Appendix D North-west Marine Region Protected Species Group Report Cards

These report cards summarise information on those species that occur in the North-west Marine Region and are protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The report cards present relevant information on species groups and are designed to be updated as new information becomes available. The report cards in this appendix are current at May 2008. Updates of the report cards will be available at <www.environment.gov.au/coasts/mbp/north-west>.

Protected species occurring in the North-west Marine Region for which species group report cards have been compiled include:

D1 Sharks

D2 Bony fish (including seahorses, pipehorses, pipefish and ghost pipefish)

D3 Reptiles – sea snakes

D4 Reptiles – marine turtles

D5 Birds (seabirds and shorebirds)

D6 Mammals – dugongs

D7 Mammals – cetaceans

D1 North-west Marine Region Protected Species Group Report Card – Sharks

Current at May 2008. See <www.environment.gov.au/coasts/mbp/north-west> for updates.

General information

Sharks belong to the taxonomic class Chondrichthyes, which are also known as the cartilaginous fish. As this name suggests, sharks do not have bones, and instead their skeletons are composed of cartilage. Sharks fall within the subclass Elasmobranchii, which are typified by cylindrical, sometimes flattened body forms, and have between five and seven gill openings.

The distribution of sharks is highly varied, and they are found in a wide range of habitats ranging from shallow to deep water, in oceanic, reef, coastal, estuarine and freshwater environments. Sharks can be pelagic (in the upper part of the water column or the open ocean) or demersal (living on or near the seafloor).

The North-west Marine Region has a rich shark fauna owing to the diversity of marine environments found across its waters. Of the 500 shark species found worldwide, 94 are found in the Region – 19 per cent of the world's shark species. A more detailed overview of the chondrichthyan species group in the North-west Marine Region can be found in Heupel & McAuley (2007). This report is available at <www.environment.gov.au/coasts/mbp/north-west>.

Grey reef shark. Photo: Photolibrary.

Table D1.1 Sharks listed as threatened or migratory under the EPBC Act that are known to occur in the North-west Marine Region

Species	Conservation Status	Conservation Plans and Policies
Whale shark (*Rhincodon typus*)	Vulnerable, Migratory Listed under CITES (Appendix II) & CMS (Appendix I & II)	• *Recovery Plan for the Grey Nurse Shark* (Carcharias taurus) *in Australia* (EA 2002a) • *White shark* (Carcharodon carcharias) *Recovery Plan* (EA 2002b) • *National Plan of Action for the Conservation and Management of Sharks* (DAFF 2004) • *Whale shark* (Rhincodon typus) *Recovery Plan 2000–2010* (DEH 2005)
Grey nurse shark (*Carcharias taurus*) – west coast population	Vulnerable Listed under CITES (Appendix II)	
White shark (*Carcharodon carcharias*)	Vulnerable, Migratory Listed under CITES (Appendix II) & CMS (Appendix I and II)	
Green sawfish (*Pristis zijsron*)	Vulnerable Listed under CITES (Appendix I)	

Nationally protected species

Four shark species found in the Region are listed under the EPBC Act (Table D1.1). All these species are also listed under international instruments. Recovery Plans are in place for each of these species and can be found at <www.environment.gov.au/coasts/species/sharks>.

As a signatory to the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS), Australia has an international obligation to protect migratory species, their habitats and their migration routes. Similarly, as a party to the *Convention on the International Trade in Endangered Species of Wild Fauna and Flora* (CITES), Australia has agreed to control the import and export of an agreed list of species that are endangered, or at risk of becoming endangered because of inadequate controls over trade in them or their products. In June 2007, six of the seven species of sawfish (family Pristidae) were listed under Appendix I of CITES. The exception was the freshwater sawfish *Pristis microdon*, which was listed under Appendix II of CITES allowing international trade in live animals to appropriate and acceptable aquaria, primarily for conservation purposes. Further information on CITES and CMS is included in Appendix A.

Ecology of protected species in the North-west Marine Region

White sharks (*Carcharodon carcharias*) are found in temperate and subtropical waters across the world. In Australian waters, their range extends from southern Queensland around the southern Australian coast to North West Cape. They generally inhabit coastal and continental shelf waters to 100 m depth.

In the North-west Marine Region they are occasionally found in waters south of Exmouth, and are rarely found in tropical waters. Non-breeding white sharks tend to have a wider temperature range and may move into tropical waters, and pass through the waters off oceanic islands (EA 2002b). Recent tagging studies recorded a female white shark travelling across the Indian Ocean, from South Africa to waters off Exmouth and back in under 9 months - the fastest trans-oceanic migration recorded among marine fauna (Bonfil *et al*. 2005).

White sharks attain a maximum size of up to 6 m and males and females reach sexual maturity at 350 cm and 400 cm, respectively. Like most other sharks, they are oviphagous. Oviphagous animals hatch from eggs, but the eggs hatch and the young develop inside the female's body. There is no placenta to nourish the pups. Instead,the pups are cannibalistic; eating any unfertilized eggs and their siblings. Very few pups in a litter survive to birth. White sharks have between two and ten young per litter, of 130 cm length (Last & Stevens 1994). They primarily feed on teleosts (bony fish) and other sharks, but adults also feed on marine mammals, such as pinnipeds and whales. They have few natural predators and do not feed continuously; a large meal (such as a seal) may last a medium-sized shark for up to a week (EA 2002b).

Few regions of the world support large white shark populations without a corresponding pinniped (sea lion and seal) population (EA 2002b). There are no known pinniped sites in the Region and no major white shark populations have been recorded in the Region. However, white sharks spend much of their life in pelagic areas away from seal colonies, and also feed on a variety of pelagic species (Boustany *et al*. 2002).

Grey nurse sharks (*Carcharias taurus*) are found in subtropical to cool temperate inshore waters around the much of world, except the western Pacific (Last & Stevens 1994). In Australian waters, they are regularly sighted from southern Queensland to the New South Wales/Victorian border, and from Esperance in southern Western Australia north to Shark Bay and North West Cape (EA 2002a).

Thus, grey nurse sharks are thought to form two distinct populations in Australian waters: an east coast and a west coast population with a strong genetic difference between the two populations (Stow *et al*. 2006). These populations are listed separately under the EPBC Act: the west coast population is listed as vulnerable and the east coast population as critically endangered.

The range of grey nurse sharks spans the whole Region, but they have rarely been found north of Shark Bay (EA 2002a). An aggregation has recently been discovered at Broome, which represents a significant extension to their range (R. McAuley, pers. comm. 2007). Grey nurse sharks generally inhabit waters between the surf zone and the outer continental shelf to 190 m water depth. The diet of grey nurse sharks is similar to other sharks, and consists of teleost (bony) fish and other sharks.

Whale sharks (*Rhincodon typus*) are found in tropical and warm temperate seas across the world (Last & Stevens 1994; Stewart & Wilson 2005). In Australia they have been reported from waters off the Northern Territory, Queensland and northern Western Australia, but they are primarily found in seasonal aggregations around Ningaloo Reef, between March and June. They have also been reported from oceanic and coastal waters across the Region (Wilson *et al*. 2006).

The whale shark is the largest living fish, with the largest measuring just over 12 m (Stevens 2007). They are thought to be ovoviviparous, retaining their egg cases until hatching, with the females releasing live young. Unlike most sharks, whale sharks are filter-feeders, and their diet includes a wide variety of planktonic and nektonic prey, including small crustaceans, fish eggs and small pelagic fish. They do not rely on forward motion to filter prey, and can hang vertically in the water column and suction feed by opening their mouths and allowing water to rush in (Last & Stevens 1994).

Whale sharks are generally solitary, but can occur in aggregations of up to hundreds of individuals, usually in tropical and subtropical waters between 21–25°C. Seasonal aggregations of whale sharks occur around dense collections of prey such as those found around Ningaloo Reef (Stevens 2007). Around Ningaloo, whale sharks spend daylight hours near the surface and nights at depths of 30–80 m.

In oceanic waters, they routinely move between the sea surface and depth, and spend over half their time at depths greater than 30 m. Off the outer North West Shelf, they spend much of their time swimming near the seafloor, and make dives to over 1000 m depth. They are able to tolerate the colder temperatures (to 5°C) found at these depths, possibly because of the insulation provided by their large body mass (Wilson *et al*. 2006). These dives into deeper oceanic waters are thought to be primarily in search of prey such as krill, lantern fish, squid and jellyfish around the deep scattering layer (Wilson *et al*. 2006).

Whale sharks are highly migratory; their longer-term movements are uncertain, but are likely to include Indonesian and other South–East Asian waters. There is evidence of substantial gene flow among populations of whale sharks, indicating they make broad-scale movements and have a high connectivity among populations (Bradshaw 2007). Their movements are thought to be related to changes in local biological productivity, and they are often associated with schools of pelagic fish. After leaving Ningaloo, most whale sharks probably travel north-east along the continental shelf, before moving offshore into the north-eastern Indian Ocean, around the Dampier Terrace and Argo Abyssal Plain (Wilson *et al*. 2006). Whale sharks have also been recorded moving further north-east toward Scott Reef and Ashmore Reef (Wilson *et al*. 2006).

Green sawfish (*Pristis zijsron*) are found mostly in tropical and subtropical waters, north of Shark Bay across northern Australian waters to Cairns. In terms of their wider distribution, they are found in the northern Indian Ocean and off Indonesia (Heupel & McAuley 2007). This species has mostly been recorded in inshore, coastal environments, as well as estuaries, but unlike other sawfish species, does not move into freshwater. There have been a number of records of this species far offshore, at water depths of up to 70 m. Smaller green sawfish are more likely to be found in inshore waters, whereas larger animals have been found in both inshore and offshore waters (Stevens *et al*. 2005). Like other sawfish species, green sawfish are thought to be long-lived, produce few young and reach sexual maturity late in life.

Important areas for sharks in the North-west Marine Region

While there are a number of known grey nurse shark aggregation sites in eastern Australian, there are no such sites in the North-west Marine Region. Some potentially suitable sites have been identified in waters off the Western Australian coast, based on their similarity to eastern Australian sites. These mostly occur around Exmouth and North West Cape where there are significant vertical and horizontal reef structures, including fringing coral reef with isolated bomboras amongst sand and rubble. However, no aggregations have been recorded from these areas (Chidlow *et al*. 2006).

