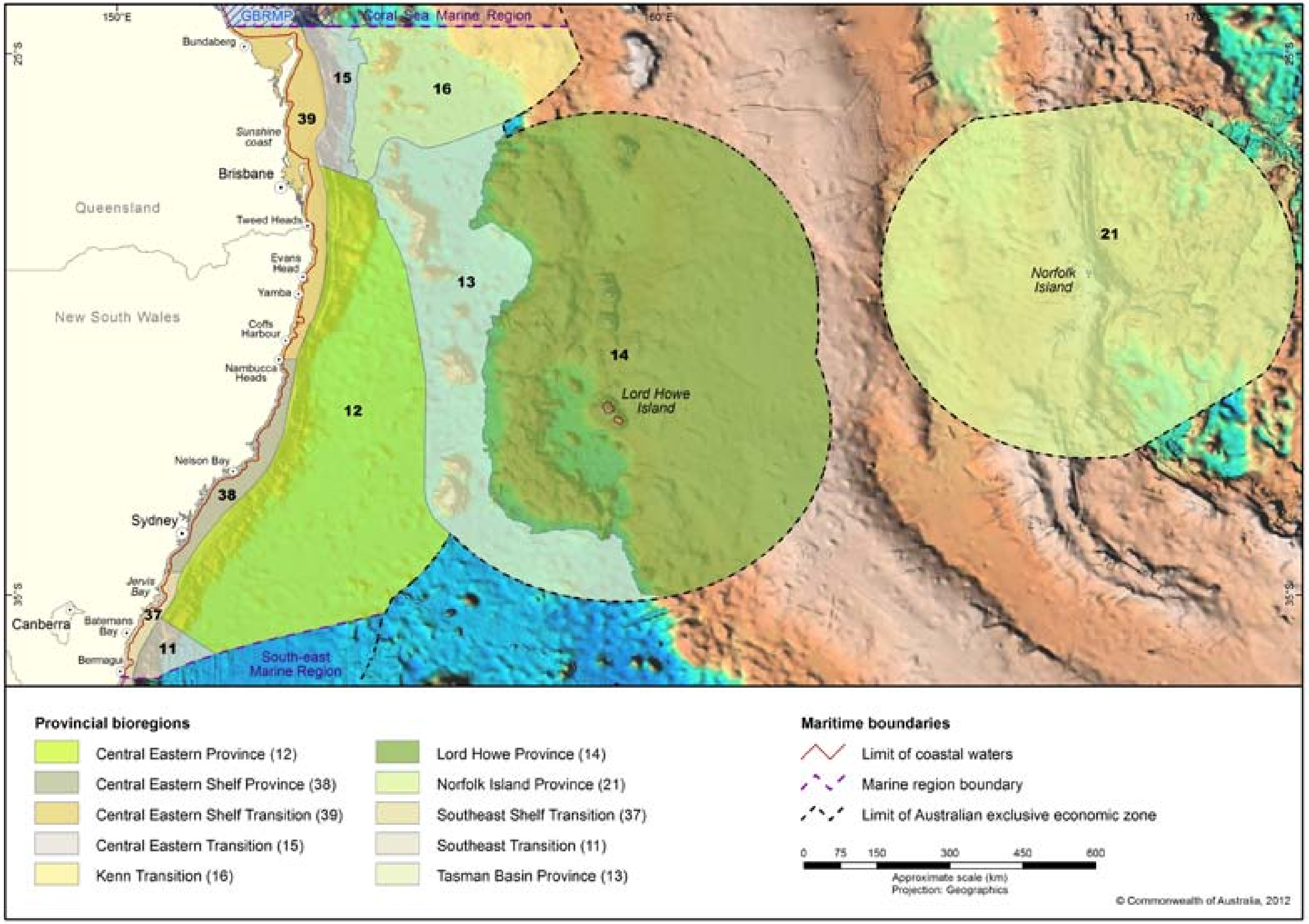


**Figure 2: Provincial bioregions that occur in the Temperate East Marine Region**

## 2. Key ecological features of the Temperate East Marine Region

Key ecological features are elements of the Commonwealth marine environment that are considered to be of regional importance for either a region's biodiversity or its ecosystem function and integrity.

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

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

Key ecological features of the Temperate East Marine Region have been identified on the basis of existing information and scientific advice about ecological processes and functioning. As new data about ecosystems and their components becomes available, the role of key ecological features in regional biodiversity and ecosystem functioning will be refined.

Eight key ecological features have been identified in the Temperate East Marine Region (Figure 3). The following sections provide a detailed description of each of these key ecological features, the pressures each feature is currently or likely to be subject to and relevant protection measures.

A Conservation Values Atlas presents a series of maps detailing the location and spatial extent of conservation values (where sufficient information exists to do so). The atlas is available at **www.environment.gov.au/cva**.

