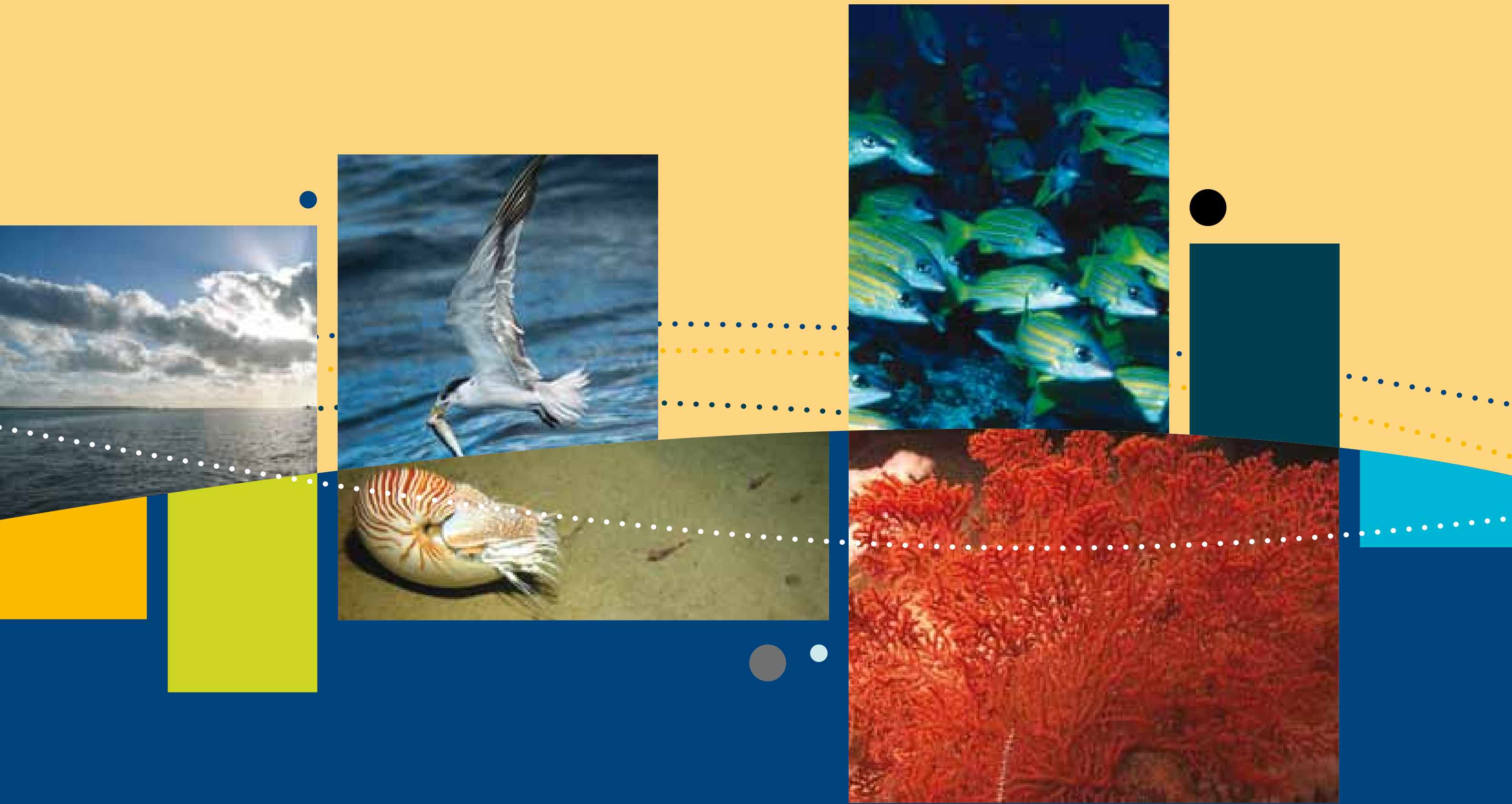
Australian Government

Department of Sustainability, Environment, Water, Population and Communities



Commonwealth marine environment report card

Supporting the marine bioregional plan for the North Marine Region

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

Images:
Yellowstripe Snapper – Robert Thorn and DSEWPaC, A gorgonian wtih polyps extended – Geoscience Australia,
Crested Tern fishing – R.Freeman, Nautilus – A.Heyward and M.Rees, Morning Light – I.Kiessling,
Soft corals – A.Heyward and M.Rees, Snubfin Dolphin – D.Thiele, Customs boat – Australian Customs,
Freshwater sawfish – R.Pillans, CSIRO Marine and Atmospheric Research, Hard corals – A.Heyward and M.Rees

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COMMONWEALTH MARINE ENVIRONMENT REPORT CARD—NORTH MARINE REGION

Supporting the marine bioregional plan for the North 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 North Marine Region

The North Marine Region covers the Commonwealth waters and seabed of the tropical Arafura and Timor seas and Gulf of Carpentaria from Cape York Peninsula to the Northern Territory –Western Australia border. The region spans approximately 625 689 square kilometres across Australia's most extensive areas of shallow continental shelf and abuts (but does not include) the coastal waters of Queensland and the Northern Territory (Figure 1).

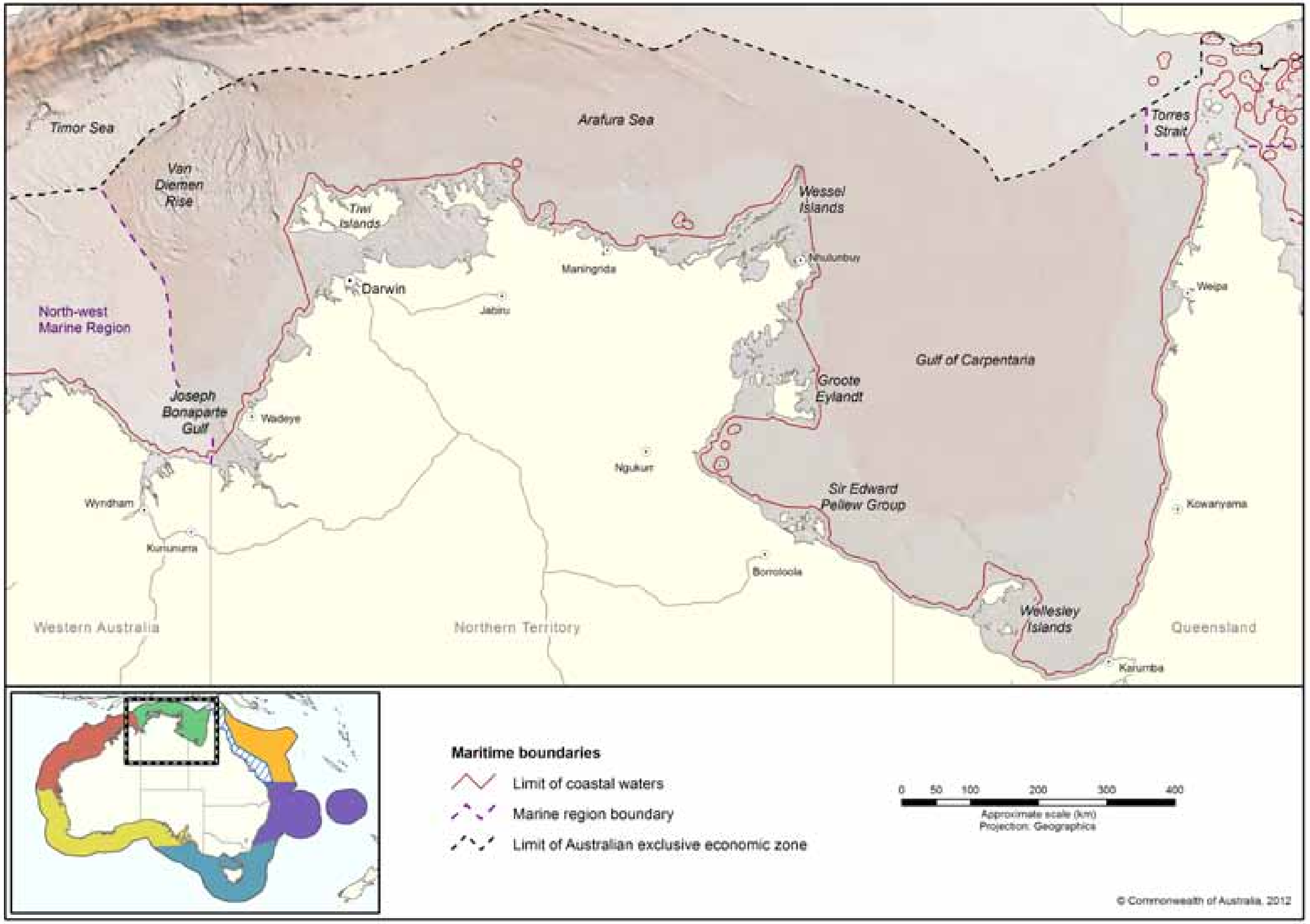

Figure 1: The North Marine Region

The North Marine Region is generally characterised by a shallow-water tropical marine ecosystem that separates the tropical waters of the Indian and Pacific oceans. The large expanse of continental shelf in the east contrasts with the more complex patterns of banks and valleys in the west and the slope and canyons to the north. The region is known for its high biodiversity of tropical species but relatively low endemism. It is part of a vast species-rich biogeographic zone stretching from the western Pacific to the east coast of Africa (DEWHA 2007).