There are no known aggregation sites for white sharks in the Region, and this species is most likely to be found south of North West Cape only, probably in low densities.

Little is known of important areas for green sawfish in the Region, but inshore waters are likely to be important for this species. Another sawfish species, the freshwater sawfish (*Pristis microdon*), which is listed as vulnerable under the EPBC Act, does not commonly occur in the Commonwealth waters of the North-west Marine Region, but the inshore waters around King Sound and the Fitzroy River are critical habitat for this species (Thorburn *et al*. 2004).

Ningaloo Reef – In Australian waters, Ningaloo Reef is the main known aggregation site for whale sharks, owing to concentrations of krill and other zooplankton associated with seasonal productivity events, which provide an abundant food source (Taylor 1996). The whale shark aggregations at Ningaloo are the largest density of whale sharks per kilometre in the world (Martin 2007).

Generally, whale shark aggregations around Ningaloo are greatest in La Niña years, in association with intensification of the Leeuwin Current in March. This results in the extension of warmer water down the Western Australian coast, and allows whale sharks to exploit more abundant food sources within this seasonally expanded geographic range (Wilson *et al*. 2001).

The Ningaloo region provides a unique habitat for whale sharks, owing to its circular current system of two opposing currents: the Ningaloo Current and the Leeuwin Current (Taylor & Pearce 1999). Offshore from the shelf break, the southerly-flowing Leeuwin Current assists whale shark migration to Ningaloo. Along the inner shelf, the Ningaloo Current flows northward and retains planktonic biomass (which whale sharks feed on) within the Ningaloo region.

Known interactions, threats and mitigation measures

Commercial fishing

None of the shark species listed under the EPBC Act are targeted by commercial fisheries in the Region and the catch of grey nurse sharks and white sharks in commercial fisheries is prohibited. Historically, the major source of grey nurse shark deaths in the Region has been incidental capture in demersal gill-net and line fisheries south of Steep Point near Shark Bay (Chidlow *et al*. 2006). Most of the protected sharks caught as by-catch are returned to the sea alive, but release of sharks after capture is likely to be associated with increased mortality (Stevens *et al*. 2000). However, due to the limited distribution of white sharks and grey nurse sharks in the North-west Marine Region, the risk to these species in the Region is negligible.

Whale sharks have limited interaction with fisheries in the Region, and the greatest threat to this species is associated with fishing pressure outside Australian waters. Whale sharks are vulnerable to over-exploitation by fishing because of their slow growth; delayed, infrequent reproduction; and widespread distribution in small, highly mobile populations. In addition, they are easily caught, as they are slow-swimming and docile when encountered near the sea surface (Stewart & Wilson 2005). Coastal harpoon and net fisheries for whale sharks exist in many countries including Taiwan, Indonesia and Pakistan (Rowat 2007). Despite bans on whale shark capture in many countries, enforcement is minimal, and trade in whale shark products is largely driven by demand for meat and fins. The killing of whale sharks in their seasonal residences, where they are the subject of targeted fisheries, is the largest threat to whale sharks (Rowat 2007). Recent evidence indicates that overseas fishing pressure may be a primary cause in inferred recent declines in whale shark numbers at Ningaloo Reef (Bradshaw *et al*. 2007).

The toothed rostrum of green sawfish (and other sawfish species) make them highly susceptible to capture in all net fisheries. As such, net and trawl fisheries within (and adjacent to) the Region pose a threat to green sawfish. Because of the danger of removing large specimens from nets and lines, fishers may kill sawfish before removing them from their fishing gear. In addition, the high value of sawfish fins (up to $250 per kg) results in animals being retained, where they would normally be released. Closing some areas to fishing at specific times of the year may decrease the likelihood of green sawfish capture, along with the use of by-catch reduction devices, but these have not been studied in any detail (Stevens *et al*. 2005).

Illegal, unreported and unregulated fishing

Sharks are thought to be major target species for illegal, unreported and unregulated fishing in the Region. Demand and prices for shark products, such as fins and jaws, are both relatively high, which coupled with the low reproductive rate of most sharks, increases the likelihood of over-exploitation. Shark fin markets are especially lucrative, as sellers can receive as much as $AUD300 per kg for dried fin. Most illegal, unreported and unregulated fishing activity in the Region comes from Indonesia. Activity increased dramatically between 2001 and 2006, but has decreased in recent times.

Generally, illegal, unreported and unregulated fishing occurs north-east of Mermaid Reef, and is unlikely to catch white or grey nurse sharks. Whale sharks may be caught by illegal, unreported and unregulated fishers in the Region, but there are no records of this. However, whale sharks are opportunistically and directly targeted for fins and meat in Indonesian waters (White & Cavanagh 2007). Stevens *et al*. (2005) noted that it is possible that green sawfish in Australian waters may be caught by illegal, unreported and unregulated fishers.

There have been some records of white sharks in Australia being caught for trade in trophy products (e.g. jaws and teeth) and fins. Listing of this species under CITES requires traders of this species to issue a Certificate of Origin, stating the origins of white shark products (EA 2002b).

Recreational fishing

There has been limited recreational fishing effort for sharks in Western Australian waters, especially when compared with eastern Australian waters. At current levels of effort, recreational fishing is not thought to be a significant threat to any listed shark species in the Region.

In the past, grey nurse sharks were heavily targeted by recreational fishers on the east coast. However, this did not occur in Western Australia. Recreational game fishing for white sharks in Australia is currently prohibited, but there has been limited recreational fishing for white sharks in Western Australian waters (and, to a more limited extent, adjacent Commonwealth waters) in the past.

Tourism

The seasonal aggregation of whale sharks at Ningaloo Reef has generated a significant tourism industry, including boat tours, flights, and snorkel and dive tours. These activities have the potential to negatively affect whale shark behaviour, habitats and ecology.

Repeated touching of whale sharks by divers or snorkellers and other interactions may result in whale sharks avoiding some waters, which could include critical habitat (Martin 2007). However, whale shark tourism activities around Ningaloo are well managed, and are not thought to have a major impact (Davis *et al*. 1997).

There is a small tourism industry associated with diving with grey nurse sharks in Western Australia. While this industry is not currently seen as a threat to this species, frequent disturbance of grey nurse sharks may displace them from important habitats (EA 2002a).

Shipping and boating

Collisions between shipping vessels and whale sharks have been recorded occasionally. While there have been fewer records in recent times, because of their size modern vessels are less likely to notice the impact of a whale shark against their hull. Studies have noted that many whale sharks have scars that may have been caused by collisions with vessels (Stevens 2007).

Disturbances of important habitat

Whale sharks rely on coral reef habitats around Ningaloo, which attract krill and zooplankton, the whale shark's main prey. Deterioration or destruction of important seasonal coral reef habitat and feeding areas by coral bleaching events, climate change or other anthropogenic disturbances (e.g. oil spills), may pose a threat to whale sharks (Stewart & Wilson 2005).

During the late 1980s, there was a decline in whale shark numbers on Ningaloo Reef, thought to be associated with the destruction of corals caused by the coral-eating sea snail *Drupella cornus* (Taylor 1996). These sea snails mainly targeted the fast growing *Acropora* coral species, which thrive in shallow water and make a major contribution to coral spawning. Reduced coral spawning is thought to have resulted in less food for krill and zooplankton that whale sharks feed on, and fewer whale sharks migrating to Ningaloo to feed (Taylor 1996).

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D2 North-west Marine Region Protected Species Group Report Card – Bony Fish

Current at May 2008. See <www.environment.gov.au/coasts/mbp/north-west> for updates.

General information

The only bony fish species listed under the EPBC Act that occur in the North-west Marine Region are the Syngnathids (seahorses, seadragons, pipefish and pipehorses), and the Solenostomids (ghost pipefish). Australia has a remarkably high diversity of syngnathid species. It is estimated that between 25 and 37 per cent of the world's syngnathid species occur in Australia, the highest number of syngnathid species recorded in any country (Martin-Smith & Vincent 2006).

Almost all syngnathids live in nearshore and inner shelf habitats. Based on current information on ecology and distribution, 16 species of syngnathid and one species of solenostomid are thought to occur in the North-west Marine Region. To date, most of these have been found in shallow waters of Commonwealth marine reserves such as Ashmore and Mermaid reefs, but at least two, the winged seahorse (*Hippocampus alatus*) and the western pipehorse (*Solegnathus* sp. 2) have also been recorded in deeper shelf waters of the Region (up to 200 m). No species of sea-dragon has been recorded in the North-west Marine Region.

There are approximately 31 additional species of syngnathids that occur in Western Australian State waters adjacent to the Region, although the taxonomy of several is uncertain. These species are listed in Table 2 of Appendix C.

Nationally protected species

All members of the family Syngnathidae and the family Solenostomidae are protected under the EPBC Act as listed marine species. No syngnathid or solenostomid species is listed as threatened or migratory.

The following syngnathids have been recorded in Commonwealth waters of the North-west Marine Region:

- western pipehorse (*Solegnathus* sp. 2)
- barbed/corrugated pipefish (*Bhanotia fasciolata*)

- Pacific short-bodied pipefish (*Choeroichthys brachysoma*)
- red-banded/brown-banded/Fijian banded pipefish (*Corythoichthys amplexus*)
- reticulate/yellow-banded/network pipefish (*Corythoichthys flavofasciatus*)
- messmate/Australian messmate/banded pipefish (*Corythoichthys intestinalis*)
- Schultz's/guilded/gilded pipefish (*Corythoichthys schultzi*)
- rough-ridge/Banner's pipefish (*Cosmocampus banneri*)
- banded/ringed pipefish (*Doryrhamphus dactyliophorus*)
- blue-stripe/bluestripe pipefish (*Doryrhamphus melanopleura*)
- Negros/flagtail pipefish (*Doryrhamphus negrosensis negrosensis*)
- ridge-nose/Duncker's/red-hair pipefish (*Halicampus dunckeri*)
- glittering pipefish (*Halicampus nitidus*)
- double-ended pipehorse/alligator pipefish (*Syngnathoides biaculeatus*)
- thorny seahorse (*Hippocampus histrix*)
- winged seahorse (*Hippocampus alatus*)

The single species of ghost pipefish that is known to occur in the North-west Marine Region is the blue-finned ghost pipefish or robust ghost pipefish (*Solenostomus cyanopterus*).