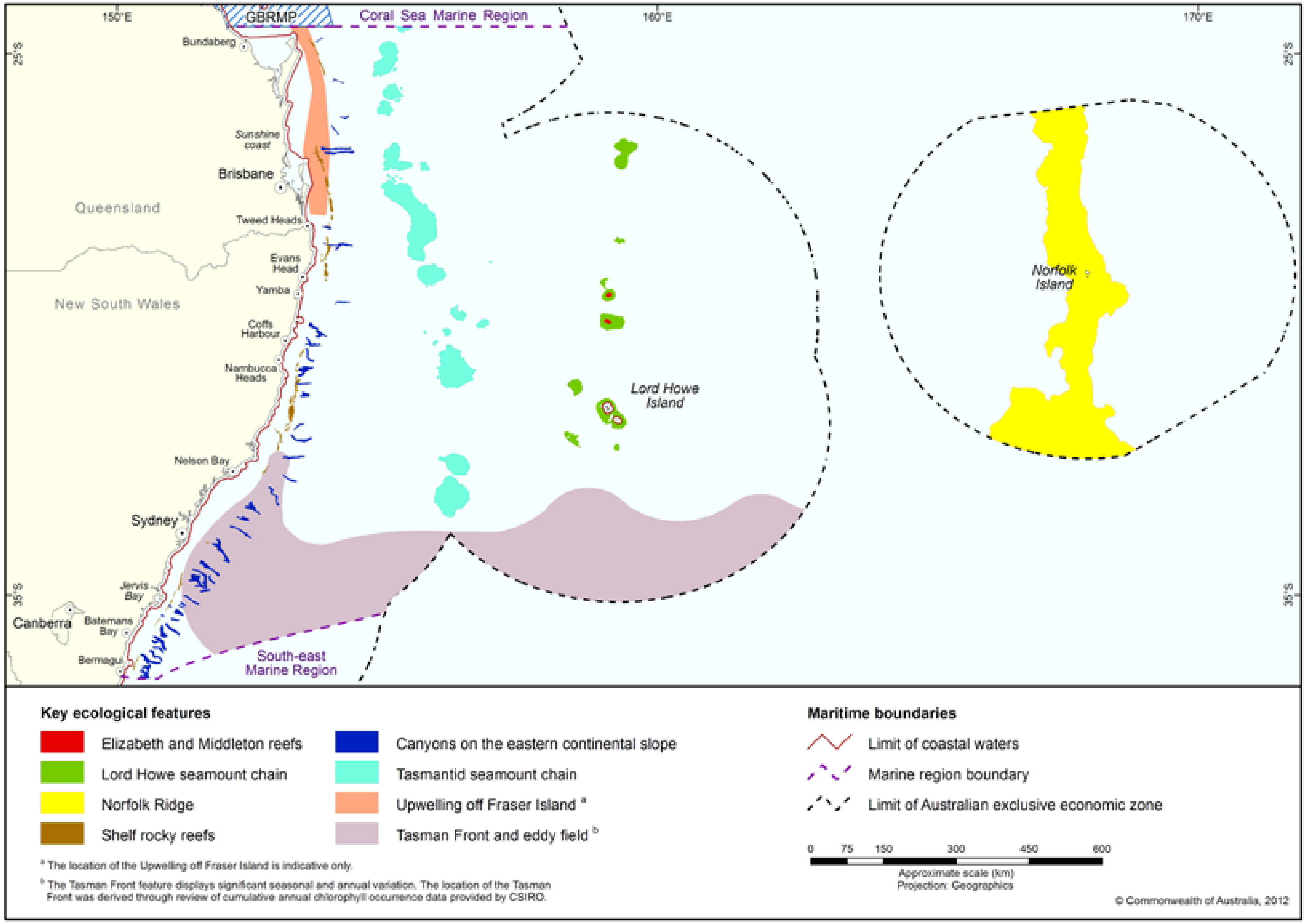


**Figure 3: Key ecological features of the Temperate East Marine Region**

## 1. Canyons on the eastern continental slope

### *National and/or regional importance*

Submarine canyons are widespread features around the Australian continent and island margins (Heap & Harris 2008, in Kloser & Keith 2010) and the eastern continental slope features a large number of canyons (Brewer et al. 2007). These features are known to have a marked influence on diversity and abundance through their combined effects of topography, geology and localised currents, all of which act to funnel nutrients and sediments into the canyon (Kloser & Keith 2010). As such, these features are valued for their enhanced productivity and biological diversity properties.

### *Values description*

Canyons contribute significantly to overall habitat diversity, providing hard substratum in depth zones where soft sediment habitats are more commonly found. This substrate type offers a range of additional benefits including solid anchorage points, vertical relief and increased availability of food items (Bax & Williams 2001). Hard substrata support different species assemblages; particularly favouring large filter feeder–dominated benthic species (e.g. attached sponges and crinoids) that thrive in abundance in the enhanced current flow conditions (Brewer et al. 2007). The high diversity is often encountered at the canyon's upper slope, at depths between 150–700 metres (Kloser & Keith 2010). A range of higher trophic level species including crustaceans, echinoderms, bivalves, cephalopods and fish are then attracted to these regions. Canyons are therefore significant contributors to overall biodiversity, particularly in terms of benthic organisms. Due to isolation, restricted dispersal and connectivity, it is also expected this diversity encompasses a high degree of endemism, further contributing to the social and biological values of these communities (Brewer et al. 2007; Stocks & Boehlert 2003).

Canyons also affect the water column, interrupting the flow of water across the sea floor and creating turbulent conditions in the water column. This turbulence transports bottom waters to the surface, creating localised upwellings of cold, nutrient-rich waters, which result in regions of enhanced biological productivity relative to surroundings waters (Prince 2001). The enhanced food availability acts to aggregate higher trophic level species, from pelagic tunicates and coelenterates to apex species such as tuna and seabirds, creating regions of high biodiversity (Brewer et al. 2007). During winter, a decrease in water temperature can change water-mass densities, creating regions of downwelling. Although generally associated with low nutrient regimes, in this context these events are thought to play an important role in breaking down shelf-edge fronts, displacing deeper oceanic slope water and consequently pushing relatively nutrient-rich water towards the photic zone (Prince 2001).

## 2. Elizabeth and Middleton reefs

### *National and/or regional importance*

The location of this key ecological feature exposes it to a mix of tropical and temperate water masses, giving rise to a unique mixed community of species. These communities are considered particularly rich biologically and are also recognised for their high levels of endemism.