Physical structure of the region

Most of the region encompasses waters over the continental shelf. Water depths are generally less than 70 metres, although water depths range from approximately 10 metres to a maximum known depth of 357 metres. Geomorphic features of the North Marine Region include vast areas of continental shelf and two basins, interspersed with areas of reefs, terraces, banks, shoals, pinnacles, valleys and canyons (Harris et al. 2004).

Much of the region's seabed consists of shallow marine continental shelf, formed less than 18 000 years ago as a result of sea level rise (Harris et al. 2005). The region is mainly flat, with water depth increasing gradually by one metre every kilometre (Torgersen et al. 1983), creating a shallow coastal zone up to 20 kilometres wide along much of the coast.

The west of the region is characterised by complex geomorphology and includes areas of shelf, shoals, banks, terraces, basins and valleys. The banks in this region are thought to be directly related to hydrocarbon seepage from the Bonaparte Basin (O'Brien et al. 2002). Palaeoriver channels up to 150 kilometres long, 5 kilometres wide and 240 metres deep between the carbonate banks connect the present-day Joseph Bonaparte Gulf ocean basin with the old shoreline at the edge of the shelf (Pinceratto 1997).

To the north, the area comprises shelf, terrace and slope that extend into waters 200–300 metres deep in the Arafura Depression. The area is extensively dissected into a series of shallow canyons around 80–100 metres deep and 20 kilometres wide. These canyons are the remnants of a drowned river system that existed during the Pleistocene era (Harris et al. 2004; Jongsma 1974).

Ecosystem drivers

The North Marine Region is less influenced by ocean currents than other Australian marine regions because it covers an area of mostly shallow-shelf sea (Hosack & Dambacher 2011) and water movement through and within the region is restricted by features such as the Arafura Sill and Torres Strait. Large parts of the region such as the Gulf of Carpentaria and the Joseph Bonaparte Gulf are also semi-enclosed (Rothlisberg et al. 2005 in Hosack & Dambacher 2011).

Currents that have some minor influence on the North Marine Region include the Indonesian Throughflow and the South Equatorial Current. Although most of the region is shallow, deeper channels in the north-west of the region carry Indonesian Throughflow waters that originate in the tropical western Pacific Ocean through a series of ocean currents through the Indonesian seas into the Indian Ocean (CSIRO 2001; Rothlisberg et al. 2005; Thackway & Cresswell 1998). The water from these currents tends to be warm and of low salinity.

Tidal currents moving forward and backward through Torres Straight affect the north-east of the North Marine Region (Saint-Cast & Condie 2006). Net flows through Torres Strait are comparatively small (Wolanski et al. 1988), but circulation modelling predicts westward flows of water through Torres Strait during winter driven by the trade winds, and generally eastward flows of water through Torres Strait in summer driven by monsoon winds (Saint-Cast & Condie 2006). A clockwise gyre in the Gulf of Carpentaria occurs during the summer monsoon and results from the net flow of the tides (Forbes & Church 1983).

Currents in the North Marine Region vary seasonally and from year to year due to factors such as seasonal wind patterns, climate variability and variation in ocean currents driven by global processes such as the El Niño Southern Oscillation (Forbes & Church 1983; Phillips & Wijffels 2005; Rothlisberg et al. 2005). There are no major upwellings in the North Marine Region; however, there appears to be some minor upwelling in the eastern Arafura Sea and Joseph Bonaparte Gulf (Rochford 1962).

Other factors that influence ecosystems in the region include stress on seafloor environments resulting from tidal currents. Particularly in the western part of the region, tidal influences on the seafloor drive sediment distribution and shape seafloor features (Condie et al. 2003). In the eastern part of the region the seafloor is likely to be less influenced by stresses associated with tidal currents due to the limited exchange of waters between the shallow waters of the Gulf of Carpentaria and the Arafura and Coral seas (Condie et al. 2003; Condie & Dunn 2006). In the Gulf of Carpentaria, waves are more likely to dominate sediment distribution and seafloor characteristics (Heap et al. 2004). Tides and wind-driven mixing of Gulf waters also have a significant influence on marine environments (Forbes 1984; Wolanski & Ridd 1990). The Gulf of Carpentaria Gyre, which occurs around the boundary of the Gulf of Carpentaria, separates waters closer to shore from the waters in the centre of the Gulf (Wolanski & Ridd 1990). This means that the seafloor basin in the centre of the Gulf receives low levels of sediment relative to seafloor areas closer to shore and tends to be flatter and less diverse than nearshore environments (Heap et al. 2004). In the southern areas of the Gulf, there are complex submerged coral reef and plateaux key ecological features that are protected from wave disturbance by the Wellesley Islands (Condie et al. 2003).

In addition to waves and tidal influences, tropical cyclones can cause localised mixing and disturbance to the seabed (Rochester et al. 2007). Cyclones can generate near-seabed currents in the Gulf of Carpentaria capable of resuspending and transporting sediments 50–100 kilometres away from the cyclone centre (Heap et al. 2004).

The waters of the North Marine Region are primarily oligotrophic (i.e. nutrient poor and oxygen rich). Low levels of nitrates occur in surface waters (Condie et al. 2003) and satellite imagery suggests that primary productivity is low in offshore areas. The highest estimates of productivity occur in the near-shore areas adjacent to the coastline (Condie et al. 2003).

Low levels of chlorophyll are understood to occur in the basin of the Gulf of Carpentaria but this understanding is based on satellite imagery that is less sensitive to primary production that occurs at depth (P Rothlisberg, pers. comm., May 2011). Recent research suggests that primary production in the central (offshore) waters in the Gulf of Carpentaria is driven directly and indirectly by cyanobacteria nitrogen fixation; during the winter months, nitrogen derived from cyanobacteria is brought into the euphotic zone to fuel primary productivity through upwelling (Burford et al. 2009).

Biological diversity

The North Marine Region is known for its high diversity of tropical species but relatively low endemism (i.e. species that are found nowhere else in the world), compared to the relatively isolated marine fauna of southern Australia, which has high species endemism (Mummery & Hardy 1994).

The composition of phytoplankton in the region is highly diverse; about 200 species are known to occur in the area. The predominant phytoplankton species are the large, tropical diatom flora (single-celled algae) on the continental shelf, which are distinctly different in abundance and diversity from the oceanic dinoflagellate flora (single-celled algae with two whip-like appendages called flagella) of the adjacent Coral Sea and Indian Ocean (Hallegraeff & Jeffrey 1984). Copepod animals (zooplankton) found in the region comprise a diverse group of small crustaceans. They are characteristic of warm shallow coastal waters, with around 88 of the 102 species identified in the region common to South-East Asia (Othman et al. 1990).

The plants and animals of the coral reef systems of the region are typical of oceanic reefs in the Indo–west Pacific region, with some endemism present in the northern areas. Coral, invertebrates and fish are highly diverse. Fish such as snapper, emperor and grouper tend to be common higher-order predators of coral and rocky reef habitats (National Oceans Office 2004). Non-reef coral communities can also be extensive and diverse (Veron et al. 2004).

For some fish species groups inhabiting the region (particularly groups associated with commercial activities), considerable information is available. For example, demersal fish including trevally, giant queenfish, barramundi, grunter, emperor, snapper, blue salmon, king threadfin, black jewfish and grouper have been extensively studied (National Oceans Office 2004). Less is known about pelagic fish species in the region, although a total of 61 pelagic fish species from 16 families have been recorded. Of these, six species—longtail tuna (*Thunnus tonggol*), grey mackerel (*Scomberomorus semifasciatus*), Spanish mackerel (*Scomberomorus commerson*), mackerel tuna (*Euthynnus affinis*), black pomfret (*Parastromateus niger*) and spotted mackerel (*Scomberomorus munroi*)—are the most abundant in trawl catches, contributing around 90 per cent to overall catches in the region. Fisheries trawl data show that at least 460 teleost (boned) and 56 elasmobranch (cartilaginous) species are found in the coastal areas in and adjacent to the region (Griffiths et al. 2006). Although the ecological role of coastal fish is not well understood, they are likely to be ecologically important as they are among the most abundant predatory species in coastal waters (Williams et al. 2004).

The Gulf of Carpentaria is the most intensively sampled area in the North Marine Region, especially for seagrasses, invertebrates and demersal fish. There are strong taxonomic affinities between seagrass species found in the Gulf of Carpentaria and those found throughout the Indo–west Pacific area (Poiner et al. 1987). Between 11 and 13 species of seagrass (or around 20 per cent of all known seagrass species) are found in the Gulf, primarily in coastal waters adjacent to the region. These waters support the greatest diversity of seagrass communities found throughout the tropical Indo–west Pacific (Kirkman 1997; Poiner et al. 1987).

A mixture of mud and fine sediments dominate the seafloor environments of the interior basin of the Gulf of Carpentaria (Somers & Long 1994). These soft sediments provide habitat for a diverse assemblage of sessile megabenthos (Long et al. 1995) including infaunal and other megabenthic organisms that form the largest proportion of biomass in the Gulf of Carpentaria (P Rothlisberg, pers. comm., May 2011). Characteristic groups include echinoids (e.g. heart urchins, sand dollars), sponges, solitary corals, polychaetes, crustaceans (e.g. decapods, amphipods, tanaids, ostracods, cumaceans), molluscs (especially bivalves), bryozoans, sea cucumbers and sea squirts.