Of the 31 species of syngnathids found in coastal waters adjacent to the North-west Marine Region (see Table 2 of Appendix C), nine are thought to be endemic to these waters:

- Helen's pygmy pipehorse (*Acentronura larsonae*)
- Muiron Island pipefish/Muiron pipefish (*Choeroichthys latispinosus*)
- ladder pipefish (*Festucalex scalaris*)
- western spiny seahorse/narrow-bellied seahorse (*Hippocampus angustus*)
- flat-face/flatface seahorse (*Hippocampus planifrons*)
- false-eyed/false-eye seahorse (*Hippocampus biocellatus*)
- Montebello/Monte Bello seahorse (*Hippocampus montebelloensis*)
- Prophet's pipefish (*Lissocampus fatiloquus*)
- bony-headed/bonyhead pipefish (*Nannocampus subosseus*)

Within the Syngnathidae, the entire genus *Hippocampus* (the seahorses) is listed on Appendix II of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES). As a signatory to this convention, Australia is obliged to manage international trade to enable the persistence of wild populations. Licences are granted under CITES for trade in these species while the EPBC Act controls international trade in all wild capture and aquarium-raised Australian syngnathid and solenostomid species. More information on CITES can be found in Appendix A.

Ecology of protected species in the North-west Marine Region

There is little knowledge on the distribution, abundance and ecology of syngnathids and solenostomids in the North-west Marine Region. Syngnathids generally have diverse characteristics ranging from apparently rare and localised species, to widely distributed and very common species. Most syngnathids are usually found in shallow, coastal tropical and temperate waters living among seagrasses, mangroves, coral reefs, macroalgae-dominated reefs, and sand/rubble habitats (Dawson 1985; Vincent 1996; Lourie *et al*. 1999, 2004). Temperate water species predominately inhabit seagrasses and macroalgae, while tropical species are primarily found among coral reefs (Foster & Vincent 2004).

The ridge-nose pipefish is known to occur on shallow coral reefs, but also in sandy/rubble areas, and stands of tropical *Sargassum* macroalgae. Sheltered bays, lagoons, and estuaries with seagrass and macroalgae are thought to be important habitats for the double-ended pipehorse. Little is known of the habitat of the pipehorse species currently recorded within the waters of the North-west Marine Region (the western pipehorse), but it is likely that tropical, sub-tropical and warm temperate reef habitats (e.g. with hard and soft coral, sponges and sand) are important. It has been found in waters between 20–200 m, with most records from deeper than 50 m. Research in eastern Australia has shown that *Solegnathus* pipehorses may be more abundant in proximity to reefs in areas having some three-dimensional structure (sessile biota), such as sponges and gorgonian corals (Zeller *et al*. 2003). Similar habitat preferences might be expected in north-west Australia.

Syngnathids tend to use only certain parts of apparently suitable habitat, for example, occupying the edges of seagrass beds or macroalgae-dominated reefs and leaving large areas unoccupied (Vincent 1996). Most species are strongly site-associated, presumably with localised reproduction, although solenostomids, such as the blue-finned ghost pipefish, may have a prolonged larval stage that may permit longer range dispersal (Kuiter 2000).

In shallower waters, pipefish and seahorses are a dominant group of fish and are important predators on benthic organisms such as mysids in the zooplankton and small amphipods on surfaces. A few species also eat shrimps, and vertebrates such as larval fish. It is thought that they eat enough to affect the structure of benthic invertebrate communities (Lourie *et al*. 1999). As such, removing these species could well disrupt ecosystems (Vincent 1996).

Syngnathid populations may be particularly susceptible to threats because their biology is characterised by:

- relatively low population densities;
- lengthy parental care combined with small brood size limiting reproductive rate;
- strict monogamy, which means that social structure is easily disrupted;
- sparse distribution, which means that lost partners are not quickly replaced;
- typically low rates of adult mortality, which means that fishing exerts a relatively substantial selective pressure;
- strong association with preferred habitat, which can make populations vulnerable to site-specific impacts; and
- low mobility and small home ranges, which restrict recolonisation of depleted areas (Vincent 1996).

Syngnathids can be used as an indicator of ecosystem health, as they are habitat-specific and can provide insights into how habitats differ or relate to each other. Most species are more localised than previously thought, and preserving habitats is one of the most important factors in protecting seahorses for the future (Kuiter 2001). Further *in situ* research is needed to confirm both general habitat-use and specific habitat critical for particular life history stages (e.g. nursery areas, spawning grounds, etc.).

Important areas for syngnathids in the North-west Marine Region

Important areas in the the North-west Marine Region are identified for species listed under the EPBC Act as threatened or migratory, since they are considered matters of national environmental significance. No species of syngnathid occurring in the North-west Marine Region has been listed under the Act as threatened or migratory. However, syngnathids have been recorded in the shallow waters of Commonwealth marine reserves including Mermaid and Ashmore reefs, and in Commonwealth waters around Scott Reef.

Known interactions, threats and mitigation measures

Seahorses (*Hippocampus* spp.) and pipehorses (*Solegnathus* spp.) are among the site-associated fish genera whose life histories might render them vulnerable to overfishing or other disruptions, such as habitat damage (Pogonoski *et al*. 2002; Martin-Smith & Vincent 2006).

In Australia, some syngnathid species are threatened by direct exploitation, incidental capture in non-selective fishing gear (by-catch), and degradation of their habitats (Lourie *et al* 2004; Martin-Smith & Vincent 2006). They are also traded internationally in dried form for traditional medicine and ornaments, and alive for aquarium display (Bruckner *et al*. 2005; Martin-Smith and Vincent 2006). Potential threats to syngnathids in the Region are discussed further below.

Habitat degradation and loss

Inshore habitat degradation is a potential threat to the survival of some populations of syngnathid species because of the decrease in available habitat (Pogonoski *et al*. 2002). Habitat loss and degradation are probably the greatest conservation concerns for most Australian coastal species of syngnathids. Degradation of estuaries and coastal lakes, declines in temperate seagrasses, loss of mangroves and salt marshes, unsustainable coastal development, effects of fishing, introduction of foreign organisms and population increases in native species all pose problems (Martin-Smith & Vincent 2006).

Endemic species with a limited geographic range, such as Helen's pygmy pipehorse, may be particularly susceptible to the impacts of habitat degradation. This is particularly true for those species that occur in the vicinity of urbanised and industrial areas, such as Port

Hedland, or in areas where nearshore waters are subject to pollutant run-off.

Climate change

The long-term effects of global warming on marine species are still speculative; however, possible habitat loss and degradation of shallow water habitats in the North-west Marine Region as a result of climate change may affect syngnathid populations. Seagrass and coral reef habitats are likely to be affected through increasing carbon dioxide levels, water temperature, ultraviolet radiation and storm activity. Changes in rainfall and coastal run off, coastal salinity, currents and winds, and sea level rise will also have an impact on these habitats (Hobday *et al*. 2006).

Over-harvesting

Over-harvesting of wild specimens for the marine aquarium trade and/or the traditional medicine trade is potentially the greatest threat to some species of syngnathids, including two species that are endemic to coastal waters of Western Australia: the flat-face seahorse and the western spiny seahorse (Pogonoski *et al*. 2002).

In Australia, syngnathids are harvested as a target species and caught as by-catch. Seahorses, pipehorses and pipefish are traded in Australia and internationally for traditional medicine and for aquaria (Bruckner *et al*. 2005; Martin-Smith & Vincent 2006). In Western Australia, the Marine Aquarium Fish Managed Fishery operates in State waters. The fishers in the Marine Aquarium Fish Managed Fishery are permitted to take species from the syngnathid family, up to an annual limit of 750 individuals (all species) set by the Department of Fisheries, Western Australia (DoF). However, this number has been slightly exceeded in some recent years (e.g. 833 specimens in 2002, DoF 2004b, 2005), and for some species, the actual catch may be higher than the reported catch (Baker 2006).

Syngnathids are caught by divers using hand-held nets. The fishery has retained at least 14 species of syngnathids, none of which occur in Commonwealth waters of the North-west Marine Region (DoF 2004b, 2005; Newman & Cliff 2006).

Trade in syngnathids is regulated in Australia through licences under CITES and permits under the EPBC Act for the export of wild-capture and aquarium-raised specimens. The Department of the Environment, Water, Heritage and the Arts is the CITES management authority in Australia and the Department relies on the Australian Customs Service to implement CITES at ports of exit and entry for the syngnathid trade.

Commercial fishing

In the Region, fishery interactions with syngnathids are most likely to occur with the Northern Prawn Fishery and the Western Trawl Fisheries (incorporating the Western Deepwater Trawl Fishery and the North-west Slope Trawl Fishery). However, the number of recorded interactions is low and incidental by-catch is not considered to be a significant issue for most syngnathid species in the North-west Marine Region.

The Australian Fisheries Management Authority and CSIRO have recently established a crew member observer program in the Northern Prawn Fishery that aims to emphasise the importance of collecting better data on syngnathids in the fishery. Since April 2001, operators have also been required to report the number of syngnathids caught, and their condition when released, and complete a separate detailed wildlife and protected species information sheet in the logbook. The Australian Fisheries Management Authority (2006) reiterated that syngnathid by-catch is being addressed in the by-catch monitoring program.

Pipehorse species inhabit trawling grounds and generally might be prone to any overfishing of these areas. Trawl by-catch in Western Australia is unquantified, but western pipehorses are caught as by-catch in the Pilbara Fish Trawl Interim Managed Fishery (DoF 2004a). This fishery operates primarily in Western Australian State waters, but may also operate in the Region. During a by-catch survey in 2002, 34 specimens were caught in 427 trawl shots, and most individuals were dead when landed (Stephenson & Chidlow 2003). Data from the survey indicated that approximately 450 pipehorses are caught by the fishery per year (DoF 2004a).