### *Values description*

The Elizabeth and Middleton reefs are small isolated oceanic platform-reefs on volcanic seamounts of the Lord Howe seamount chain (Kennedy & Woodroffe 2004, in Dambacher et al. 2011). The reefs are influenced by currents linked to the East Australian Current and represent an overlap of warm-water hermatypic (reef building) and cool-water ahermatypic (non-reef-building) corals (Veron & Done 1979, in Dambacher et al. 2011), which in turn provide habitat for both tropical and temperate fish and invertebrates (Choat et al. 2006, in Dambacher et al. 2011; Oxley et al. 2003).

Elizabeth and Middleton reefs are home to a diverse assemblage of tropical and temperate fish species (Australian Museum 1992, in Dambacher et al. 2011), with a list of over 300 fish species compiled from literature reviews and surveys (Choat et al. 2006, in Dambacher et al. 2011; Oxley et al. 2003). The lagoons of both reefs are strongholds for populations of the black cod and Galapagos shark (Dambacher et al. 2011). A recent study of the genetic diversity and connectivity of the reefs suggests that their gene pools are periodically supplemented by long-distance migrants, which are likely to have population sizes large enough to avoid inbreeding and maintain genetic diversity (Noreen et al. 2009, in Dambacher et al. 2011). For example, 48 per cent of the coral species of the southern Great Barrier Reef are also found on Elizabeth and Middleton reefs (Dambacher et al. 2011). Many tropical species of reef-building corals are absent, especially those with massive growth forms, and branching corals are dominant (Choat et al. 2006 & Veron & Done 1979, in Dambacher et al. 2011; Harriott & Banks 2002; Oxley et al. 2003).

## 3. Lord Howe seamount chain

### *National and/or regional importance*

A significant topographic feature off Australia's east coast, the Lord Howe seamount chain supports both tropical shallow coral reefs (Veron & Done 1979, in Dambacher et al. 2011) and cold water corals (depths greater than 40 metres) (Speare et al. 2004), making it an important site of biodiversity and endemism. The chain also influences the surrounding waters, giving rise to areas of enhanced productivity which in turn aggregate a range of marine species.

### *Values description*

The Lord Howe seamount chain runs for approximately 1000 kilometres along the western margin of the Lord Howe Rise, extending from Lord Howe Island in the south to Nova Bank in the north (Harris et al. 2005; van der Linden 1970, in Dambacher et al. 2011). Within the Lord Howe subregion of the Temperate East Marine Region, 80 per cent of the subregion is classed as plateau with depths ranging between 805 metres and 5140 metres, and 1 per cent is classed as seamount/guyot with depths as shallow as 75 metres (Keene et al. 2008). The chain includes Lord Howe Island, Balls Pyramid, Elizabeth Reef, Middleton Reef and Gifford Guyot, all of which are within the Temperate East Marine Region. To the north of the Temperate East Marine Region are Capel, Kelso, Argo and Nova banks (Dambacher et al. 2011).The fringing coral reefs around Lord Howe Island and Elizabeth and Middleton reefs are the most southerly tropical coral reefs in the Pacific Ocean (Harriott et al. 1995; Veron & Done 1979, in Dambacher et al. 2011).

The seamount chain lies in the path of the Tasman Front, which brings a mix of warm tropical waters and colder nutrient-rich waters from the south, depending on the season (Ridgway & Dunn 2003). In general, waters surrounding this feature are nutrient poor and relatively unproductive (Dambacher et al. 2011). Species distributions of large deep water benthic animals overlap on the Lord Howe Rise and southern portion of the Norfolk Ridge, where both are influenced by the Tasman Front, but do not overlap in the northern portion, which lacks a hydrographic connection (Williams et al. 2011).

## 4. Norfolk Ridge

### *National and/or regional importance*

Stretching across the Temperate East Marine Region, the Norfolk Ridge provides a rich biological source of benthic biodiversity and endemism. Similarly to the Lord Howe chain, the ridge also generates localised oceanographic changes which create sites of enhanced productivity and aggregate marine species.

### *Values description*

The Norfolk Ridge is set within a region of remnant volcanic arcs, plateaux, troughs and basins (Keene et al. 2008; Mortimer et al. 2007, in Dambacher et al. 2011). The ridge runs southward from New Caledonia to New Zealand, and lies between the New Caledonia Trough to the west and the Norfolk Basin to the east. Within the Norfolk subregion of the Temperate East Marine Region, 41 per cent of the area is classed as plateau with depths ranging between 50 metres and 3900 metres, and 1.24 per cent is classed as pinnacles or seamount/guyot, with depths as shallow as 205 metres (Keene et al. 2008). The high diversity in seamount benthos is likely to be caused by relatively productive benthic habitats, which support population densities that are far higher than surrounding regions (de Forges et al. 2000; Samandi et al. 2006, in Dambacher et al. 2011). Benthic habitats along the entire length of Norfolk Ridge are also thought to act as stepping stones for fauna dispersal, connecting deep water fauna from New Caledonia to New Zealand (Williams et al. 2006; Zintzen et al. 2011, in Dambacher et al. 2011). However, the semipermanent Norfolk Eddy may create a closed system that limits connectivity and increases endemism within the South Norfolk Basin (Williams et al. 2006). Significantly higher catch rates of tuna have also been reported from the Norfolk Ridge (Morato et al. 2010).

The Tasman Front conveys tropical species to the southern portion of the ridge within the Temperate East Marine Region, and there is a diverse assemblage of tropical and temperate species with evidence of connectivity to the benthic fauna of Lord Howe Rise (Williams et al. 2011; Zintzen et al. 2011, in Dambacher et al. 2011).

## 5. Shelf rocky reefs

### *National and/or regional importance*

The shelf rocky reefs habitat has been identified as a key ecological feature as it is considered a unique sea-floor feature which is associated with ecological properties of regional significance.