The Wessel Islands in the north-west of the Gulf in particular are known for high biodiversity of corals and fish, and are likely to contain around 70 per cent of the coral species found on the Great Barrier Reef, based on coral records of the Arnhem Land coast (Veron 2004). The Wessel Islands are also known to have comparatively high levels of endemism compared to the rest of the region, and form a distinct biogeographical boundary for sponge taxa (Hooper & Ekins 2005).

Around 136 mangrove-lined estuaries have been identified in the coastal waters of the Gulf of Carpentaria (Saenger & Bucher 1989) and on land adjacent to the North Marine Region. Mangrove species richness tends to be greatest on the western side of Cape York Peninsula and along the northern coast of Arnhem Land. Approximately 31 of northern Australia's 47 species of mangrove are found in the Gulf of Carpentaria (Duke 1992; Hanley 1992; Wightman 1989). Mangroves provide important nesting sites, feeding sites and staging points for seabirds, waterbirds, waders and migratory birds (Chatto et al. 2004a; Chatto et al. 2004b). Some of the largest waterbird breeding colonies in Australia are on islands and mangrove coastline adjacent to the region along the east coast of the Northern Territory (Chatto et al. 2000).

The North Marine Region is of global significance for breeding and/or feeding grounds for a number of protected, rare and endangered marine animals. For example, six of the world's seven species of marine turtle are found in the region, all of which are listed as endangered or vulnerable under the EPBC Act. The breeding populations of green turtle (Chelonia mydas), hawksbill turtle (Eretmochelys imbricata) and flatback turtle (Natator depressus) found in the region are globally significant (Limpus & Chatto 2004). Dugong (Dugong dugon) populations throughout the region are also globally significant (Saalfeld & Marsh 2004). Of the 31 'true' sea snake species (family Hydrophiidae) known to occur in Australian waters (Wilson & Swan 2003), 19 of these species are found in the North Marine Region.

Bioregional framework

The North Marine Region covers all or part of four provincial bioregions[1] (Figure 2):

- Timor Transition
- Northwest Shelf Transition
- Northern Shelf Province
- Northeast Shelf Transition

These provincial bioregions were identified as part of the Integrated Marine and Coastal Regionalisation of Australia version 4.0 (IMCRA v.4.0), 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.

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).

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. The North Marine Region covers all or part of fifteen meso-scale bioregions.

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 North-west Marine Bioregional Profile at **www.environment.gov.au/marineplans/north**.

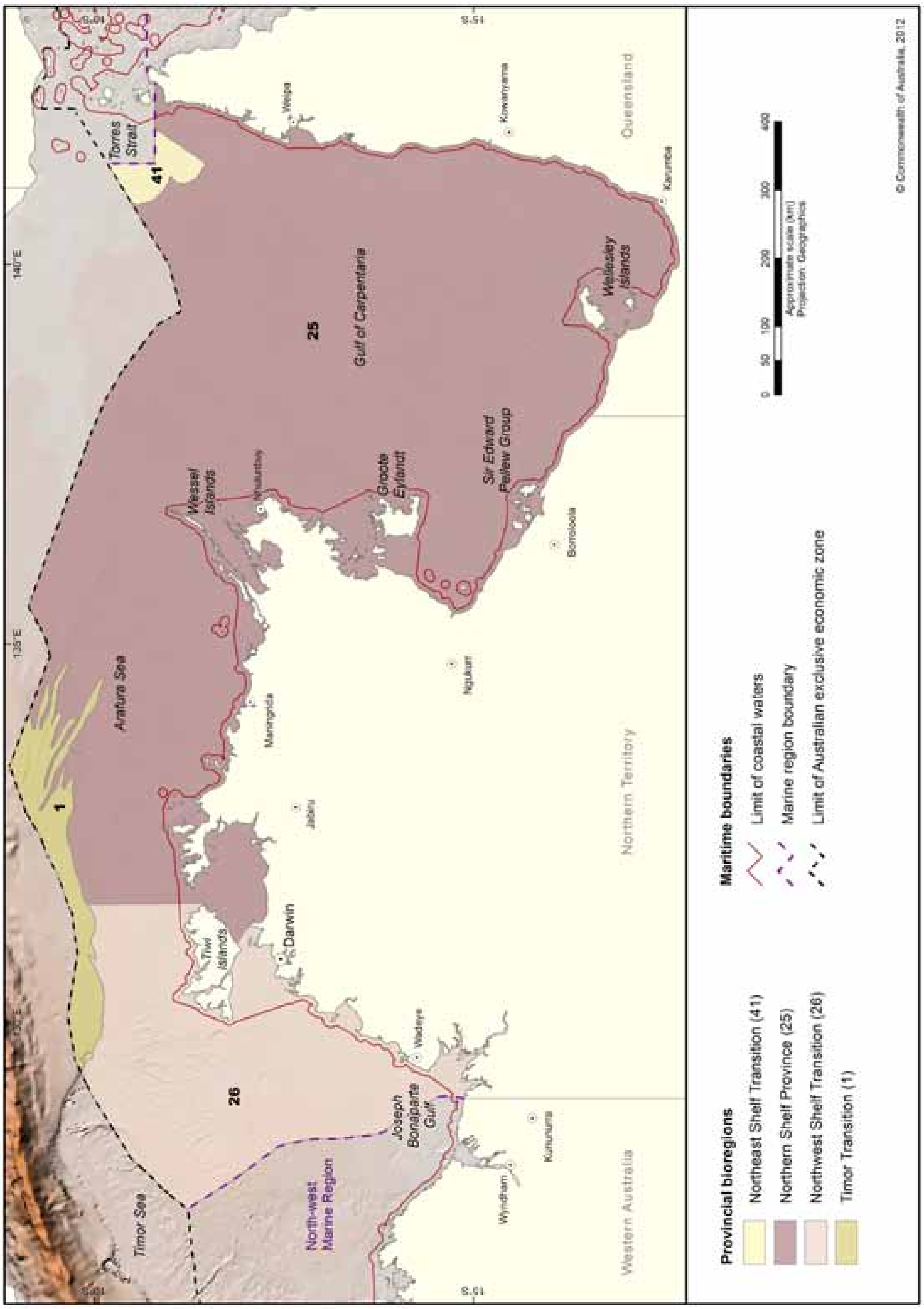

Figure 2: Provincial bioregions that occur in the North Marine Region

2. Key ecological features of the North 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 North 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 North 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**).