More information is required on trawl by-catch of pipehorses in the Region and adjacent State waters, in both State and Commonwealth-managed fisheries. Monitoring of by-catch of these species taken in trawl fisheries will help to obtain baseline data on their distribution and abundance in Western Australian waters.

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D3 North-west Marine Region Protected Species Group Report Card – Sea Snakes

Current at May 2008. See <www.environment.gov.au/coasts/mbp/north-west> for updates.

General information

This report card discusses those species of sea snake that are listed as marine species under the EPBC Act. While snakes of at least four families can be found in the marine environment, members of only two families, the Hydrophiidae (true sea snakes) and the Laticaudidae (sea kraits) are listed under the EPBC Act. Of these, only members of the Hydrophiidae occur regularly in the North-west Marine Region. A full list of sea snake species known to occur in the Region can be found in Appendix C.

True sea snakes inhabit the tropical waters of the Indian and Pacific oceans. They are characterised by their many adaptations to the marine environment including a paddle-like tail, dorsally positioned nostrils with valves, salt regulating glands and a single lung that extends nearly the full length of the body.

Twenty species of true sea snakes are resident in the North-west Marine Region. Eight are restricted to Australian waters and five of these are endemic to the Region. Several other species mainly occur on intertidal mudflats and mangrove habitats in coastal areas adjacent to the Region. These species are unlikely to interact significantly with the Commonwealth waters of the Region and will not be considered further here.

Information in this Report Card is largely drawn from *Marine Snakes: Species Profile for the North-west Planning Area* (Guinea 2007), which is available at <www.environment.gov.au/coasts/mbp/north-west>.

Nationally protected species

All sea snakes of the family Hydrophiidae are listed under Section 248 of the EPBC Act and are protected as listed marine species. No species of sea snake is listed as migratory or threatened under the EPBC Act, nor are any that occur in the Region listed under international conventions.

Ecology of protected species in the North-west Marine Region

The habitat and distribution of sea snakes in the North-west Marine Region is not well understood because of the remoteness and potentially dangerous marine conditions in parts of the Region. The Region supports populations of at least 20 species of sea snake, including common species such as the elegant seasnake (*Hydrophis elegans*) and the ornate seasnake (*Hydrophis ornatus*), as well as rare species such as the fine-spined seasnake (*Hydrophis czeblukovi*), and species that are endemic to the Region, such as the Shark Bay seasnake (*Aipysurus pooleorum*), the brown-lined seasnake (*Aipysurus tenuis*) and the dusky seasnake (*Aipysurus fuscus*). Sea snakes in the Region occupy three broad habitat types: shallow water coral reef and seagrass habitats, deep water soft bottom habitats away from reefs, and surface water pelagic habitat.

Sea snakes occupy a diverse range of habitats in and around coral reefs. Some species are specialist feeders, possessing distinctive adaptations for their particular foraging strategy. For example, the turtle-headed seasnake (*Emydocephalus annulatus*) feeds exclusively on the eggs of blennies, gobies and coral fish and has evolved large scales on each side of the lip for scraping fish eggs off corals and rocks. The horned seasnake (*Acalyptophis peronii*) is also a specialist, feeding on the gobies that share the burrows of shrimps on the bottom of channels in the reef. Other species such as the olive seasnake (*Aipysurus laevis*) and the dusky seasnake are generalists, feeding on a variety of fish species that inhabit small crevices in the coral, or small gobies, eels and fish eggs gleaned from the reef flats. The olive seasnake also feeds on dead fish and has been known to take fish from baited hooks and feed on trawl discards. Species abundance and diversity can vary from reef to reef despite apparent similarities in habitat. For example, Berry (1986) notes the absence of sea snakes from the Rowley Shoals despite their abundance at Scott Reef and Ashmore Reef.

Many sea snake species live between the reefs and the mainland, over a wide range of water depths and types of seafloor. Some, such as the spine-tailed seasnake (*Aipysurus eydouxii*) and the beaked seasnake (*Enhydrina schistosa*), may enter rivers and bays, while others, such as the fine-spined seasnake, are known only from deep water. The elegant seasnake and the olive-headed seasnake (*Disteira major*) frequent the seagrass beds and sandflats in Shark Bay, but range over a variety of other habitats, while the Shark Bay seasnake is restricted to this habitat type. Other species, such as the ornate seasnake and the spine-bellied seasnake (*Lapemis curtus*) occur in a wide range of habitats from coral reefs to turbid estuaries. Many sea snake species tend to be found in the shallower parts of the Region and species diversity appears to decrease in deeper waters. This may be because most sea snakes are benthic feeders, with foraging time decreasing as water depth increases.

The yellow-bellied seasnake (*Pelamis platurus*) is the only truly pelagic species of sea snake in the Region, as it inhabits the open ocean and rarely enters shallow water, unless washed ashore by storms. This species inhabits the slicks and drift lines of ocean convergences and is often associated with eddies down current of islands in the South Pacific Ocean. The yellow-bellied seasnake feeds by drifting motionless on the surface and catching small fish that mistake the snake for driftwood and seek shelter beneath it. The yellow-bellied seasnake is one of only two sea snake species that can capture fish in open waters. This species has an unusual ability to tie itself in knots and intricate coils, which is thought to help moulting and the removal of algae and barnacles (Pickwell 1971).

While many species are sedentary or occupy small home ranges, others may show some seasonal movements. Seasonal changes in sea snake diversity and abundance are more noticeable in the southern parts of the Region than they are in the more northern areas. Several species such as the ornate seasnake, the olive-headed seasnake and some populations of Stokes' seasnake (*Astrotia stokesii*) range further south during summer. The ornate seasnake is one of only three sea snakes that range as far south as Tasmania. In contrast, the spine-bellied seasnake moves closer to the coast during spring and occurs further offshore in autumn. Similarly, the spine-tailed seasnake moves further into estuaries during the dry season, sometimes occurring as far as 30 km upriver. Other species are more sedentary, such as the olive seasnake, which occupies small home ranges on coral reefs with females remaining resident throughout the year. Turtle-headed seasnakes also appear to occupy small home ranges throughout the year. Mark-recapture studies indicate that this species may live in groups, with the same individuals maintaining an association over several years (Shine *et al*. 2005), indicating that social organisation in sea snakes may be more complex than previously thought.

Generally, sea snakes are long-lived and slow-growing with small broods and high juvenile mortality. Little is known of the age at which sea snakes reach sexual maturity. All phases of the reproductive cycle of sea snakes takes place in the sea and reproductive seasonality varies among species with some, such as the horned seasnake, the spectacled seasnake (*Disteira kingii*) and the elegant seasnake giving birth between March and June, while others such as the dusky seasnake and the olive seasnake give birth between December and February. All members of the Hydrophiidae family bear live young, rather than lay eggs, with a gestation period of between six to seven months, indicating that females are unlikely to breed every year.

Important areas for sea snakes in the North-west Marine Region

Protected species group report cards in the North-west Bioregional Profile identify important areas for species listed under the EPBC Act as threatened or migratory, since they are considered matters of national environmental significance. No species of sea snake occurring in the Region has been listed under the Act as threatened or migratory. However the Region is considered of international significance for the diversity and abundance of its sea snake fauna, particularly the reefs of the Sahul Shelf (EA 2002a).

In the early 1990s, there was estimated to be 40 000 sea snakes from at least 13 species at Ashmore Reef National Nature Reserve, which represented the greatest number of sea snake species recorded for any locality in the world (EA 2002a). In addition, other reefs on the Sahul Shelf, particularly Hibernia, Scott and Seringapatam reefs, support important sea snake populations, with species such as the leaf-scaled seasnake (*Aipysurus foliosquama*) and the dusky seasnake occurring nowhere else. However, recent surveys at Ashmore Reef have recorded a severe reduction in the number of sea snakes recorded from the reserve. In 2007, a 10 day survey recorded only seven snakes. It appears that only generalist feeders remain in small numbers, with some species, including the short-nosed seasnake (*Aipysurus apraefrontalis*) and the leaf-scaled seasnake not being recorded at Ashmore for several years. Reasons for these declines remain speculative. There has been no similar decline in sea snake numbers at Scott Reef, Hibernia Reef or Cartier Island.

Known interactions, threats and mitigation measures

As listed marine species, sea snakes are protected in Australian waters. However, sea snakes may interact with human activities in the Region either directly, through interactions with commercial fisheries, or indirectly, through habitat degradation and climate change.

Commercial fishing

Incidental catch and death in commercial prawn trawling fisheries appears to be the biggest threat to sea snakes in the North-west Marine Region (Guinea 2007). High catch rates are exacerbated by the high death rate of snakes caught in trawl nets. Even when retained aboard to recuperate, sea snakes seldom survive (Guinea 2007). Sea snakes may be more vulnerable to overfishing than other species because of their longevity and low reproductive rates. In addition, females appear to be caught more often than males (Fry *et al*. 2001).

The Northern Prawn Fishery extends into the easternmost part of the Region to Cape Londonderry and has historically had high levels of interaction with sea snakes, particularly the large-headed seasnake (*Hydrophis pacificus*), which does not occur in the Region, and the spectacled seasnake, which is resident in the Region throughout the year. Elegant, ornate, spine-bellied and olive-headed seasnakes are also commonly caught in the Northern Prawn Fishery. Estimates from the Gulf of Carpentaria, outside the Region, indicate that in 1991 between 30 000 and 67 000 sea snakes were killed as a result of commercial trawling (Wachenfeld *et al*. 1998). However, due to the small area and shorter season of the Northern Prawn Fishery in the North-west Marine Region, the number of sea snakes caught in the Region is likely to be much lower.

In reaction to the large amounts of sea snake by-catch, by-catch reduction devices have been compulsory in the Northern Prawn Fishery since 2000 (DEH 2003). These appear to be effective at reducing sea snake by-catch (Brewer *et al*. 1998). Other prawn fisheries in the Region, such as the Pilbara Trawl Fishery, the Exmouth Gulf Prawn Fishery and the Shark Bay Prawn Fishery, also occasionally catch small numbers of sea snakes; however, their impact on sea snake populations is considered negligible (EA 2002b, c; DoF 2006).