### *Values description*

Along the continental shelf, south of the Great Barrier Reef, benthic communities on rock outcrops and boulder substrates shift from algae-dominated communities to those dominated by attached invertebrates (Jordan et al. 2005; Underwood et al. 1991, in Dambacher et al. 2011), including dense populations of large sponges, with a mixed assemblage of moss animals and soft corals (Bax & Williams 2001; Beaman et al. 2005; NSWMPA 2010). This shift generally occurs at a depth of 45 metres (Jordan et al. 2005). Below wave-influenced areas, massive and branched growth forms of sponges are more prevalent (Ponder et al. 2002, in

Dambacher et al. 2011), and sponge species richness and density generally increases with depth along the New South Wales coast (Roberts & Davis 1996, in Dambacher et al. 2011).

Collectively, these invertebrates create a complex habitat-forming community (Buhl-Mortensen et al. 2010) that supports microorganisms and other invertebrates, such as crustaceans, molluscs, annelids and echinoderms (Ponder et al. 2002; Wulff 2006 & Taylor et al. 2007, in Dambacher et al. 2011). These habitats also contribute to increased survival of juvenile fish by providing refuge from predation (Lindholm et al. 1999). Rocky reef habitats on Australia's east coast support a diverse assemblage of demersal fish, which show distinct patterns of association with shelf-reef habitats (Malcolm et al. 2010; Moore et al. 2010; Williams & Bax 2001). For example, the jackass morwong, barracouta, orange-spotted catshark, eastern orange perch, butterfly perch and warehou are species that distinguish rocky-reef habitats at depths greater than 45 metres from those of soft sediments (Williams & Bax 2001).

This feature has an overlap of temperate and tropical species, the distributions of which are strongly regulated by the East Australian Current. In general, the proportion of tropical fish and invertebrate species increases to the north and off shore towards the shelf edge (Cairns 2004, in Dambacher et al. 2011; Malcolm et al. 2010; O'Hara 2008; Williams & Bax 2001).

## 6. Tasman Front and eddy field

### *National and/or regional importance*

The Tasman front and associated eddy field are considered to be a biologically significant feature, giving rise to areas of enhanced productivity which are important aggregation sites for a range of marine animals, particularly pelagic species. The feature is also thought to provide critical connectivity pathways between seamount habitats in the region and beyond.

### *Values description*

The Tasman Front is a region of intermediate productivity that separates the nutrient-poor waters of the Coral Sea from the nutrient-rich waters of the Tasman Sea (Condie & Dunn 2006; Denham & Crook 1976; Stanton 1981, in Dambacher et al. 2011). The front is formed by a meandering current between 27° S and 33° S that moves to the north in winter and to the south in summer (Ridgway & Dunn 2003). The front's boundary can appear diffuse and impermanent, and its associated eddies vary in strength, shape and location. The front is therefore best characterised as an average over time (K Ridgway, pers. comm., in Dambacher et al. 2011).

Across the southern portion of the Temperate East Marine Region, the Tasman Front creates a complex oceanographic environment with vertical mixing (Ridgway & Dunn 2003; Tilburg et al. 2002, in Dambacher et al. 2011). Patches of productivity are important for mid-level consumers including turtles (Boyle et al. 2009; Young et al. 2011) and top fish predators (Lansdell & Young 2007 and Young et al. 2001, 2006, in Dambacher et al. 2011; Young et al. 2011). Fisheries oceanography studies describe a positive relationship between fish catch rates and proximity to frontal features, and a predominance of bigeye tuna and swordfish associated with the Tasman Front (Campbell & Hobday 2003; Young et al. 2001, 2011, in Dambacher et al. 2011).

The feature is also considered important for providing connectivity to the Lord Howe seamount chain and Norfolk Ridge for tropical species (Dambacher et al. 2011). The front's interaction with bathymetric platforms and basins causes it to meander (Stanton 1979, in Dambacher et al. 2011) and shed a series or field of large, warm-core, quasi-permanent eddies that extend from the southern portion of the Norfolk Basin, south-east of Norfolk Island, to New Zealand's East Cape (Ridgway & Dunn 2003).

## 7. Tasmantid seamount chain

### *National and/or regional importance*

The Tasmantid seamount chain is recognised as an important conservation value for its enhanced productivity, aggregations of marine life, and biodiversity and endemism. It supports a diverse range of habitats and communities, including deep sea sponge gardens and near-pristine tropical coral reef systems.

### *Values description*

The Tasmantid seamount chain is a prominent chain of submarine guyots, plateaux and terraces, running north–south at approximately 155° E and extending into the Tasman Basin (Harris et al. 2005). At its deepest, features rise to between 900 and 1400 metres below sea level; at its northern extent, features rise to between 150 and 400 metres, with some breaking the surface to form islands (Brewer et al. 2007; Keene et al. 2008). These are biological hotspots that support significant demersal and pelagic diversity, as well as feeding grounds and sites of reproduction for a number of open ocean species (e.g. billfish, marine turtles, marine mammals) (Young et al. 2003, 2006; Morato et al. 2010). Some information on pelagic species composition around these seamounts exists (Young et al. 2011), but there is little information on benthic species. High species diversity and endemicity has been reported from the neighbouring Lord Howe seamount chain (de Forges et al. 2000).

## 8. Upwelling off Fraser Island

### *National and/or regional importance*

The upwelling off Fraser Island is recognised as an important conservation value for its enhanced productivity and aggregations of marine life. The upwelled waters off Fraser Island support blooms of large diatoms that are important to food chains and support valuable fisheries in the area (Hallegraeff & Jeffrey 1993, Young et al. 2001, in Dambacher et al. 2011; Young et al. 2011). An example of such a food chain is lantern fish and squid that eat diatoms and plankton, and are themselves eaten by tuna and billfish. A shorter food chain is diatoms that are eaten by crustaceans, which are in turn eaten by tuna (Dambacher et al. 2011; Lansdell & Young 2007; Young et al. 2011). The entire food web for this system is complex and includes small pelagic fish, mid-sized fish predators and top predators (Dambacher et al. 2011).