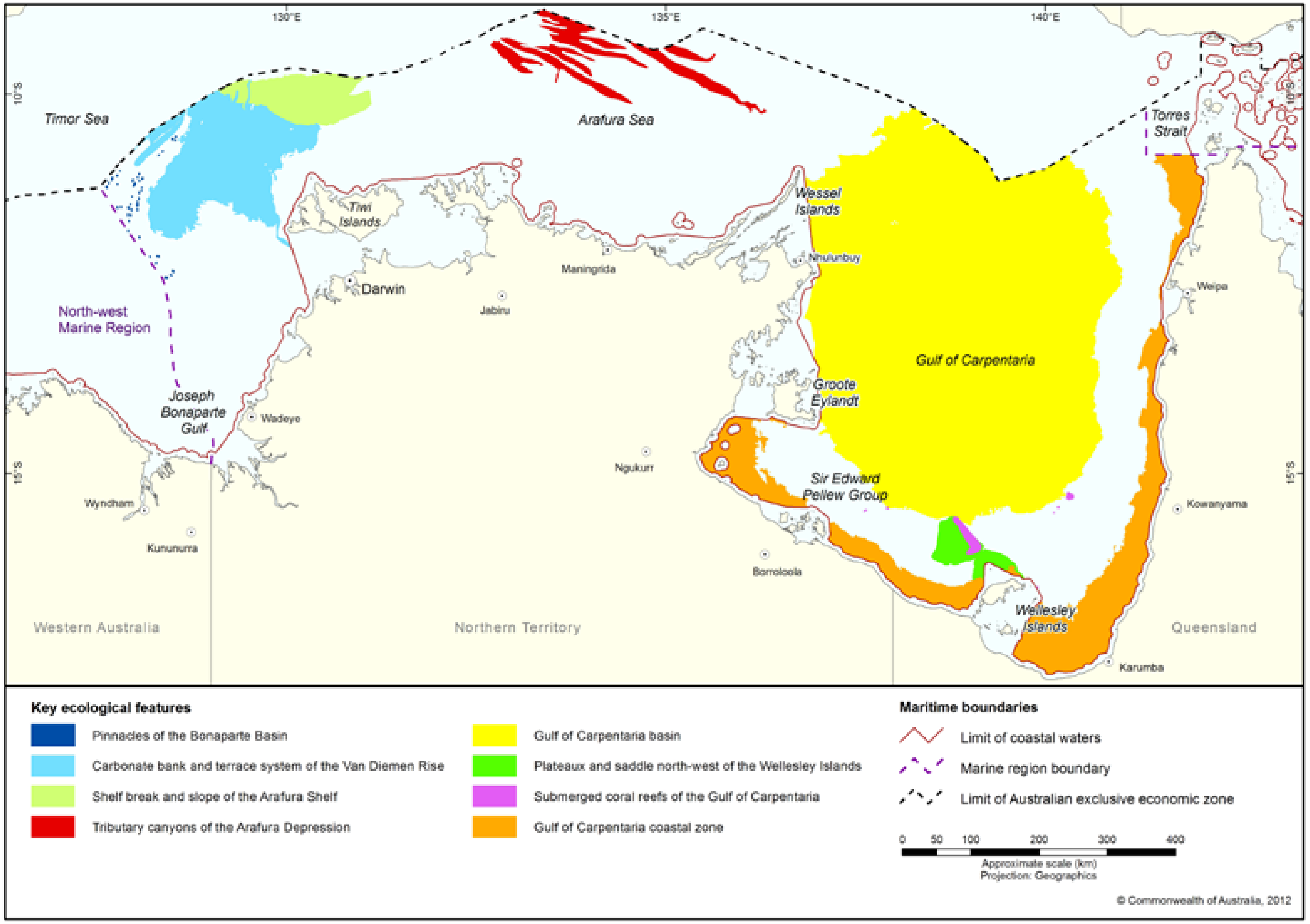

Figure 3: Key ecological features of the North Marine Region

1. Pinnacles of the Bonaparte Basin

National and/or regional importance

The limestone pinnacles in the Bonaparte Basin are likely to be of important conservation value as they support a diverse community in an otherwise oligotrophic system. The pinnacles found in the Bonaparte Basin represent 40 per cent of all pinnacles that exist in the North Marine Region. The largest concentration of pinnacles along the entire Australian margin occurs in the Northwest Shelf Transition provincial bioregion where more than 110 pinnacles are found, covering a total area of more than 520 square kilometres (Heap & Harris 2008).

Values description

The limestone pinnacles of the Bonaparte Basin form part of the Oceanic Shoals meso-scale bioregion. They occur adjacent to the carbonate banks in the Bonaparte Depression of the Joseph Bonaparte Gulf. These limestone pinnacles lie on the mid-outer shelf, which is dominated by soft sediments and limited other seabed structure (Brewer et al. 2007). The pinnacles can be up to 50 metres high and 50–100 kilometres long (Baker et al. 2008) and are thought to be the eroded remnants of the underlying strata (van Andel & Veevers 1967; Marshall et al. 1994 in Harris et al. 2005). As the hard substrate of the pinnacles is surrounded by a relatively featureless environment the pinnacles are presumed to support relatively high numbers of species; however, there are significant gaps in understanding about the species richness and diversity of these structures (Brewer et al. 2007).

The Indonesian Throughflow brings warm, low-salinity water into the Bonaparte Basin and nutrients may be transported into the area through storm and cyclone events (Brewer et al. 2007). Primary productivity is largely from phytoplankton and zooxanthellae within the hard corals on the limestone pinnacles and through sporadic upwelling across the Sahul Shelf. Generally, the processes associated with the presumed enhanced productivity of the limestone pinnacles are not well understood.

Communities associated with the limestone pinnacles are thought to include sessile benthic invertebrates such as hard and soft corals and sponges, and aggregations of demersal fish species such as snapper, emperor and grouper (Brewer et al. 2007). Marine turtles including flatback, olive ridley and loggerhead turtles are known to forage around the pinnacles (Donovan et al. 2008; Whiting et al. 2007), and flatback turtles feed on squid eggs laid on the hard substrate of the pinnacles (M Guinea, pers. comm., 2009). The pinnacles are considered a ‘general use’ area for sawfishes (green and freshwater), although the functioning of the pinnacles ecosystem is not thought to depend on these species (Donovan et al. 2008).

2. Carbonate bank and terrace system of the Van Diemen Rise

National and/or regional importance

The Van Diemen Rise key ecological feature is considered to be an important conservation value for its role in enhancing biodiversity and local productivity relative to its surrounds and for supporting relatively high species diversity. The carbonate banks and shoals found within the Van Diemen Rise make up 80 per cent of the banks and shoals, 79 per cent of the channels and valleys, and 63 per cent of the terrace found across the North Marine Region.

Values description

The bank and terrace system of the Van Diemen Rise is part of the larger system associated with the Sahul Banks to the north and Londonderry Rise to the east. It is characterised by terrace, banks, channels and valleys. The carbonate banks that form the Van Diemen Rise are thought to be directly related to hydrocarbon seepage from the Bonaparte Basin (O'Brien et al. 2002). The existing banks are thought to have formed through erosion of the exposed shelf during periods of low sea level. Channel systems between the banks range from approximately 60–150 metres to 10–40 metres in depth (Anderson et al. 2011).

Recent surveys suggest sediment found in some deeper channels may be from deposition in a brackish (marginal marine) or lacustrine environment, but the age and origin of these channel fill sediments is not well understood (Heap et al. 2010). The variability in water depth and substrate composition across the feature may contribute to the presence of unique ecosystems in the channels (Heap et al. 2010).

The Indonesian Throughflow transports warmer oligotrophic waters of lower salinity into the area from the tropical western Pacific Ocean. The extent to which this supports ecological functioning and biodiversity in the area is largely unknown.

Species present in this key ecological feature include sponges, soft corals and other sessile filter feeders associated with hard substrate sediments of the deep channels. Rich sponge gardens and octocorals have been identified on the eastern Joseph Bonaparte Gulf along the banks, ridges and some terraces (Heap et al. 2010). Plains and deep hole/valleys are characterised by scattered epifauna and infauna that include polychaetes and ascidians. Epibenthic communities such as the sponges found in the channels are likely to support first and second-order consumers. Biophysical maps associated with clustering analysis (Ellis & Pitcher 2009) show greater clustering in this area, which indicates greater environmental variability compared with the rest of the North Marine Region.

Pelagic fish such as mackerel, red snapper and a distinct gene pool of gold band snapper are found in the Van Diemen Rise (Blaber et al. 2005; Salini et al. 2006). Olive ridley turtles and sea snakes, including the olive seasnake and turtle headed seasnake, occur in the area (M Guinea, pers. comm., 2009). Sharks are also found in the area, although not as frequently as they once were (Blaber et al. 2009). The reason for this decline in shark numbers is unknown.

3. Shelf break and slope of the Arafura Shelf

National and/or regional importance

The shelf break and slope of the Arafura Shelf is an important conservation value for its ecological significance associated with productivity emanating from the slope. It also forms part of a unique biogeographic province (Last et al. 2005).

Values description

The shelf break and slope of the Arafura Shelf is characterised by continental slope, patch reefs and hard substrate pinnacles (Harris et al. 2005). Seaward of the Van Diemen Rise, the shelf edge occurs at water depths of 120–180 metres (Jongsma 1974). On the outer shelf and upper shelf slope carbonate sediments are mixed with terrigenous clays from Indonesian rivers (Heap et al. 2004).

Ecosystem processes operating within this key ecological feature are largely unknown but oceanographic processes, possibly associated with the Indonesian Throughflow, and surface wind–driven circulation resulting from the north-west monsoon are thought to have strong ecosystem influences (DEWHA 2007). The Indonesian Throughflow brings warm waters from the western Pacific Ocean through the Indonesian archipelago into the Timor and Arafura seas. This is likely to influence pelagic dispersal of nutrients, species and biological productivity. Pelagic dispersal in turn drives long-term patterns of transport and dispersal of larvae, juvenile and migrating adult organisms across the region. Localised seasonal influences of the Indonesian Throughflow are likely to occur between the north-west monsoon and south-east trade winds. During the monsoon period (December to March) surface currents are weak and have no distinct direction (Harris et al. 1991).

The shelf break and slope of the Arafura Shelf is situated in a major biogeographic crossroad where biota is largely affiliated with the Timor–Indonesian–Malay region (Hooper & Ekins 2005). Phytoplankton and invertebrates have been sampled in the area (Hallegraeff & Jeffrey 1984; Wilson 2005), and primary production of phytoplankton is thought to form the basis for offshore food webs (DEWHA 2007). Fish communities that occur in this key ecological feature represent the break between the Timor Province provincial bioregion and the Timor Transition provincial bioregion (Last et al. 2005). Records show at least 284 demersal fish species are found in the area (Last et al. 2005), including commercially fished red snapper species (Lutjanus erythropterus). The area is also likely to support whale sharks, sharks and marine turtles (DEWHA 2007).

4. Tributary canyons of the Arafura Depression

National and/or regional importance

The tributary canyons of the Arafura Depression are considered to be a conservation value because of their ecological significance associated with productivity and species biodiversity. Almost all canyons found in the North Marine Region are located in this key ecological feature and endemic benthic species are believed to occur there (Wilson 2005).

Values description

The tributary canyons of the Arafura Depression are located in the Timor Transition provincial bioregion. The canyons are around 80–100 metres deep and 20 kilometres wide. The largest of the canyons extend some 400 kilometres from Cape Wessel into the Arafura Depression, and are the remnants of a drowned river system that existed during the Pleistocene era (Heap et al. 2004). As a result of the history and geography of the Arafura Sea, sea-floor sediments are calcium carbonate rich with substantial but varying fractions of carbonate sand and subfossil shell fragments (Wilson 2005). Sampling in the area has revealed calcareous sand and gravel or sandy mud. The deeper channel sediments are composed of calcareous mud and some areas of rocky substrate (Logan et al. 2006).