Habitat degradation

Indirectly, human activities can interact with sea snakes through the degradation of sea snake habitat. Sea snakes may be affected by oil spills and other contamination, dredging activities and increased boat traffic causing boat strikes and disruption of feeding behaviour. In addition, while the long-term effect of climate change on sea snakes is unclear, an increase in the frequency of bleaching events, reduced rates of calcification, increased sediment loads, higher sea levels and changes in the intensity and frequency of storm activity are also likely to have a negative effect on coral reef habitats, which are used by some sea snake species (Hobday *et al*. 2006).

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D4 North-west Marine Region Protected Species Group Report Card – Marine Turtles

Current at May 2008. See <www.environment.gov.au/coasts/mbp/north-west> for updates.

General information

Marine turtles have lived in the oceans for over 100 million years and have a global distribution in tropical and temperate waters. There are seven species of marine turtles representing two families: the Cheloniidae, or hard-shelled turtles, and the Dermochelyidae, or leatherback turtles, of which there is only one species. In recognition of the global decline in marine turtle populations, six of the seven species are listed on the *IUCN Red List* as endangered or critically endangered; the remaining species, the flatback turtle (*Natator depressus*) is listed as data deficient (IUCN 2006). Six marine turtle species are found in Australia, which all have a global distribution, except for the flatback turtle, which is endemic to the Australian–New Guinea continental shelf.

Green turtle hatchling. Photo: Robert Thorn,Great Barrier Reef Marine Park Authority.

Table D4.1 Marine turtles listed as threatened or migratory under the EPBC Act that are known to occur in the North-west Marine Region

Species	Conservation Status	Conservation Plans and Policies
Loggerhead turtle (*Caretta caretta*)	Endangered, Migratory, Marine Listed under CITES (Appendix I) & CMS (Appendix I & II)	• *Action Plan for Australian Reptiles* (Cogger *et al.* 1993) • *Memorandum of Understanding on the Conservation and Management of Marine Turtles and Their Habitats of the Indian Ocean and South-East Asia* (CMS 2001) • *Recovery Plan for Marine Turtles in Australia* (EA 2003) • *Sustainable Harvest of Marine Turtles and Dugongs in Australia – A National Partnership Approach* (Australian Government 2005)
Green turtle (*Chelonia mydas*)	Vulnerable, Migratory, Marine Listed under CITES (Appendix I) & CMS (Appendix I & II)	
Hawksbill turtle (*Eretmochelys imbricata*)	Vulnerable, Migratory, Marine Listed under CITES (Appendix I) & CMS (Appendix I & II)	
Olive ridley turtle, Pacific ridley turtle (*Lepidochelys olivacea*)	Endangered, Migratory, Marine Listed under CITES (Appendix I) & CMS (Appendix I & II)	
Flatback turtle (*Natator depressus*)	Vulnerable, Migratory, Marine Listed under CITES (Appendix I) & CMS (Appendix II)	
Leatherback turtle, Leathery turtle (*Dermochelys coriacea*)	Vulnerable, Migratory, Marine Listed under CITES (Appendix I) & CMS (Appendix I & II)	

Nationally protected species

All six species of marine turtles found in Australia occur regularly in the North-west Marine Region and all are listed under the EPBC Act as threatened and/or migratory (Table D4.1). Under the EPBC Act, actions in all Australian waters that have, will have or are likely to have a significant impact on marine turtles are subject to a rigorous referral, assessment, and approval process.

As a signatory to the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS), Australia has an international obligation to protect migratory species, their habitats and their migration routes. Similarly, as a party to the *Convention on the International Trade in Endangered Species of Wild Fauna and Flora* (CITES), Australia has agreed to control the import and export of an agreed list of species that are endangered, or at risk of becoming endangered, because of inadequate controls over trade in them or their products. Further information on CITES and CMS is included in Appendix A.

Ecology of protected species in the North-west Marine Region

The life cycle of all marine turtles is broadly similar. Adults migrate from remote feeding grounds to aggregate at mating areas. After mating, males return to their foraging grounds, while females move to their natal (place of birth) beaches to nest. Unlike females, male marine turtles rarely come ashore. Females bury their eggs in nests above the tidal range on sandy beaches in tropical or subtropical regions. They generally lay between three and five clutches over a two to three month period, with an approximate two week internesting period between each clutch (Limpus 2004). Nests must have a temperature range of 25–33°C, with the hatchling's sex being determined by the temperature of the nest. After completing nesting, the females also return to their feeding grounds until their next reproductive migration, which can be up to five years later.

After leaving the nest, hatchlings leave their natal beaches and generally migrate to open ocean nursery habitat where they may spend 5–20 years. However, the flatback turtle differs in this respect, remaining within Australian coastal waters. This at-sea period for the smaller immature cheloniid turtles has been referred to in the past as the 'lost years' because little was known of their behaviour or ecology at this time, but recent research has been filling the gaps. There is some speculation that hatchling and juvenile turtles may drift over the ocean in association with rafts of *Sargassum*, a type of planktonic macroalgae, which accumulate along ocean convergences and current boundaries. It is thought that *Sargassum* rafts provide the small turtles with food, shade and protection from predators, although this is yet to be confirmed (Collard 1990; Hasbún 2002).

Immature cheloniid turtles eventually migrate to shallow, nearshore feeding grounds where they continue growing until they reach sexual maturity at anywhere between about 15–20 and 30–50 years, depending on their location. Reproductively mature individuals then travel periodically to the general vicinity of the nesting beaches on which they were born to begin the reproductive cycle again. It is thought that hatchling turtles are imprinted to the earth's magnetic field as they emerge from the nest and that individuals also imprint on the feeding areas where they end the pelagic phase of their life cycle (Limpus et al. 1992). Therefore, feeding areas are much more widely dispersed than rookeries and may contain individuals from several nesting areas (Limpus *et al*. 1992).

The North-west Marine Region supports important nesting areas for green, hawksbill, loggerhead and flatback turtles, while leatherback turtles may occasionally nest in the Region. Olive ridley turtles are known to forage in the northern parts of the Region, but there are no records of nesting for this species in Western Australia. The Western Australian populations of the hard-shelled turtles are the only remaining populations in the south-east Indian Ocean.

Further details on the six species found in the North-west Marine Region are below:

Green turtle (*Chelonia mydas*)

Green turtles are the most common marine turtle in the North-west Marine Region and breed extensively in the Region (Limpus & Chatto 2004). Western Australia supports one of the largest green turtle populations remaining in the world, estimated to be in the tens of thousands of adult turtles. The principal near-coastal rookeries include the Lacepede Islands, some islands of the Dampier Archipelago, Barrow Island and the Montebello Islands, North West Cape and the Muiron Islands. Smaller rookeries offshore of the Kimberley region include the Maret Islands, Browse Island, Cassini Island and other islands of the Bonaparte Archipelago, and Sandy Islet on Scott Reef.

There are three distinct genetic stocks of green turtles in the Region: the North West Shelf stock, the Scott Reef stock and the Ashmore stock (Dethmers *et al*. 2006). Adults display a high level of philopatry (a tendency to return to a specific area for different parts of their lifecycle) both to their natal nesting areas and to their feeding areas throughout their lives, irrespective of the distance between them. Tagging studies by Limpus *et al*. (1992) showed that distances between nesting and feeding areas can range between 2– 2600 km.

North-west Australian breeding green turtles have ranged as far afield as the Cape York coast on the Gulf of Carpentaria, to parts of the Indonesian archipelago, and to south-western Western Australia. On Barrow Island, the green turtle nesting season begins in November, peaks in January/February and ends in April (Pendoley Environmental 2005). The re-nesting period for these female green turtles is approximately every five years. Green turtles forage for seagrass and algae within estuarine, rocky and coral reef and seagrass habitats. They occasionally feed on macroplankton including jellyfish, dead fish and small crustaceans (Limpus & Chatto 2004; Limpus 2004).

Hawksbill turtle (*Eretmochelys imbricata*)

The North-west Marine Region supports one of the largest nesting populations of hawksbill turtles in the world. This population is genetically distinct from the populations breeding in north-east Arnhem Land and the Torres Strait (Limpus 2004). The most significant breeding areas include Rosemary Island within the Dampier Archipelago, Varanus Island in the Lowendal group, and some islands in the Montebello Island group, with hundreds of females nesting every year. The nesting range extends south from North West Cape to around Coral Bay on the Ningaloo coast. The apparent scarcity of nesting in the Kimberley is in part because of the lack of suitable nesting beaches among the numerous islands. Nesting females dispersing from Pilbara beaches may disperse to the Kimberley waters, but this is yet to be confirmed (Pendoley Environmental 2005). Hawksbill turtles nest in the Region all year round with a peak between October and January. Individuals may migrate up to 2400 km between their nesting and foraging grounds. On Rosemary Island, the inter-seasonal re-nesting period for hawksbill turtles is generally every three years, but may be more than 10 years. Hawksbill turtles are generally associated with rocky and coral reef habitats, foraging on sponges and soft coral (Pendoley Environmental 2005).

Flatback turtle (*Natator depressus*)

After green turtles, flatback turtles are the second most common species in northern Australia. Flatback turtles differ from other marine turtles in that they do not have a pelagic phase to their life cycle. Instead, hatchlings grow to maturity in shallow coastal waters thought to be close to their natal beaches. This may explain why flatback turtles are one of only two species of marine turtles not to have a global distribution (Walker & Parmenter 1990), although there is evidence that some flatback turtles undertake long-distance migrations between breeding and feeding grounds (Limpus *et al*. 1983). This species is endemic to the northern Australian-southern New Guinea continental shelf, extending south in the Region as far as the Muiron Islands (Pendoley Environmental 2005).