### *Values description*

In two areas near Fraser Island, upwelled waters mix with surface waters and are drawn onto the shelf through a number of processes including tidal currents, wind and eddies (Griffin & Middleton 1986; Middleton et al. 1994; Oke & Middleton 2000; Roughan & Middleton 2002, in Dambacher et al.2011; Tranter et al. 1986). Along the continental shelf south of Fraser Island, the East Australian Current converges and moves closer to the shelf's slope, drawing cold and nutrient-rich slope waters from depths greater than 200 metres to near the surface. In the Capricorn Channel, to the north of Fraser Island, an area of enhanced productivity is associated with large tidal flows that bring nutrient-rich waters from the slope onto the shelf edge (Griffin & Middleton 1986; Middleton et al. 1994, in Dambacher et al. 2011).

The feature also appears to be an important area of connectivity in migrations of small pelagic fish and top predators. The subtropical waters off Fraser Island are an important spawning area for temperate small pelagic fish (i.e. the sardine, round herring and Australian anchovy), the adults of which appear to migrate from the south and whose larvae are subsequently transported back into temperate nursery areas by the East Australian Current (Halliday 1990, Mann 1992, Pollock 1984 & Ward et al. 2003, in Dambacher et al. 2011). The area has also been identified as an important residency site for juvenile and adult white sharks (Bruce & Bradford 2008; Werry et al. 2011, cited in Dambacher et al. 2011): adults have demonstrated directed migrations to the area from South Australia (Bruce et al. 2006) and New Zealand (Duffy et al. 2011) and have shown residencies as long as four months.

# 3. Vulnerabilities and pressures

Analysis of pressures on key ecological features is limited by knowledge of ecological functioning and structures and the vulnerability of ecosystems to human activities. Information on the implications of environmental pressures on ecosystems at different spatial, temporal and ecological scales in the Temperate East Marine Region is scant. As a consequence, the analysis that has been undertaken on the pressures affecting the key ecological features of the region is an initial assessment intended to guide further research and analysis.

The results of the pressure analysis are summarised in Table 1. Only those pressures identified as *of concern* or *of potential concern* are discussed in further detail in this report card. A description of the pressure analysis process is provided in Part 3 and Schedule 1 of the plan.

## Table 1: Outputs of the key ecological feature pressure analysis for the Temperate East Marine Region

| Pressure | Source | Key ecological features: Canyons on the eastern continental slope | Elizabeth and Middleton Reefs | Lord Howe seamount chain | Norfolk Ridge | Shelf rocky reefs | Tasman Front and eddy field | Tasmantid seamount chain | Upwelling off Fraser Island |
|---|---|---|---|---|---|---|---|---|---|
| Sea level rise | Climate change | not of concern | of potential concern | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern |
| Changes in sea temperatures | Climate change | of potential concern | of concern | of potential concern | of potential concern | of potential concern | of potential concern | of potential concern | of potential concern |
| Changes in oceanography | Climate change | of potential concern | of potential concern | of potential concern | of potential concern | of potential concern | of potential concern | of potential concern | of potential concern |
| Ocean acidification | Climate change | of less concern | of concern | of potential concern | of potential concern | of potential concern | of less concern | of potential concern | of less concern |
| Chemical pollution/ contaminants | Shipping | of potential concern | of potential concern | of potential concern | of less concern | of less concern | of potential concern | of potential concern | of potential concern |
| | Agricultural activities<br>Urban development | of less concern | not of concern | not of concern | of less concern | of less concern | not of concern | not of concern | of less concern |
| Nutrient pollution | Agricultural activities<br>Urban development | of less concern | not of concern | not of concern | of less concern | of less concern | not of concern | not of concern | of less concern |
| Marine debris | Fishing vessels<br>Shipping | of potential concern | of potential concern | of potential concern | of potential concern | of potential concern | of potential concern | of potential concern | of potential concern |
| Noise pollution | Seismic exploration | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern |
| | Shipping<br>Vessels (other) | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern |
| | Urban development | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern |
| Light pollution | Land-based activities | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern |
| | Offshore activities | not of concern | of potential concern | not of concern | not of concern | not of concern | of less concern | not of concern | of less concern |
| Physical habitat modification | Fishing gear | of potential concern | of less concern | not of concern | not of concern | of potential concern | not of concern | of less concern | not of concern |
| | Off-shore mining operations<br>Offshore construction and installation of infrastructure<br>Dredging | of less concern | not of concern | of less concern | not of concern | of less concern | not of concern | not of concern | not of concern |
| | Tourism | not of concern | of less concern | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern |
| | Shipping (anchorage) | not of concern | of less concern | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern |
| Human presence at sensitive sites | Tourism | not of concern | of less concern | not of concern | not of concern | not of concern | not of concern | not of concern | of less concern |
| Extraction of living resources | Commercial fishing | of potential concern | not of concern | of potential concern | of potential concern | of potential concern | of potential concern | of potential concern | of potential concern |
| | Recreational and charter fishing | of less concern | of less concern | not of concern | of less concern | of less concern | not of concern | not of concern | of less concern |
| | Indigenous harvest | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern |
| | Illegal, unregulated and unreported fishing | not of concern | of less concern | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern |
| | Commercial fishing (non-domestic) | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern |
| Bycatch | Commercial fishing (domestic) | of potential concern | not of concern | of potential concern | of potential concern | of potential concern | of potential concern | of potential concern | of potential concern |
| | Recreational and charter fishing | of less concern | of less concern | not of concern | not of concern | of less concern | not of concern | not of concern | of less concern |
| Oil pollution | Shipping | of potential concern | of potential concern | of potential concern | of less concern | of less concern | of potential concern | of potential concern | of potential concern |
| | Oil rigs | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern | not of concern |
| Invasive species | Shipping<br>Fishing vessels<br>Tourism<br>Vessels (other) | not of concern | of less concern | not of concern | not of concern | of less concern | not of concern | not of concern | of less concern |