Although some water flows through the key ecological feature may be associated with the Indonesian Throughflow, the strongest influence on water flows at the sea floor is thought to be tidal ranges that can exceed five metres vertically (Wilson 2005). Sampling in the area has identified relatively high seafloor currents, particularly across ridges on Pillar Bank and hard grounds. These parts of the feature were also found to support diverse populations of large sessile filter-feeding biota such as sponges, octocorals and comatulacean crinoids (Wilson 2005). Primary productivity in this key ecological feature is believed to be associated with movements of water through the canyons and surface water circulation driven by seasonal north-west monsoon winds.

Studies have shown that biological diversity and ecosystem processes in the area are influenced by the heterogeneity of canyon habitats. The steep topography of the canyons, their diverse current regimes, nutrient enrichment and entrapment, detritus funnelling and diverse substrate types form widely divergent ecosystems (McClain & Barry 2010; Vetter 1994; Vinogradova 1959) which, in combination with the regional setting and geological origins of the area, strongly influence species biodiversity (Kloser et al. 2010; RJ Kloser, pers. comm., May 2011).

Detailed seabed mapping in the vicinity of Pillar Bank has shown a correlation between habitats and the biodiversity of various benthic fauna. Areas of high biodiversity and abundance generally correlate with harder substrates where sessile benthos such as sea whips and fans, soft corals, hydroids, crinoids and octocorals—some up to 50 centimetres in height—have been frequently found. In comparison, soft substrates tend to be associated with low-relief benthos that covers less than 5 per cent of the surface area (Logan et al. 2006).

A survey conducted in the area has identified at least 245 macroscopic species, including a diverse variety of invertebrates (e.g. sponges, corals, sea anemones, tunicates, worms, crustaceans, brittle stars, feather stars) and six small fish species (Wilson 2005). It is estimated that a further 500 species could be identified from post-survey analysis of grab and dredge samples (Wilson 2005). Marine turtles (most likely olive ridleys) have been reported to feed in the vicinity of the canyons (Whiting et al. 2007).

Water temperatures recorded in parts of the tributary canyons are generally higher (14–16 °C at approximate depths of 230 metres) than typical deep-sea environments (usually less than 8 °C) (Wilson 2005). However, despite these warmer temperatures, deepwater fauna such as stalked crinoids, hexactinellid sponges and deepwater pedunculate barnacles are known to occur (Wilson 2005).

5. Gulf of Carpentaria Basin

National and/or regional importance

The Gulf of Carpentaria basin is an important conservation value due to the aggregations of marine life, biodiversity and endemism found there. The Gulf of Carpentaria is believed to be one of the few remaining near-pristine marine environments in the world (Bustamante et al. 2010; Coles et al. 2004; Wightman et al. 2004).

Values description

The Gulf of Carpentaria basin is located in the Northern Shelf Province provincial bioregion and is characterised by gently sloping soft sediments and water varying in depth from around 45 metres to 80 metres. Sediment types differ across the basin—shelf sandy muds (less than 50 per cent sand) are found on the western side, shelf muddy sands (50–80 per cent sand) on the eastern side and relict sands and muddy sands dominate the sea floor of the southern basin (DEWHA 2007; Somers & Long 1994). The waters in the Gulf mix little with waters of the Arafura and Coral seas (Condie & Dunn 2006; Forbes 1984), and instead form a distinct semi-enclosed system with limited inputs from either oceanographic or terrestrial sources.

Primary productivity in the Gulf of Carpentaria basin is driven mainly by cyanobacteria that fix nitrogen (Burford et al. 2009), but is also strongly influenced by seasonal processes. During the monsoon, Gulf waters become stratified, resulting in the development of high concentrations of chlorophyll at depths of around 40 metres. In the dry season (April–October), strong south-east trade winds mix Gulf waters and resuspend nutrients generated from benthic microbial processes high in the euphotic zone. This results in primary productivity throughout the water column (Burford & Rothlisberg 1999). Higher-order species including cetaceans and large pelagic fish prey on pelagic species that benefit from this productivity (Hosack & Dambacher 2011).

Nitrogen is also derived from benthic pathways created by detrital rain that is degraded by microbes (Burford et al. 2009). This source of nutrients is consumed by epifauna and invertebrate infauna (Hosack & Dambacher 2011). Snapper and other detritus-feeding fish consume the epifauna, which links higher-order predators such as sharks to both the benthic and pelagic food webs (Griffiths et al. n.d. in Hosack & Dambacher 2011).

The soft sediments of the Gulf of Carpentaria basin are characterised by benthic invertebrates including echinoids (e.g. heart urchins and sand dollars), sponges, solitary corals, molluscs, decapods, bryozoans, sea cucumbers and sessile tunicates (Long et al. 1995; Haywood et al. 2005). Deposit-feeding epifauna in the soft sediments are more abundant than suspension-feeding epifauna (Long et al. 1995).

The Gulf of Carpentaria basin also supports assemblages of pelagic fish species including planktivorous and schooling fish, and top predators such as shark, snapper, tuna and mackerel (Smith et al. 2006). The Gulf is also an important migratory route for seabirds, shore birds and marine turtles.

6. Plateaux and saddle north-west of the Wellesley Islands

National and/or regional importance

The plateaux and saddle north-west of the Wellesley Islands is an important conservation value due to its aggregations of marine life, biodiversity and endemism. It is the only example of a plateaux feature in the North Marine Region and provides important habitat for corals.

Values description

The plateaux and saddle north-west of the Wellesley Islands is located in the Northern Shelf provincial bioregion and is characterised by two hard substrate plateaux separated by a narrow saddle. Isolated living patch reefs occur on the broad, flat-topped plateaux, which extend north-east from Mornington Island. The plateaux are made up of old, eroded karst surfaces (Harris et al. 2007) and are at depths of 15–30 metres (P Rothlisberg, pers. comm., May 2011).

Strong tidal influences occur in this area (S Condie, pers. comm., May 2011). Abundance and diversity of species is higher in the sandy sediments of the east and south-east of the Gulf of Carpentaria (Long & Poiner 1994) and in coastal waters that receive nutrients from river flows (National Oceans Office 2003). However, biological activity around the plateaux and saddle is believed to be associated more with habitat type than productivity or oceanic processes (P Rothlisberg, pers. comm., May 2011).

The species found in the plateaux and saddle north-west of the Wellesley Islands differ from those found in other areas of the Gulf of Carpentaria. In particular, reef fish species found in this key ecological feature are different from those found elsewhere in the Gulf (S Blaber, pers. comm., May 2011). Higher trophic species present in the area and throughout the Gulf of Carpentaria include hawksbill, olive ridley, green and flatback turtles (Robbins et al. 2002). Fish such as snapper, cod and emperor occur around reefs (DEEDI 2009), and Spanish mackerel is concentrated to the north and west of the Wellesley Islands. Seabird species known to occur in the area include frigates, boobies and shearwaters that most likely rely on the area's predictable food sources (C Limpus, pers. comm., 8 November 2009a). Corals in the area are likely to include typical northern Australian coral reef fauna such as octocorals, sponges, ascidians, and gorgonians, and they have zooxanthellae that are bleach resistant in the submerged reefs (A Baker, pers. comm., 8 November 2009). Low abundance of macroalgae and comparatively high abundance of coral and filter feeders have been observed (Harris et al. 2004; DT Brewer unpublished data from survey voyage in Hosack & Dambacher 2011), indicating a competitive dominance of corals in the area (Hosack & Dambacher 2011).

7. Submerged coral reefs of the Gulf of Carpentaria

National and/or regional importance

The submerged coral reefs of the Gulf of Carpentaria are an important conservation value due to the aggregations of marine life, biodiversity and endemism they support. Twenty per cent of the reefs found in the North Marine Region are situated within this key ecological feature and it is likely that more reefs than have been identified occur there (Harris et al. 2007).

Values description

The submerged coral reefs of the Gulf of Carpentaria are located in the Northern Shelf provincial bioregion and have only recently been described (Harris et al. 2004). They are characterised by submerged patch, platform and barrier reefs that form a broken margin around the perimeter of the Gulf of Carpentaria basin. The coral reefs exhibit flat-topped path reef morphology and rise from sea-floor depths of 30–50 metres. Reef platforms occur at depths of around 18–30 metres and reef tops or crests lie at depths of up to 20 metres (Harris et al. 2008).

Relict reef structures support a thin patchy cover of slow growing (1 metre per 1000 years) live corals that includes large plate corals (Turbinaria spp.), abundant hard corals and a large proportion of soft corals (Harris et al. 2007). Corals found in the submerged reefs in the area have zooxanthellae that are bleach resistant (A Baker, pers. comm., 8 November 2009). The relatively closed circulation of the Gulf of Carpentaria may restrict recolonisation of reef species from the Indo–Pacific and limit dispersal within the Gulf (Condie et al. 2005).

Coral reefs found in the Gulf of Carpentaria are likely to comprise typical northern Australian coral fauna including octocorals, sponges, ascidians, gorgonians and reef fish. The submerged reefs also provide breeding and aggregation areas for many fish species including mackerel (Scomberomorus spp.) and large commercially fished snapper (Lutjanid spp.). They provide refuges for sea snakes and apex predators such as sharks (DEWHA 2007), and they sustain invertebrates such as crustaceans and polychaete worms, invertivorous fish and turtles (Marshall & Schuttenberg 2006). Coral trout species that inhabit Gulf reefs are smaller than those found in the Great Barrier Reef and may prove to be an endemic subspecies (DEWHA 2007).