There are two breeding units of flatback turtles in the North-west Marine Region. Most of the flatback turtles in the Region are part of the North West Shelf breeding unit, while the population that breeds in Cape Domett in the Bonaparte Gulf is probably part of the western Northern Territory breeding unit (Limpus 2004). The North West Shelf stock nests from approximately Exmouth Gulf to the Lacepede Islands with significant rookeries on Thevenard Island, Barrow Island, the Montebello Islands, Varanus Island, the Lowendal Islands, islands of the Dampier Archipelago, coastal areas around Port Hedland, along much of the Eighty Mile Beach and inshore islands of the Kimberley region where suitable beaches occur. Nesting is also widespread along mainland beaches. On Barrow Island, flatback turtles nest annually or biennially. Nesting commences in late November/December, peaks in January and finishes by February/March. It is estimated that hundreds to thousands of individuals nest on the North West Shelf annually (Pendoley Environmental 2005). Flatback turtles that nest on the Pilbara coast disperse to feeding areas extending from Exmouth Gulf to the Tiwi Islands in the Northern Territory. Flatback turtles eat jellyfish and soft-bodied benthic invertebrates such as sea pens, sea cucumbers, crustaceans, molluscs and soft corals in habitats with unconsolidated substrates.

Loggerhead turtle (*Caretta caretta*)

In the North-west Marine Region, loggerhead turtles breed principally from Dirk Hartog Island in the south, along the Ningaloo coast to North West Cape and the Muiron Islands region in the north, although there have been occasional nesting records from Barrow, Varanus, and Rosemary islands in the Pilbara, and occasional records as far north as Ashmore Reef. The annual nesting population in the Region is thought to be several thousand females (Limpus 2004). From current knowledge, all nesting adult loggerhead turtles dispersing from Dirk Hartog Island beaches (near Shark Bay) have remained within Western Australian waters extending from southern Western Australia to the Kimberley. Turtles dispersing from the North West Cape – Muiron Islands nesting area have ranged north as far afield as the Java Sea and the north-western Gulf of Carpentaria, and to south-western Western Australia. Loggerhead turtles forage across a wide range of habitats including rocky and coral reefs, seagrass pastures, and estuaries (Limpus & Chatto 2004). In Shark Bay, loggerhead turtles feed on bivalve and gastropod molluscs and crabs (Limpus 2004).

Leatherback turtle (*Dermochelys coriacea*)

The leatherback turtle is an oceanic, pelagic species that feeds primarily on jellyfish, sea squirts and other soft-bodied invertebrates (Limpus 2004). Leatherback turtles have the greatest distribution worldwide but are uncommon throughout their range and rarely breed in Australia. There have been at least two unconfirmed reports of nesting attempts in Western Australia; however it is presumed that leatherbacks foraging in Australian waters may have migrated from the larger nesting populations in Indonesia, Papua New Guinea and the Solomon Islands, or from populations in the Americas or India (Limpus 2004).

Olive ridley turtle (*Lepidochelys olivacea*)

Olive ridley turtles are the most abundant marine turtle species globally but the least common in the North-west Marine Region. They breed at low densities on Northern Territory beaches outside the Region but no breeding records exist within the North-west Marine Region (Limpus 2004). However, olive ridley turtles forage as far south as the Dampier Archipelago–Montebello Islands area. This species is primarily carnivorous, feeding on gastropod molluscs and small crabs from soft bottom habitats ranging in depth from 6–35 m. Olive ridley turtles may also forage in pelagic waters.

Important areas for marine turtles in the North-west Marine Region

All marine turtles that occur in the Region are listed under the EPBC Act as threatened and/or migratory and as such, are considered matters of national environmental significance. (see Section 3.1 for more information). Important areas for marine turtles in the North-west Marine Region and State waters adjacent to the Region are identified below. Some of these areas are already afforded protection through their status as Commonwealth or State marine parks or reserves.

Ashmore Reef – Ashmore Reef is a significant breeding area for green turtles and low levels of nesting activity by loggerhead turtles have also been recorded here (Limpus 2004). Ashmore possesses critical nesting and internesting habitat for green turtles (EA 2003) and supports one of three genetically distinct breeding populations of green turtles in the Region (Dethmers *et al*. 2006). Hundreds of green turtles nest at Ashmore each year, mostly on West Island (Limpus 2004). Ashmore Reef also supports large and significant feeding populations of green, hawksbill and loggerhead turtles. It is estimated that approximately 11 000 marine turtles feed in the area throughout the year (EA 2002).

Bonaparte Archipelago – The Maret Islands and other islands of the Bonaparte Archipelago including the Montalivet islands, Albert Island and Lamarck Islands support significant green and flatback turtle rookeries.

Browse Island – Browse Island is a major rookery for green turtles (Limpus 2004).

Cape Domett – Cape Domett is a major rookery for flatback turtles (Limpus 2004).

Dampier Archipelago – Rosemary Island in the Dampier Archipelago has important nesting and internesting habitat for hawksbill turtles (EA 2003). The island supports the most significant hawksbill turtle rookery in Western Australia and one of the largest in the Indian Ocean. Over 100 animals nest on the island at the peak of the season, more than at any other Western Australian rookery (Pendoley Environmental 2005). The Dampier Archipelago also supports major green turtle and flatback turtle nesting sites (Limpus 2004; Pendoley Environmental 2005).

Eighty Mile Beach – Eighty Mile Beach is a major rookery for flatback turtles (B. Prince, pers. comm. 2007).

Joseph Bonaparte Gulf – Carbonate banks in the Joseph Bonaparte Gulf are foraging areas for flatback and loggerhead turtles, while green, olive ridley, flatback and loggerhead turtles forage around pinnacles in the Bonaparte Depression (DEWHA 2008; Donovan *et al*. 2008).

Lacepede Islands – The Lacepede Islands have critical nesting and internesting habitat for green turtles (EA 2003). They support the largest green turtle rookeries in Western Australia with nightly nesting effort numbering in the thousands (Pendoley Environmental 2005).

Mangrove Islands – Aggregations of male green turtles occur on the Mangrove Islands, north east of Onslow, before the nesting season, however, the purpose of these aggregations is unknown (Pendoley Environmental 2005).

Montebello and Barrow islands – Five of the six species of marine turtles found in Western Australia have been recorded in this area. Green, hawksbill and flatback turtles regularly nest in the area, and loggerhead turtles have occasionally been recorded nesting on Barrow Island (DEC 2007). Barrow Island has critical nesting and internesting habitats for green turtles (EA 2003) and also supports an important flatback rookery (Pendoley Environmental 2005). The Montebello Islands have critical nesting and internesting habitat for flatback and hawksbill turtles (EA 2003) with low levels of nesting activity by both these species recorded on Barrow Island and the Lowendal Islands (Pendoley Environmental 2005). Varanus Island also has critical nesting and internesting habitat for hawksbill turtles (EA 2003) and supports an important flatback turtle rookery (Limpus 2004). The West Australian hawksbill turtle population is the only large population of this species remaining in the Indian Ocean (DEC 2007).

Summer mating aggregations of green turtles occur to the west of Barrow Island and within the Montebello Island group south of North-west Island and east of Trimouille Island (Pendoley Environmental 2005). A large summer aggregation of unknown purpose also occurs west of Hermite Island (Pendoley Environmental 2005).

The waters surrounding Barrow Island support year-round foraging populations of marine turtles. Possible green turtle feeding grounds occur over the Barrow Shoals off the south-east coast of Barrow Island and on the algae-covered rocky intertidal and subtidal platforms off the west coast (Pendoley Environmental 2005), with some individuals thought to be resident in the area throughout the year (DEC 2007). Hawksbill turtle feeding grounds occur in the Mary Anne and Great Sandy island groups to the south of the Barrow Shoals, while there is some evidence that juvenile flatback turtles use the Barrow Island region as developmental habitat (Pendoley Environmental 2005).

Montgomery Reef – Montgomery Reef is a feeding area for green turtles and possibly other species (Prince 1993).

Ningaloo Reef, North West Cape and Exmouth Gulf – The Muiron Islands off North West Cape have critical nesting and internesting habitat for loggerhead turtles (EA 2003) and support a major green turtle rookery (Limpus 2004). North West Cape itself is also a major green turtle nesting area, while Ningaloo Reef supports an important nesting area for loggerhead turtles (Limpus 2004). Aerial surveys in 1989 and 1994 estimated a population of between 2000 and 5000 turtles at Ningaloo Reef and between 3000 and 5000 in Exmouth Gulf (Preen *et al*. 1997).

Port Hedland – Important flatback turtle rookeries occur at Port Hedland and Cape Thouin. Critical nesting and internesting habitat for flatback turtles has also been identified at Mundabullangana Beach (EA 2003).

Quondong Point – Quondong Point is a feeding area for flatback, green, hawksbill and loggerhead turtles (DEWHA 2008; Donovan et al. 2008).

Scott Reef – Scott Reef supports a small but genetically distinct breeding population of green turtles (Limpus 2004; Dethmers *et al*. 2006).

Serrurier Island – Serrurier Island is a major nesting area for green turtles and may also be a feeding ground for this species (Pendoley Environmental 2005). Loggerhead nesting has also been recorded.

Shark Bay/Dirk Hartog Island – Shark Bay contains the largest breeding population of loggerhead turtles in Australia and the third largest in the world. Up to 1500 females may nest annually in this area (Baldwin *et al*. 2003). Dirk Hartog Island has critical nesting and internesting habitats for loggerhead turtles (EA 2003), and may accommodate up to 75 per cent of the Western Australian breeding population (Prince 1994). Shark Bay has critical feeding habitat for both loggerhead and green turtles (EA 2003). The area is probably the southern-most major foraging area for Western Australian green turtles (Limpus 2004). Aerial surveys conducted in winter in 1989 and 1994 estimated a population of between 7000 and 9000 turtles using the Shark Bay area (Preen *et al*. 1997).

Thevenard Island – Thevenard Island supports a significant flatback rookery (Limpus 2004), as well as a smaller green turtle presence. Surrounding waters also include a feeding area for green turtles (Pendoley Environmental 2005).

Known interactions, threats and mitigation measures

Marine turtles are long-lived, slow to mature and have low hatchling to maturity survival rates, making them particularly vulnerable to anthropogenic impacts. Potential interactions and threats to marine turtles in the North-west Marine Region are listed below. The *Recovery Plan for Marine Turtles in Australia* (EA 2003) aims to reduce the detrimental impacts on Australian populations of marine turtles and promote their recovery in the wild. However, as migratory species, impacts at a local level have the capacity to affect populations across the entire species' range. Some of the turtles that breed in the North-west Marine Region have feeding areas in Indonesian waters, including western Papua. Therefore, conservation efforts, even for local populations, need international coordination. In recognition of this, 27 countries, including Australia, are signatories to the *Memorandum of Understanding on the Conservation and Management of Marine Turtles and Their Habitats of the Indian Ocean and South-East Asia* (CMS 2001), an intergovernmental agreement that provides a framework for countries to work together to conserve and protect marine turtles and their habitat.