**Legend** — of concern (red); of potential concern (orange); of less concern (green); not of concern (grey)

### *Sea level rise—climate change*

Global sea levels have risen by 20 centimetres between 1870 and 2004, and predictions estimate a further rise of 5–15 centimetres by 2030, relative to 1990 levels (Church et al. 2009). Longer term predictions estimate increases of 0.5–1 metre by 2100, relative to 2000 levels (Climate Commission 2011). Sea level rise has been rated *of potential concern* for Elizabeth and Middleton reefs. A sudden increase in sea level may change coral assemblages by altering light levels required for coral growth, particularly if the rise is associated with increased turbidity due to wave-induced erosion or deposition from increased storm frequency (Anthony & Marshall 2009). Consequently, rising sea levels may impact on shallow reef systems and the species that depend on them, such as seabirds and turtles that forage in these areas (Chambers et al. 2009; Hyder Consulting 2008).

### *Changes in sea temperature—climate change*

Changing sea temperature is *of concern* for Elizabeth and Middleton reefs, and *of potential concern* to the remaining seven key ecological features. Sea temperatures have warmed by 0.7 ºC between 1910–29 and 1989–2008, and current projections estimate ocean temperatures will be a further 1 ºC warmer by 2030 (Lough 2009). At depth, the future scenario is less clear, although Hobday et al. (2006) suggest the rate of warming will be similar to that of surface waters.

There is a high level of confidence in the predicted rates of sea warming (Lough 2009) and an understanding that warming will alter food web dynamics (Hoegh-Guldberg & Bruno 2010) by changing zooplankton communities (Richardson et al. 2009). Key ecological features that support important aggregations of marine life and biodiversity at or near the sea surface are vulnerable; for example, there are predictions of coral bleaching and large-scale mortality; changes in the distribution of pelagic fish, with species moving further south; and altered breeding success among seabirds (Hobday et al. 2006). At the community level, ecosystem responses to rising temperatures will be dictated by species' tolerance and adaptive capacity.

For features located in the deeper waters of the region (such as the shelf rocky reefs, seamounts and ridges), the impacts of rising sea temperatures are complex. Rising temperatures drive changes such as thermal expansion (Hoegh-Gulberg et al. 2009), which increases stratification in the water column, reduces mixing in some parts of the ocean and consequently affects nutrient availability and primary production at depth (Hoegh-Gulberg et al. 2009).

### *Changes in oceanography—climate change*

Changes in oceanography are rated of *potential concern* for all key ecological features in the region. Oceanographic changes in the Temperate East Marine Region will be primarily driven by the East Australian Current. Studies indicate this major boundary current has been strengthening, pushing warmer, saltier water up to 350 kilometres further southward along the east coast (Ridgway & Hill 2009). There will also be associated circulation effects arising from expected changes to the El Niño–Southern Oscillation. Potential consequences for ocean circulation patterns arising from these changes include a change in the bifurcation point of the East Australian Current leading to changes in upwelling current direction, changes to upwelling events, increased thermal stratification, increased eddy activity and a shift in the thermocline depth (Chin et al. 2010).

The East Australian Current is considered one of the key drivers of the region's biological productivity, species distribution and abundance (Dambacher et al. 2011). For example, the seasonal expansion and contraction of the East Australian Current is linked to longline catch records of species such as yellowfin and bigeye tuna. (Campbell 2008). The East Australian Current is also responsible, in its role as one of the initiating factors in the Tasman Front, for the unique mix of warm and cold water species supported by coral reef systems associated with the Tasmantid and Lord Howe seamount chains, and the Elizabeth and Middleton reefs (Dambacher et al. 2011). These mixed species assemblages are supported by tropical waters driven southwards by the East Australian Current, extending the range of tropical species into transitional and temperate waters. Further offshore, this major current continues to influence species assemblages, distributing species to offshore, deep water communities (Dambacher et al. 2011).

The key ecological features driven by oceanographic processes may experience these changes most directly. For example, upwellings such as those off Fraser Island are influenced in part by the circulation patterns of waters within the southern Great Barrier Reef. When these circulations patterns strengthen, upwelling is suppressed (Steinberg 2007). Without upwellings to deliver cold, nutrient-rich waters to the surface, the region's ability to support enhanced productivity will be impacted. However, the projected strengthening of the East Australian Current may increase upwelling events, such as the Fraser Island upwelling (Ridgway & Hill 2009).

### *Ocean acidification—climate change*

Ocean acidification is *of concern* for Elizabeth and Middleton reefs, and *of potential concern* to the Tasmantid and Lord Howe seamount chains, Norfolk Ridge and the shelf rocky reefs. These key ecological features are particularly vulnerable because they support a range of shallow and deep water coral reef systems. Driven by increasing levels of atmospheric $CO_2$ and subsequent chemical changes in the ocean, ocean acidification is already under way and detectable. Since pre-industrial times, acidification has lowered ocean pH by 0.1 units (Howard et al. 2009). Furthermore, climate models predict this trend will continue, with a further 0.2–0.3 unit decline by 2100 (Howard et al. 2009).