8. Gulf of Carpentaria coastal zone

National and/or regional importance

The Gulf of Carpentaria coastal zone is an important conservation value for its enhanced productivity, aggregations of marine life, biodiversity and endemism (Smith et al. 2006). Nutrient flows into the coastal zone from rivers support higher productivity and more diverse and abundant biota than elsewhere in the North Marine Region (Burford et al. 2010; National Oceans Office 2003). The area is near pristine; ecosystems remain relatively intact, rivers flow largely uninterrupted (Burford et al. 2010), and diverse estuarine and coastal primary ecosystems remain near pristine and provide habitats for many species that move between shallow coastal and offshore waters (Poiner et al. 1987; Wightman et al. 2004).

Values description

The Gulf of Carpentaria coastal zone key ecological feature occurs in Commonwealth waters that extend from the outer boundary of Queensland/Northern Territory waters (generally 3 nautical miles from the coast) to a contour at a depth of 20 metres. The feature stretches from west Cape York Peninsula to Limmen Bight in the south-west Gulf of Carpentaria.

Sediments in the feature are relatively fine muddy sands and sandy muds (Somers 1987; Somers & Long 1994). Waters within the feature are well mixed throughout the year (Burford & Rothlisberg 1999) but are more heavily influenced by freshwater flows during the monsoon. Mixing of freshwater flows and ocean currents tend to trap nutrients in the coastal zone (Wolanski & Ridd 1990), leading to high productivity and diverse and abundant marine life in this area (National Oceans Office 2003).

A large proportion of the coastal waters of the Gulf of Carpentaria lie within the jurisdictions of Queensland and the Northern Territory. These inshore waters support mangroves, seagrasses and coral reefs, which help to drive primary production and diversity in contiguous offshore Commonwealth waters (Poiner et al. 1987; Wightman et al. 2004). They are also the source of organic matter found in Commonwealth waters that is transported through ontogenetic migration of fish and crustaceans (Brewer et al. 1991; Kenyon et al. 2004; Salini et al. 1990).

Species found in this key ecological feature include marine turtles (olive ridley, green, hawksbill and loggerhead) (Poiner et al. 1990), 16 species of sea snake (Fry et al. 2001), colonial and solitary seabirds (e.g. terns, frigatebirds, white bellied sea eagles, osprey, brown boobies) (Chatto et al. 2004a), dugongs (Marsh et al. 2008), and aggregations of fish and sharks (DEWHA 2007). Small whales (false pilot whales) and bottlenose dolphins are numerous (Freeland & Bayliss 1989), and sawfishes (freshwater and green), syngnathids, rare rays and other elasmobranchs are also present (Griffiths et al. 2006; Smith et al. 2006; Stobutzki et al. 2000).

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 North 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 section 1.1 of Schedule 1 in the plan.

Table 1: Outputs of the key ecological features pressure analysis for the North Marine Region

Pressure	Source	Key ecological feature: Pinnacles of the Bonaparte depression	Key ecological feature: Carbonate bank and terrace system of the Van Diemen Rise	Key ecological feature: Shelf break and slope of the Arafura Shelf	Key ecological feature: Tributary canyons of the Arafura Depression
Sea level rise	Climate change	not of concern	not of concern	not of concern	not of concern
Changes in sea temperature	Climate change	of potential concern	of potential concern	of potential concern	of potential concern
Changes in oceanography	Climate change	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Ocean acidification	Climate change	of potential concern	of potential concern	of potential concern	of potential concern
Chemical pollution/ contaminants	Shipping	not of concern	not of concern	not of concern	not of concern
	Vessels (other)	not of concern	not of concern	not of concern	not of concern
	Aquaculture operations	not of concern	not of concern	not of concern	not of concern
	Renewable energy operations	not of concern	not of concern	not of concern	not of concern
	Urban development (urban and/or industrial infrastructure)	not of concern	not of concern	not of concern	not of concern
	Agricultural activities	not of concern	not of concern	not of concern	not of concern
	Onshore and offshore mining operations	not of concern	not of concern	not of concern	not of concern
Nutrient pollution	Aquaculture operations	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Agricultural activities	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Urban development	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Marine debris	Land-based activities	of less concern	of less concern	of less concern	of less concern
	Fishing boats	of less concern	of less concern	of less concern	of less concern
	Shipping	of less concern	of less concern	of less concern	of less concern
	Vessels (other)	of less concern	of less concern	of less concern	of less concern
Noise pollution	Seismic exploration	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
	Defence/surveillance activities	not of concern	not of concern	not of concern	not of concern
	Shipping	not of concern	not of concern	not of concern	not of concern
	Vessels (other)	not of concern	not of concern	not of concern	not of concern
	Aquaculture infrastructure	not of concern	not of concern	not of concern	not of concern
	Renewable energy infrastructure	not of concern	not of concern	not of concern	not of concern
	Onshore and offshore mining operations	not of concern	not of concern	not of concern	not of concern
	Onshore and offshore construction	not of concern	not of concern	not of concern	not of concern
Light pollution	Oil and gas infrastructure	not of concern	not of concern	not of concern	not of concern
	Fishing boats	not of concern	not of concern	not of concern	not of concern
	Vessels (other)	not of concern	not of concern	not of concern	not of concern
	Land-based activities	not of concern	not of concern	not of concern	not of concern
	Onshore and offshore activities	not of concern	not of concern	not of concern	not of concern
	Renewable energy infrastructure	not of concern	not of concern	not of concern	not of concern
	Onshore and offshore mining operations	not of concern	not of concern	not of concern	not of concern

Legend of concern | of potential concern | of less concern | not of concern | data deficient or not assessed

Table 1 continued: Outputs of the key ecological features pressure analysis for the North Marine Region

Pressure	Source	Key ecological feature			
		Gulf of Carpentaria basin	Plateaux and Saddle north-west of the Wellesley Islands	Submerged coral reefs of the Gulf of Carpentaria	Gulf of Carpentaria coastal zone
Sea level rise	Climate change	not of concern	of less concern	of less concern	of potential concern
Changes in sea temperature	Climate change	of potential concern	of potential concern	of potential concern	of potential concern
Changes in oceanography	Climate change	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Ocean acidification	Climate change	of potential concern	of potential concern	of potential concern	of potential concern
Chemical pollution/ contaminants	Shipping	of less concern	of less concern	of less concern	of less concern
	Vessels (other)	of less concern	of less concern	of less concern	of less concern
	Aquaculture operations	of less concern	of less concern	of less concern	of less concern
	Renewable energy operations	of less concern	of less concern	of less concern	of less concern
	Urban development (urban and/or industrial infrastructure)	of less concern	of less concern	of less concern	of less concern
	Agricultural activities	of less concern	of less concern	of less concern	of less concern
	Onshore and offshore mining operations	of less concern	of less concern	of less concern	of less concern
Nutrient pollution	Aquaculture operations	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Agricultural activities	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Urban development	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Marine debris	Land-based activities	of concern	of concern	of potential concern	of concern
	Fishing boats	of concern	of concern	of potential concern	of concern
	Shipping	of concern	of concern	of potential concern	of concern
	Vessels (other)	of concern	of concern	of potential concern	of concern
Noise pollution	Seismic exploration	not of concern	of less concern	not of concern	not of concern
	Urban development	not of concern	of less concern	not of concern	not of concern
	Defence/surveillance activities	not of concern	of less concern	not of concern	not of concern
	Shipping	not of concern	of less concern	not of concern	not of concern
	Vessels (other)	not of concern	of less concern	not of concern	not of concern
	Aquaculture infrastructure	not of concern	of less concern	not of concern	not of concern
	Renewable energy infrastructure	not of concern	of less concern	not of concern	not of concern
	Onshore and offshore mining operations	not of concern	of less concern	not of concern	not of concern
	Onshore and offshore construction	not of concern	of less concern	not of concern	not of concern
Light pollution	Oil and gas infrastructure	not of concern	data deficient or not assessed	not of concern	data deficient or not assessed
	Fishing boats	not of concern	data deficient or not assessed	not of concern	data deficient or not assessed
	Vessels (other)	not of concern	data deficient or not assessed	not of concern	data deficient or not assessed
	Land-based activities	not of concern	data deficient or not assessed	not of concern	data deficient or not assessed
	Onshore and offshore activities	not of concern	data deficient or not assessed	not of concern	data deficient or not assessed
	Renewable energy infrastructure	not of concern	data deficient or not assessed	not of concern	data deficient or not assessed
	Onshore and offshore mining operations	not of concern	data deficient or not assessed	not of concern	data deficient or not assessed

Legend of concern · of potential concern · of less concern · not of concern · data deficient or not assessed

Table 1 continued: Outputs of the key ecological features pressure analysis for the North Marine Region