Past commercial exploitation

Commercial harvesting of green turtles occurred in the Region between the 1930s and 1973. Turtles caught from around the Montebello Islands, the Dampier Archipelago and around North West Cape were processed in turtle soup factories in Cossack and Perth. It is estimated that approximately 3000–4000 green turtles were harvested annually through the 1960s and in greater numbers leading up to cessation of the fishery in 1973. Eggs and flipper skins were also harvested for sale or export and it is thought that loggerheads as well as green turtles may have been targeted (Limpus 2004). As of 30 June 1973, there was no renewal of turtle harvesting licences in Western Australia, marking the end of commercial turtle harvest in the Region.

Commercial fishing

The incidental catch (by-catch) of marine turtles during coastal otter trawling in Australian waters north of 28°S was listed as a key threatening process under the EPBC Act in 2001. The Northern Prawn Fishery, which extends into the north-eastern part of the North-west Marine Region to Cape Londonderry, has historically had a very high level of interaction with marine turtles. In 1989 and 1990, it was estimated that over 5000 turtles were caught in the fishery, with between 550 and 950 individuals killed (DEH 2003). The use of Turtle Exclusion Devices was made compulsory in the fishery in 2000. Since then, the number of marine turtles caught has been reduced to less than five per cent of previous numbers, with approximately 120 individuals caught each year. Deaths have also been reduced from 40 per cent to 22 per cent of turtles caught (DEH 2003). Flatback turtles are the most commonly caught species in the Northern Prawn Fishery and significant numbers of olive ridley turtles are also taken, followed by smaller numbers of loggerhead, green and hawksbill turtles.

Other fisheries operating in or adjacent to the Region that are known or suspected to have an impact on marine turtles include the Western Tuna and Billfish Fishery, the Pilbara Fish Trawl Interim Managed Fishery, and Western Australian prawn and scallop fisheries (EA 2003). The Western Tuna and Billfish Fishery has reported interactions mainly with leatherback and loggerhead turtles (DEH 2004a). Interactions are reported to be at low levels in these fisheries, and the use of Turtle Exclusion Devices and other by-catch reduction devices has been compulsory since 2003. The recently established crab fisheries within the Region may also be affecting loggerhead turtles by removing prey species within Shark Bay and around the Dampier Archipelago, but this requires further investigation (DEH 2004b).

Outside the Region, turtles continue to be harvested in Indonesia, Malaysia, Papua New Guinea, Fiji, Vanuatu, New Caledonia and the Solomon Islands. The migratory nature of marine turtles means that Indonesian harvests are likely to include individuals from the Region. In addition, for a number of years there has been an illegal harvest of green turtles and/or their eggs from the more remote rookeries in the Timor Sea off north-western Western Australia and the Northern Territory by indigenous Indonesian fishers (Limpus 2004). Moreover, some eggs are taken directly from gravid (pregnant) nesting females, resulting in the death of the animals (Limpus 2004).

Traditional harvest

Turtles are of enormous cultural, spiritual and economic importance to Indigenous people. Under Section 211 of the *Native Title Act 1993*, Indigenous people with a native title right can legitimately hunt marine turtles in Australia for communal personal, domestic or non-commercial purposes. All Australian marine turtle populations are affected by Indigenous harvest of eggs. In addition, green turtle populations from the North West Shelf are also affected by harvest for meat.

In 2005, the *Sustainable Harvest of Marine Turtles and Dugongs in Australia – A National Partnership Approach* (Australian Government 2005) was endorsed by the Marine and Coastal Committee, a body of the Natural Resource Management Ministerial Council. This approach is a partnership among the Australian, Western Australian, Northern Territory and Queensland governments and relevant Aboriginal and Torres Strait Islander communities established to support management of the hunting of marine turtles and dugongs in order to contribute to the conservation of these species while maintaining traditional cultural practices. Further information is available at <www.environment.gov.au/coasts/publications/turtle-harvest-national-approach.html>.

Marine debris

The injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris is listed as a key threatening process under the EPBC Act. Entanglement in marine debris such as discarded fishing gear can lead to restricted mobility, starvation, infection, amputation, drowning and smothering. The ingestion of plastic marine debris can cause physical blockages leading to starvation, or injuries to the digestive system leading to infection or death.

Marine turtles are particularly at risk from discarded trawl and gill-nets, and plastic bags, which can be mistaken for jellyfish and ingested (Carr 1987a, b; White 2005). Outside the Region, a survey of marine debris in the Gulf of Carpentaria found that 25 per cent of white plastic bottles and 15 per cent of rubber thongs contained bite marks from fish and marine turtles (White 2005). The Australian Government is currently developing a threat abatement plan that aims to minimise the impacts of marine debris on threatened marine species. Further information is available at <www.environment.gov.au/biodiversity/threatened/publications/marine-debris.html>.

Boat strikes

Marine turtles are vulnerable to boat strikes when at the surface to breathe and rest between dives. This is particularly an issue in waters adjacent to large urban populations where there are large numbers of boats and other pleasure craft.

Light pollution

In the absence of artificial light, the horizon over the ocean is brighter than over land, owing to the reflection of stars and moonlight. Marine turtles tend to hatch at night and find their way to the ocean by cueing in to this difference in brightness. In areas of coastal development, hatchlings as well as nesting females may become disoriented by artificial light and head inland where they are vulnerable to dehydration, exhaustion, predation and collisions with traffic (Nicholas 2001). In the Region, gas flares and facility lights on petroleum production and processing plants are a significant source of artificial light near nesting beaches (EA 2003). However, some developments are working to shield light sources, establish light-free zones around nesting beaches or use types of lights that are less attractive to turtles (e.g. Chevron Australia 2005).

Destruction of nest sites

Vehicles driving along beaches can damage marine turtle nests and nesting habitat by compacting sand, crushing nests and creating wheel ruts that impede or trap hatchlings. Unmanaged mainland nesting sites along the Pilbara coast have been identified as particularly affected by vehicle damage in the *Recovery Plan for Marine Turtles in Australia* (EA 2003).

Nest predation

Both introduced and native fauna are known to prey upon marine turtle eggs. Feral pigs, foxes, feral dogs, dingoes, bandicoots and goannas predate on marine turtle eggs in parts of mainland Australia, and goannas are thought to be a problem on some islands; however the magnitude of the problem is not known. Saltwater crocodiles may also prey on adult flatback turtles on nesting beaches where the species' distributions overlap. In the Region, the *Recovery Plan for Marine Turtles in Australia* (EA 2003) identifies the North West Shelf populations of marine turtles as being particularly affected by predation, especially by foxes. Predation by foxes is a key threatening process for green and loggerhead turtles nesting on mainland Western Australia. Predation levels appear to have been reduced since the introduction of a fox baiting program in 1980 (Limpus 2004). The *Threat Abatement Plan for Predation by the European Red Fox* was developed in 1999, and further information is available at <www.environment.gov.au/biodiversity/threatened/publications/tap/foxes>.

Climate change

The long-term consequences of climate change on marine species is still speculative, however, a warmer environment is likely to be a major threat to marine turtles globally. Sex determination is dependent on the temperature of the nest and a small increase in temperature may bias the sex ratio of hatchlings towards females, reducing or even eliminating the production of males in some areas. Marine turtles have been subject to changes in sea temperature and sea levels for thousands of years (e.g. Dethmers *et al*. 2006). However, rising sea levels in the short-term could lead to a loss of nesting habitat and inshore foraging habitats such as seagrass beds, while changes to prey availability may result in a decrease in reproductive success and affect distribution, abundance, migration patterns and community structure (Hobday *et al*. 2006).

Diseases

The fibropapilloma virus causes a disabling, life-threatening tumour disease that primarily affects sub-adult green turtles but has also been found in loggerhead turtles and olive ridley turtles. It reached plague proportions in Hawaii and Florida in the 1990s, affecting up to 92 per cent of some populations (Aguirre & Lutz 2004). It now has a world-wide, circum-tropical distribution. The disease was first identified in the North-west Marine Region in 1995 (Raidal & Prince 1996), but from observations of green turtles in Shark Bay, the prevalence of this virus appears to be low (2.6 per cent; Heithaus *et al*. 2005). Observations indicate that the disease is most prevalent in areas close to intense human activity and may be associated with heavily polluted coastal areas (Aguirre & Lutz 2004).

Habitat degradation and loss

Marine turtle habitat may be lost or degraded in many ways. In the North-west Marine Region, pollution from oil and gas production and shipping is a potential problem for marine turtles, which may ingest floating tar or be fouled by oil. Noise pollution such as that from seismic testing associated with oil and gas exploration activities may also affect marine turtles (McCauley *et al*. 2000). Increased urban and industrial development may introduce pollution and contaminants that are harmful to marine turtles, such as heavy metals or organochlorines, and potentially reduce the availability of nesting and feeding habitat. Decreased water quality and trawling operations may reduce the quality of important seagrass and benthic feeding habitat. The identification and protection of marine turtle habitat is one objective of the *Recovery Plan for Marine Turtles in Australia*, developed by Environment Australia in 2003.

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D5 North-west Marine Region Protected Species Group Report Card – Birds

Current at May 2008. See <www.environment.gov.au/coasts/mbp/north-west> for updates.

General information

This report card deals with those bird species that are listed under the EPBC Act as marine species. A list of all the listed bird species that regularly occur or are likely to occur in the North-west Marine Region can be found at Appendix C. The marine birds of the North-west Marine Region can be divided into three categories:

- coastal or terrestrial species that inhabit the offshore islands and coastal areas of the mainland adjacent to the Region;
- migratory species that pass through the Region on their way to northern Australia from breeding grounds in the Northern Hemisphere or wintering grounds in New Guinea; and
- seabirds whose primary habitat and food source is derived from the pelagic waters of the Region.