Direct impacts of ocean acidification are expected to be most marked for organisms with calcareous skeletons, such as corals, plankton, molluscs and echinoderms (Doney et al. 2009). Increasing acidity reduces the ability of these organisms to form skeletal structures, which is likely to affect not only their ability to function within the ecosystem, but also the workings of the ecosystem itself (Kleypas & Yates 2009). For example, research on coral cores in the Great Barrier Reef identified a 14 per cent decline in coral calcification rates between 1990 and 2005 (De'ath et al. 2009), which the authors attribute to excessive temperature increases, ocean acidification, or a combination of the two. For the Temperate East Marine Region, increased ocean acidification and sea surface temperatures are predicted to work in conjunction, prompting reef conditions to shift from 'marginal' (Kleypas et al. 1999) to 'extremely marginal' by the middle of this century (Noreen 2010). For Elizabeth and Middleton reefs, as well as the northern subtropical regions of the Tasmantid and Lord Howe seamount chains, it is likely that increased ocean acidity will reduce coral growth rates and resilience, making the reef systems more susceptible to erosion and disturbance from storms (Anthony & Marshall 2009). Predictive climate models indicate that the unique, deep, cold water reefs and sponge gardens of the Norfolk Ridge, shelf edge and seamount chains are also at risk from a similar range of impacts (Cohen & Holcomb 2009; Howard et al. 2009; Hyder Consulting 2008). Corals provide structural habitat complexity for a range of invertebrates and fish (Althaus et al. 2009). Any impact on coral reef habitat is therefore likely to change the distribution and abundance of species that depend on them for food and shelter.

### *Chemical pollution/contaminants*

Chemical pollution/contaminants are *of potential concern* for key ecological features with values that make them particularly vulnerable to the impacts of a chemical spill, such as important aggregations of marine life at or near the sea surface. Vulnerable key ecological features include the Tasman Front and eddy field; the Fraser upwelling; the Tasmantid and Lord Howe seamount chains; canyons on the eastern continental slope; and Elizabeth and Middleton reefs. As is the case with oil spills, chemical spills are unpredictable events and their likelihood is low in the context of the international and domestic regulatory mitigation measures that apply in Australia. The effects of a major chemical spill can be similar to those of oil spills

(GBRMPA 2009), particularly in areas and at times of biological significance for important or threatened species. The impacts vary depending on the toxicity of chemicals, how the materials are packaged and transported, the quantity spilled, the site and ecological sensitivity.

*Chemical and nutrient pollution at Norfolk Island*

Although these pressures are not considered a significant concern for the broader Norfolk Ridge feature (and thus only assessed as *of less* concern), chemical and nutrient pollution arising from land-based sources (e.g. urban development) on Norfolk Island continue to be an ongoing problem for the localised marine environment. Current limitations in waste management (both refuse and wastewater) practices and infrastructure on the island are leading to 'at-sea' dumping and ongoing water contamination (Commonwealth of Australia 2010; Wilson 2010).

### Marine debris

Marine debris has been assessed as *of potential concern* to all key ecological features in the region. Marine debris is defined as any persistent, manufactured or processed solid material discarded that has been disposed of, or abandoned, in the marine and coastal environment (UNEP 2005). This includes a range of material from plastics (e.g. bags, bottles, ropes, fibreglass and insulation) to derelict fishing gear, and ship-sourced, solid, non-biodegradable floating materials (DEWHA 2009b). Although region-specific marine debris data is limited, key sources for the introduction and spread of debris (such as shipping, commercial fishing and major current systems) are present across the region. This suggests that all key ecological features will experience a high degree of overlap with this pressure (Katsanevakis 2008).

Marine debris has been listed as a key threatening process under the EPBC Act, in recognition of its negative impacts on substantial numbers of Australia's marine wildlife, including protected species of birds, turtles and marine mammals. Therefore, this pressure has implications for key ecological feature values such as biodiversity and aggregations of marine life. The Australian Government has developed a threat abatement plan that provides a coordinated national approach to prevent and mitigate the effects of harmful marine debris on marine life (DEWHA 2009b).

### Light pollution

Light pollution is *of potential concern* to those key ecological features that support important aggregations of marine life that are vulnerable to light (such as turtles) including Elizabeth and Middleton reefs. Light quality is important for turtles (Salmon 2003) and lighting from shipping and fishing vessels offshore can attract hatchlings to vessels hulls, exposing them to predation. Shipping traffic, including fishing vessels anchoring in close proximity to Elizabeth and Middleton reefs, have the potential to impact on the behaviour of turtles that forage in these areas.

### *Physical habitat modification*

Physical habitat modification is *of potential concern* to those key ecological features that are either subject to bottom trawl activities or are inherently vulnerable to habitat modification, including shelf rocky reefs and the canyons on the eastern continental slope. Corals provide structural habitat complexity for a range of invertebrates and fish (Althaus et al. 2009). Demersal trawl is one activity in the region that has the potential to modify coral habitats because it involves the removal, modification or disturbance of seabed flora and fauna (Furlani et al. 2007). Deepwater coral reef habitats are highly fragile and long lived, and are therefore susceptible to damage by trawling (Williams et al. 2011). Impacts of trawling on corals and associated species on Tasmanian seamounts include declines in richness, diversity and density of benthic species associated with loss of coral habitat (Althaus et al. 2009).

### *Extraction of living resources*

Extraction of living resources has been assessed as *of potential concern* for those key ecological features in which fishing activities occur. This occurs in all the key ecological features, with the exception of the Elizabeth and Middleton reefs. In considering the impacts of this pressure, focus has been given primarily to top predators as a key functional species group of the region's key ecological features. Reef sharks, cod and groupers are considered important for coral reef communities, while tuna and billfish are important for pelagic systems (Ceccarelli & Ayling 2010). The extraction of top predators by fishing activities has implications for ecological communities by influencing abundance, recruitment, species composition, diversity and behaviour of prey species. Their removal can have a 'cascading' effect on all the components of a food web (Baum & Worm 2009; Ceccarelli & Ayling 2010; Ings et al. 2009).