Pressure	Source	Key ecological feature: Pinnacles of the Bonaparte depression	Carbonate bank and terrace system of the Van Diemen Rise	Shelf break and slope of the Arafura Shelf	Tributary canyons of the Arafura Depression
Physical habitat modification	Offshore construction and installation of infrastructure	of less concern	of less concern	of less concern	of potential concern
	Climate change (changes in storm frequency etc)	of less concern	of less concern	of less concern	of less concern
Human presence at sensitive sites	Aquaculture operations	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Seismic exploration	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Tourism	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Recreational and charter fishing (burleying)	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Research	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Defence/ surveillance activities	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Aircraft	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Extraction of living resources	IUU (domestic or non-domestic)	of potential concern	of potential concern	of potential concern	of potential concern
Bycatch	Commercial fishing	of less concern	of less concern	of less concern	of less concern
	Recreational and charter fishing	of less concern	of less concern	of less concern	of less concern
	IUU fishing (domestic or non-domestic)	of less concern	of less concern	of less concern	of less concern
Oil pollution	Shipping	not of concern	not of concern	of potential concern	of potential concern
	Oil rigs	not of concern	not of concern	of potential concern	of potential concern
Collision with vessels	Shipping	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Fishing	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Tourism	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Invasive species	Shipping	of less concern	of less concern	of less concern	of less concern
	Fishing vessels	of less concern	of less concern	of less concern	of less concern
	Vessels (other)	of less concern	of less concern	of less concern	of less concern
	IUU fishing and illegal immigration vessels	of less concern	of less concern	of less concern	of less concern
	Aquaculture operations	of less concern	of less concern	of less concern	of less concern
	Tourism	of less concern	of less concern	of less concern	of less concern
	Land-based activities	of less concern	of less concern	of less concern	of less concern
Changes in hydrological regimes	Land-based activities	not of concern	not of concern	not of concern	not of concern

Legend of concern | of potential concern | of less concern | not of concern | data deficient or not assessed

Table 1 continued: Outputs of the key ecological features pressure analysis for the North Marine Region

Pressure	Source	Key ecological feature			
		Gulf of Carpentaria basin	Plateaux and Saddle north-west of the Wellesley Islands	Submerged coral reefs of the Gulf of Carpentaria	Gulf of Carpentaria coastal zone
Physical habitat modification	Offshore construction and installation of infrastructure	of less concern	of less concern	of less concern	of potential concern
	Climate change (changes in storm frequency etc)	of less concern	of less concern	of less concern	of potential concern
Human presence at sensitive sites	Aquaculture operations	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Seismic exploration	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Tourism	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Recreational and charter fishing (burleying)	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Research	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Defence/ surveillance activities	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Aircraft	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Extraction of living resources	IUU (domestic or non-domestic)	of potential concern	of potential concern	of potential concern	of potential concern
Bycatch	Commercial fishing	of less concern	of less concern	of less concern	of less concern
	Recreational and charter fishing	of less concern	of less concern	of less concern	of less concern
	IUU fishing (domestic or non-domestic)	of less concern	of less concern	of less concern	of less concern
Oil pollution	Shipping	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Oil rigs	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Collision with vessels	Shipping	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Fishing	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Tourism	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Invasive species	Shipping	of less concern	of less concern	of less concern	of less concern
	Fishing vessels	of less concern	of less concern	of less concern	of less concern
	Vessels (other)	of less concern	of less concern	of less concern	of less concern
	IUU fishing and illegal immigration vessels	of less concern	of less concern	of less concern	of less concern
	Aquaculture operations	of less concern	of less concern	of less concern	of less concern
	Tourism	of less concern	of less concern	of less concern	of less concern
	Land-based activities	of less concern	of less concern	of less concern	of less concern
Changes in hydrological regimes	Land-based activities	data deficient or not assessed	of less concern	data deficient or not assessed	of potential concern

Legend of concern | of potential concern | of less concern | not of concern | data deficient or not assessed

Sea level rise – climate change

Global sea levels have risen by 20cm between 1870 and 2004 and predictions estimate a further rise of 5-15cm by 2030, relative to 1990 levels (Church et al. 2009). Longer term predictions estimate increases of 0.5 to 1.0 metre by 2100, relative to 2000 levels (Climate Commission 2011).

Sea level rise is *of potential concern* for the Gulf of Carpentaria coastal zone. Sea level rise will potentially reduce critical nursery habitats such as seagrass and mangroves for many marine species (Hobday et al. 2008) in the southern Gulf of Carpentaria (Hill et al. 2002). Declines in coastal habitats could lead to changes in ecosystem structure, processes and connectivity between inshore and offshore habitats. Nutrients and organic matter sourced from dynamic, productive coastal environments could be disrupted, and ontogenetic movements by fish and crustacean fauna between inshore habitats and the contiguous offshore Commonwealth marine environment could be disrupted (Haywood & Kenyon 2009). Erosion of terrigenous landforms through rising sea levels may also create highly turbid coastal waters that will cause further declines of seagrass and coral habitats.

Changes in sea temperature – climate change

Sea temperatures have warmed by 0.7 °C between 1910–1929 ad 1989–2008, and current projections estimate ocean temperatures will be 1 °C warmer by the 2030s (Lough 2009). Projected temperature changes in Australian waters are expected to exceed the threshold for inducing coral bleaching on an annual basis (Hoegh-Guldberg 1999, 2004 in Hobday et al. 2006). Sea temperature changes are *of potential concern* with respect to all key ecological features in the North Marine Region due to expected impacts such as changes to the distribution, abundance, physiology, morphology and behaviour of zooplankton, and of pelagic, benthic and demersal fish (Hobday et al. 2006).

Extended periods of elevated temperatures in shallow estuarine and coastal waters in the Gulf of Carpentaria coastal zone are likely to affect the distribution of fish and prawn nursery habitats such as estuarine and coastal seagrasses and mangroves (Hobday et al. 2008). Coastal fringing coral reef communities are expected to be affected (Hoegh-Guldberg 2011). However, the degree to which impacts on corals in the submerged reefs of the Gulf of Carpentaria and the plateaux and saddle north-west of the Wellesley Islands could occur is unknown considering that some corals in the North Marine Region may contain zooxanthellae that show resilience to bleaching (A Baker, pers. comm., 8 November 2009).

Any decreases in coral abundance could lead to changes in ecosystem structure, processes and connectivity between coral reefs and the adjacent waters. Nutrients and organic matter sourced from dynamic reef complexes and ontogenetic movements of fish and crustaceans may be disrupted (Haywood & Kenyon 2009). Epifauna such as sponges, algae and coralline algae may also be affected by elevated sea water temperatures (Brooke et al. 2009).

Habitat declines are likely to have implications for marine species aggregations and biodiversity in the Gulf of Carpentaria coastal zone through disruption of ecosystem processes and connectivity between coastal and offshore ecosystems (Blaber 2009; Haywood & Kenyon 2009). Studies elsewhere showed during an El Niño event in the 1990s, for example, the supply and survival of reef fish larvae in coral reef habitats was affected by elevated sea surface temperatures, causing declines in reef fish communities (Lo-Yat et al. 2011).

The nature and strength of the thermocline that develops in the Gulf of Carpentaria during the monsoon will most likely change with increased sea temperature, becoming shallower and stronger. While this may further depress the transfer of nutrients into the euphotic zone, potentially limiting primary productivity, the interaction with increased productivity due to increased water temperatures is unclear (Behrenfeld 2011).

Ocean acidification – climate change

Driven by increasing levels of atmospheric CO_2 and subsequent chemical changes in the ocean, acidification is already underway and detectible. Since pre-industrial times, acidification has lowered ocean pH by 0.1 pH 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).

Ocean acidification is *of potential concern* for all key ecological features in the North Marine Region, and in particular for those key ecological features that have coral formations. Acidification of corals is likely to alter the distribution and abundance of corals generally (Hobday et al. 2006), and atmospheric CO_2 levels above 500 parts per million will severely compromise coral viability (Hobday et al. 2006). Ocean acidification will also compromise carbonate accretion (Hoegh-Guldberg 2011). The acidification of the ocean will impair the ability of species with calcareous shells—such as echinoderms, crustaceans and molluscs—to maintain shell integrity, resulting in reductions in the overall abundance and biodiversity of these species (Lawrence et al. 2007).

For the plateaux and saddle north-west of the Wellesley Islands and the submerged reefs of the Gulf of Carpentaria, a decrease in coral abundance could lead to changes in ecosystem structure, processes and connectivity between plateaux and reef waters. Nutrients and organic matter sourced from dynamic reef complexes could also be disrupted. For the Gulf of Carpentaria coastal zone, changes in dissolved CO_2 levels represent a threat to calcifying organisms such as corals, pteropods and coccolithophores (Poloczanska et al. 2007).

Growth of mangroves and seagrasses may increase with elevated levels of atmospheric and dissolved CO_2 but any rises in sea level could at the same time compromise mangrove and seagrass habitats that support a diversity of marine life (Hill et al. 2002). Any declines in the ecological health of coral reef, mangrove and seagrass habitats in the coastal waters of the Gulf of Carpentaria will have a direct impact on ecosystem processes and biodiversity within adjacent offshore Commonwealth waters (Blaber 2009). This is because nutrients and organic matter exported from dynamic inshore complex habitats to offshore environments as well as ontogenetic movements of fish and crustaceans between inshore and reef systems and offshore waters are likely to be disrupted (Haywood & Kenyon 2009).

Marine debris – fishing boats; land-based activities; shipping; vessels (other)

Marine debris is *of concern* for the Gulf of Carpentaria basin, the plateaux and saddle north-west of the Wellesley Islands and the Gulf of Carpentaria coastal zone, and is *of potential concern* for the submerged coral reefs of the Gulf of Carpentaria.