In the context of active fisheries management and the steady move towards ecosystem-based management of fisheries by all jurisdictions in Australia, the rating *of potential concern* 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.

### *Bycatch*

Bycatch has been assessed as *of potential concern* for those key ecological features in which bycatch of non-target species occur. This occurs in all the key ecological features, with the exception of the Elizabeth and Middleton reefs. This rating is considered a conservative assessment in the context of active fisheries management and the steady move towards ecosystem-based management of fisheries by all jurisdictions in Australia. For example, a recent review of all Commonwealth fisheries found that current numbers of independent observers were not sufficient to provide a cumulative assessment of the catch of non-target species. The review stated that such assessment is important to understand the environmental performance of fisheries more broadly, and to underpin a holistic approach to the management of ecosystem impacts (Phillips et al. 2010). There is also a need to increase our understanding of the effectiveness of bycatch mitigation measures (Bensley et al. 2010).

### *Oil pollution*

Australia has a strong system for regulating industry activity that is the potential source of oil spills and this system has been strengthened further in response to the Montara oil spill. While oil spills are unpredictable events and their likelihood is low based on past experience, their consequences, especially for threatened species at important areas, could be severe, particularly for some ecosystems and at times of biological significance for important and/or threatened species. Shipping is a key activity in the region, with shipping routes servicing a number of ports adjacent to the region.

Oil pollution is *of potential concern* for key ecological features with values that make them particularly vulnerable to the impacts of an oil spill, such as important aggregations of marine life at or near the sea surface. Vulnerable key ecological features include the Tasman Front and eddy field; upwelling off Fraser Island; Tasmantid and Lord Howe seamount chains; canyons on the eastern continental slope; and Elizabeth and Middleton reefs. These key ecological features are highlighted because of their characteristics that make their ecosystems and communities vulnerable to the effects of an oil spill; for example, features that include regions of high productivity that attract aggregations of marine life.

Examples of the biodiversity associated with these features include: seasonal feeding aggregation of pelagic invertebrates, fish and mammals associated with the Tasman Front and eddy field, and the upwelling off Fraser Island; seabirds and turtles that forage at Elizabeth and Middleton reef and the tropical and temperate demersal and pelagic fish assemblages supported by these reefs; fish that seek refuge on seamounts; and predatory fish and seabirds that forage in waters surrounding seamounts. Oil spills impact on marine life in a number of ways, such as causing damage to fish eggs, larvae and young fish; hypothermia; increased vulnerability to predation; and loss of body condition (AMSA 2010). Habitats such as coral reefs are also susceptible to impacts from oil spills or dispersants (Shafir et al. 2007), as coral eggs and larvae are buoyant for the first few days after spawning and may die if they encounter oil or oil/dispersant mixture in significant concentrations. The metamorphosis stage of juvenile coral development (around 1–3 weeks following spawning) is particularly susceptible to oil (Negri & Heyward 2000). The ability of coral reefs to self-propagate may therefore be impacted by oil pollution.

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

## 4. Relevant protection measures

The environment in Commonwealth marine areas, including the Temperate East Marine Region is protected under the EPBC Act as it is a matter of national environmental significance. Details about measures to protect components of key ecological features (e.g. protected species or protected places) under the EPBC Act can be found in the relevant species group report cards or protected places report card (**www.environment.gov.au/marineplans/temperate-east**).

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* (**www.environment.gov.au/coasts/fisheries/publications/guidelines.html**). 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.

In addition to the EPBC Act, a broad range of sector-specific management measures to address environmental issues and mitigate impacts apply to activities within the Commonwealth marine environment. 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, port activities and maritime transport. In some instances, as in the case of shipping, these measures also fulfill Australia's environmental obligations under international agreements.

Relevant international measures and agreements relating to the Commonwealth marine environment include:

- *United Nations Convention on the Law of the Sea 1982*
- *Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) 1972 and the 1996 Protocol to the Convention*
- *Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention) 1972*
- *International Convention for the Prevention of Pollution from Ships 1973/78 (MARPOL)*
- *International Convention on Oil Pollution Preparedness, Response and Cooperation 1990*
- *The International Convention for the Control and Management of Harmful Anti-Fouling Systems on Ships 2001*
- *International Convention for the Regulation of Whaling 1946*
- *International Whaling Commission*
- *Convention on International Trade in Endangered Species of Wild Fauna and Flora 1973 (CITES).*

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# MAP DATA SOURCES

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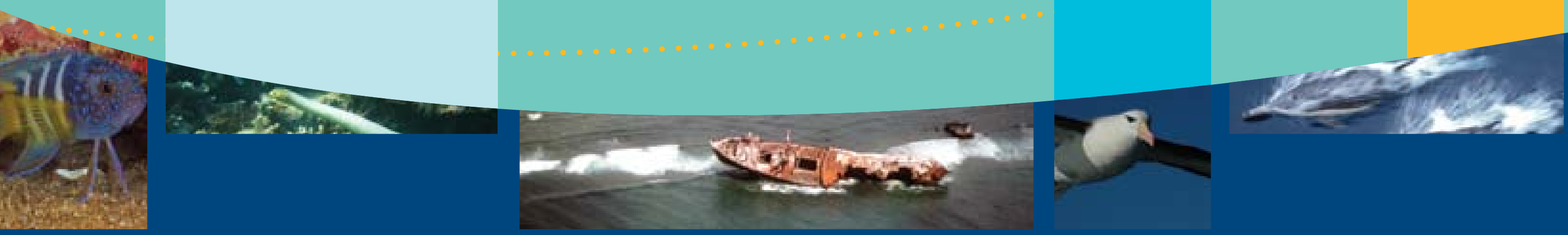

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