Marine debris such as derelict fishing nets are an increasing global threat to marine life (Macfadyen et al. 2009) and in northern Australia have been documented to entangle sharks, cetaceans, large piscivorous fishes and turtles (Kiessling 2003). In the Arafura Sea, reports suggest high numbers of marine species are being harmed and killed by debris while at sea, or as a result of injuries on shore (Chatto 1995 in Kiessling 2003). A number of different plastic types are recorded as impacting seabirds, with derelict fishing nets dominating entanglement records (Ceccarelli 2009). Smaller plastic items tend to be found wrapped around seabirds' bills or legs (Ceccarelli 2009). Shearwaters, terns and petrels are known to ingest plastics. Some seabirds ingest plastic that they mistake for food. This can eventually cause mortality of individuals (Baker et al. 2002).

Marine debris affects a range of species although the extent of impacts is currently unquantified. For example, marine debris may disrupt breeding cycles of individual animals and compromise foraging habitats. Turtle mortality associated with derelict nets in the Gulf of Carpentaria is uncertain but is likely to amount to many hundreds of turtles per year (Limpus 2009b). For example, in the six weeks after Cyclone Abigail in February 2001, it is estimated that more than 4000 nets were washed ashore containing around 400 (order of magnitude) turtles. Similar strandings and entanglements have been recorded for subsequent cyclonic events (Limpus 2009b).

Monofilament is highly persistent in the marine environment and has been documented as a major source of coral mortality in heavily fished localities (Smith et al. 2006).

Physical habitat modification – offshore construction and installation of infrastructure; storm events

Physical habitat modification caused by offshore construction and installation of infrastructure has been rated as *of potential concern* for the tributary canyons of the Arafura Depression and the Gulf of Carpentaria coastal zone. Physical habitat modification caused by storm events has been assessed as *of potential concern* for the Gulf of Carpentaria coastal zone.

Physical habitat modification caused by offshore construction and installation of infrastructure may occur through activities associated with the mining, oil and gas sectors. While there is currently no extraction of oil and gas in the North Marine Region, nine exploration wells have been drilled in the Arafura Basin adjacent to the tributary canyons (DRET 2011) and two exploration permits cover much of the area. In addition, a number of offshore basins are considered highly prospective for economically viable extraction of oil and gas deposits (Cadman & Temple 2003; Earl et al. 2006). The potential for pressures associated with oil and gas exploration and extraction in the Arafura Basin is therefore high.

There are mining tenements to the west and north-west of Groote Eylandt for submarine mining of manganese ore. While any activities associated with these tenements will occur in Northern Territory waters they have the potential to impact ontogenetic movements of crustacean and fish species from inshore to offshore Commonwealth waters (Haywood & Kenyon 2009). Mining tenements also exist in Commonwealth waters south of Groote Eylandt.

Storms and cyclones have heavily modified marine habitats in the North Marine Region, and their intensity is predicted to increase (Hyder Consulting 2008). Present indications are that modest to moderate (up to 20 per cent) increases in average and maximum cyclone intensities are expected by the end of the century in some regions (Walsh & Ryan 2000).

Cyclone activity has the ability to remove seagrass beds and impact mangrove habitats (Hobday et al. 2008). For example, Cyclone Sandy (18–24 March 1985) removed approximately 20 per cent coverage of seagrass beds in the Gulf of Carpentaria, which have taken around 10 years to recover (Hill et al. 2002). Shallow habitats including mangroves are most at risk from severe weather. Intensive storms can cause large levels of damage, and increased frequency of storms means that habitats and communities have less time to recover between storm events. Habitat loss will occur when the frequency and intensity of severe weather events exceed the habitat's ability to recover from one event to the next (Chin & Kyne 2007).

Impacts associated with storms and cyclones include declines in coral reef, mangrove and seagrass communities located in nearshore waters, which can lead to changes in ecosystem processes and connectivity in adjacent offshore Commonwealth waters (Blaber 2009). Nutrients and organic matter exported from dynamic inshore complex habitats may be disrupted. Ontogenetic movements by fish and crustaceans between inshore and offshore waters are also likely to be disrupted (Haywood & Kenyon 2009).

Extraction of living resources – illegal, unregulated and unreported fising

Due in part to close proximity to Australia's international borders, illegal, unregulated and unreported (IUU) fishing is a pressure considered to be *of potential concern* to all key ecological features in the North Marine Region. In recent years, IUU fishing has been a considerable issue across northern Australian waters for the threat it poses to target and bycatch species, border security, quarantine concerns and conservation of the marine environment more generally (Vince 2007). In 2005 for example, 13 018 illegal foreign fishing vessels were observed in Australian waters and, of those, only 600 were apprehended by Australian officials (Vince 2007).

Illegal foreign fishers have tended to target sharks for the valuable shark fin market, although the full extent of IUU fishing for shark in northern Australia is largely unquantified. Selected shark stocks targeted by IUU fishers have declined or are overfished (Heupel & McAuley 2007). Whale sharks have also been targeted by IUU fishers. Whale sharks caught by fishers outside Australian jurisdiction (in northern Arafura and Timor seas and Indo–Pacific region) could also impact on the health of whale shark populations in the North Marine Region (I Field, pers. comm., 28 May 2009).

The number of IUU fishing vessels sighted in northern Australian waters has declined significantly since 2005. However, while the total number of IUU vessels observed may have declined, there is some concern that fewer numbers of more powerful and sophisticated IUU fishing vessels may be targeting Australian stocks (Lack & Sant 2008).

Oil pollution – oil rigs; shipping

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. The National Marine Oil Spill Contingency Plan (AMSA 2010) rates most waters in the North Marine Region as being at low risk of pollution from oil and other noxious and hazardous substances. The consequences of oil pollution, 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* for the shelf break slope of the Arafura Depression and the tributary canyons of the Arafura Depression. Key ecological features associated with aggregations of pelagic feeding marine life at or in proximity to the sea surface (such as seabirds along the migratory flyway) are particularly vulnerable to oil pollution. Turtles, sea snakes, whales and dolphins all breathe at the sea surface and are therefore also very susceptible to oil slicks.

There is currently no extraction of oil and gas in the North Marine Region. However, a number of offshore basins are considered highly prospective for viable extraction of oil and gas (e.g. Cadman & Temple 2003; Earl et al. 2006), and the intensity and distribution of activities such as oil production and transport that might lead to oil spills are expected to increase in the region.

To manage oil spills, chemical dispersants (powerful detergents) may be applied to the sea surface to accelerate weathering processes and to disperse the oil into the water column in order to minimise the surface transport of oil to sensitive habitats such as foreshores. These chemical dispersants contain toxic elements that can be harmful to coral (Shafir et al. 2007). Gulec and Holdway (2000, cited in Fandry et al. 2006) have found that if certain dispersants are combined with crude oil, the toxicity of oil to species of fish and invertebrates is increased. However, dispersants are only used when all environmental effects have been considered and are generally not used in close proximity to coral reefs (AMSA 2011).

Oil spills are rare and their impacts depend on a number of factors including the concentration of oil, the chemical and physical properties of the oil (or oil/dispersant mixture), timing of breeding cycles and seasonal migrations of species, timing of contact between the oil and species/habitats, susceptibility of particular species, and the health, age and reproductive status of individual animals (AMSA 2011).

Changes in hydrological regimes – land based activities

Changes in hydrological regimes associated with land-based activities such as agriculture, mining, river abstraction, channelling and damming, and coastal development is considered as *of potential concern* for the Gulf of Carpentaria coastal zone. Changes in flows and characteristics of fresh water into the Gulf of Carpentaria coastal zone have the potential to affect higher trophic species and commercial fishery species due to reduction in the transport of terrigenous nutrients to coastal habitats, loss of food availability and changes to triggers such as flooding that are emigration cues for key marine species (Burford et al. 2010). Impacts on key ecological features in the North Marine Region related to changes in hydrological regimes may be of concern if there is significant growth in agricultural and water resource development in adjacent coastal areas (CSIRO 2009).

4. Relevant protection measures

The environment in Commonwealth marine areas, including the North 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/north**).

Under the EPBC Act, all fisheries managed under Commonwealth legislation, and state/territory 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 and territory? 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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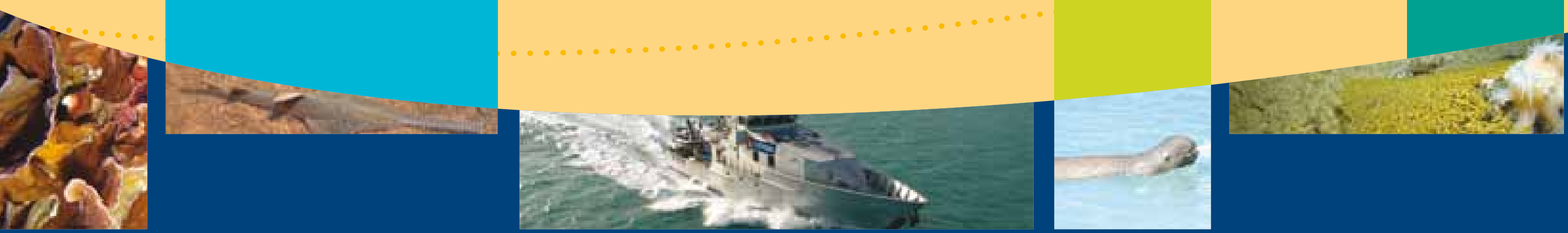

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