Most of the offshore islands of northern Western Australia and their surrounding waters (up to three nautical miles from land) fall under State Government jurisdiction, and are not considered part of the North-west Marine Region. However, many of these islands support important habitat for threatened and migratory bird species and, as such, are considered important areas for matters of national environmental significance (see Section 3 for more information on matters of national environmental significance and requirements under the EPBC Act).

Some species that occur on the offshore islands adjacent to the Region are primarily terrestrial such as Australian kestrels, magpie-larks and Richard's pipits. Others, such as eastern reef egrets, silver gulls and Australian pelicans are predominantly coastal species that spend the majority of their time foraging in coastal waters close to shore. Some species, such as white-bellied sea-eagles and Caspian terns may occasionally forage further out to sea, however, many shore birds and terrestrial species that inhabit these areas are unlikely to interact significantly with the Commonwealth waters of the North-west Marine Region.

The waters of the North-west Marine Region are used by many bird species as important resting and foraging

Great frigatebird. Photo: Fusion films.

habitat on long-distance migrations. The Region is an important part of the East Asian–Australasian Flyway, a migratory pathway for millions of migratory shorebirds that travel from breeding grounds in the Northern Hemisphere to spend the Southern Hemisphere summer in northern Australia. Offshore islands adjacent to the Region are important staging or stopover sites, with some individuals remaining on the islands for the duration of the non-breeding season. A small number of species also pass through the Region on their way to overwinter in New Guinea after breeding in Australia. There are 34 bird species that regularly migrate through the Region, including 26 species of migratory shorebirds of the Scolopacidae (curlews, sandpipers etc.) and Charadriidae (plovers and lapwings) families, as well as swifts, kingfishers, cuckoos and dollarbirds.

There are 26 species of seabirds that occur in the Region including terns, noddies, petrels, shearwaters, tropicbirds, frigatebirds and boobies. These species spend the majority of their lives at sea, ranging over large distances to forage over the open ocean. Many of these species also breed in and adjacent to the North-west Marine Region and are likely to interact significantly with the Commonwealth waters of the Region.

Nationally protected species

All migratory shorebirds that occur in the Region are listed under the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS) and one or more of the *Agreement Between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and Their Environment 1986* (CAMBA), the *Agreement Between the Government of Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and Their Environment 1974* (JAMBA), and the *Agreement between the Government of Australia and the Government of the Republic of Korea on the Protection of Migratory Birds 2007* (ROKAMBA). These species are also covered by the *World Summit on Sustainable Development Type II Partnership for the Conservation of Migratory Waterbirds and the Sustainable Use of their Habitats in the East Asian – Australasian Flyway* and its implementation strategy (DEW 2007a, b) and the *Wildlife Conservation Plan for Migratory Shorebirds* (DEH 2006a).

There are a further 24 species that occur regularly in the Region that are listed under the EPBC Act as either Migratory and/or Threatened (Table D5.1). Some of these are also listed under CMS, JAMBA, CAMBA and/or ROKAMBA. In addition, some species are listed under the *Convention on the International Trade in Endangered Species of Wild Fauna and Flora* (CITES).

As a signatory to the CMS, Australia has an international obligation to protect migratory species, their habitats and their migration routes. Similarly, as a party to the CITES, Australia has agreed to control the import and export of an agreed list of species that are endangered, or at risk of becoming endangered, because of inadequate controls over trade in them or their products. Albatrosses and petrels are also covered by the *Agreement on the Conservation of Albatrosses and Petrels* (ACAP), a multilateral agreement developed under the auspices of the CMS that seeks to coordinate international activity to mitigate known threats to albatross and petrel populations. Other conservation plans and policies that relate to these species are listed in Table D5.1.

Table D5.1 Seabirds listed as threatened or migratory under the EPBC Act that are known to occur in the North-west Marine Region

Species	Conservation Status	Conservation Plans and Policies
Southern giant petrel (*Macronectes giganteus*)	Endangered, Migratory, Marine Listed under CMS (Appendix II)	• *Guidelines for Managing Visitation to Seabird Breeding Islands* (WBM Oceanics & Claridge 1997) • *Action Plan for Australian Birds* (Garnett & Crowley 2000) • *Recovery Plan for Albatrosses and Giant-petrels* (EA 2001) • *National Recovery Plan for Ten Species of Seabirds 2005–2010* (DEH 2005a) • *National Recovery Plan for Ten Species of Seabirds – Issues Paper* (DEH 2005b) • *Threat Abatement Plan for the Incidental Catch (or Bycatch) of Seabirds During Oceanic Longline Fishing Operations* (DEH 2006b)
Soft-plumaged petrel (*Pterodroma mollis*)	Vulnerable, Marine	
Streaked shearwater (*Calonectris leucomelas*)	Migratory, Marine Listed under CAMBA (as *Puffinus leucomelas*) & JAMBA	
Wedge-tailed shearwater (*Puffinus pacificus*)	Migratory, Marine Listed under JAMBA	
Indian yellow-nosed albatross (*Thalassarche carteri*)	Vulnerable, Migratory, Marine Listed under CMS (Appendix II; as *Diomedea chlororhynchos*)	

Species	Conservation Status	Conservation Plans and Policies
Wilson's storm-petrel (*Oceanites oceanicus*)	Migratory, Marine Listed under JAMBA	
White-tailed tropicbird (*Phaethon lepturus*)	Migratory, Marine Listed under CAMBA & JAMBA	
Masked booby (*Sula dactylatra*)	Migratory, Marine Listed under JAMBA	
Red-footed booby (*Sula sula*)	Migratory, Marine Listed under CAMBA & JAMBA	
Brown booby (*Sula leucogaster*)	Migratory, Marine Listed under CAMBA & JAMBA	
Great frigatebird, greater frigatebird (*Fregata minor*)	Migratory, Marine Listed under CAMBA & JAMBA	
Lesser frigatebird, least frigatebird (*Fregata ariel*)	Migratory, Marine Listed under CAMBA & JAMBA	
Eastern reef egret (*Egretta sacra*)	Migratory, Marine Listed under CAMBA	
Osprey (*Pandion haliaetus*)	Migratory, Marine Listed under CMS (Appendix II) & CITES (Appendix II)	
White-bellied sea-eagle (*Haliaeetus leucogaster*)	Migratory, Marine Listed under CAMBA & CITES (Appendix II)	
Caspian tern (*Sterna caspia*)	Migratory, Marine Listed under CAMBA as (*Hydroprogne caspia*) & JAMBA (as *Hydroprogne caspia*)	
Lesser crested tern (*Sterna bengalensis*)	Migratory, Marine Listed under CAMBA	
Roseate tern* (*Sterna dougallii*)	Migratory, Marine Listed under CAMBA & JAMBA	
Common tern (*Sterna hirundo*)	Migratory, Marine Listed under CAMBA & JAMBA	
Little tern (*Sterna albifrons*)	Migratory, Marine Listed under CAMBA, JAMBA and CMS (Appendix II)	
Bridled tern (*Sterna anaethetus*)	Migratory, Marine Listed under CAMBA & JAMBA	
White-winged black-tern (*Chlidonias leucoptera*, *Chlidonias leucopterus*)	Migratory, Marine (as *Chlidonias leucopterus*) Listed under CAMBA (as *Chlidonias leucoptera*) & JAMBA (as *Chlidonia leucoptera*)	
Common noddy (*Anous stolidus*)	Migratory, Marine Listed under CAMBA & JAMBA	
Australian lesser noddy (*Anous tenuirostris melanops*)	Vulnerable, Marine	

*The roseate tern has been added to the updated list of species included under CAMBA and JAMBA, however, the amendments have not yet been formally adopted.

Ecology of protected species in the North-west Marine Region

The distribution and abundance of seabirds in the North-west Marine Region is strongly influenced by the oceanography of the Region, in particular the Leeuwin Current. The Leeuwin Current is an unusual, south-flowing eastern boundary current that carries warm, low-salinity water south to south-western Western Australia and inhibits upwellings of cooler, nutrient rich waters, resulting in low biological productivity. As a consequence, seabird abundance in the Region is much lower, and tropical species occur much further south, than at equivalent latitudes off the west coasts of Africa and South America, which possess north-flowing currents and strong coastal upwellings (Wooller *et al*. 1991).

The seabird fauna of the Region consists of predominantly tropical species, such as boobies, frigatebirds and tropicbirds, as well as tropical terns and noddies, but includes many Pacific Ocean pelagic species such as streaked shearwaters, Tahiti petrels, Hutton's shearwaters and Matsudaira's storm-petrels, which migrate into the Region from the Pacific via the Indonesian Throughflow (Wooller *et al*. 1991). Others such as the Indian yellow-nosed albatross and southern giant petrel are predominantly Antarctic or sub-Antarctic species that migrate to the Region during the non-breeding season.

The offshore islands in and adjacent to the North-west Marine Region support breeding populations of many species, including significant populations of terns, shearwaters and boobies. North of 20°S, most species breed in autumn, while in the southern parts of the Region, breeding can occur in both summer and autumn. Breeding seasons, the size of breeding populations and reproductive success of some species are influenced by the annual and inter-annual variability in the strength and timing of the Leeuwin Current and Indonesian Throughflow, which affects the availability and abundance of prey (Dunlop *et al*. 2002; Nicholson 2002).

Some species such as bridled terns and wedge-tailed shearwaters migrate to the Region to breed, taking advantage of temporary abundances in food sources. Others such as lesser crested terns and boobies are resident in the Region throughout the year although they may forage long distances over the open ocean. Several species of petrel spend their non-breeding seasons foraging in the Region while other species pass through the Region only briefly as part of longer distance migrations.

Further details on the main groups of seabirds that occur in the Region are below.

Migratory shorebirds

There are 26 species of migratory shorebirds of the Scolopacidae and Charadriidae families that regularly migrate through the Region as part of the East Asian–Australasian Flyway. These species complete a round trip of up to 26 000 km every year from their breeding grounds in Alaska and Siberia to their non-breeding habitat in Australia. Migrants arrive in the Region around September, using offshore islands as staging or stopover sites before moving to freshwater wetlands, grasslands, coastal areas and intertidal mudflats on the mainland. Some individuals remain in the Region throughout the non-breeding season on the rocky platforms and intertidal sand flats of Ashmore Reef and the Montebello Islands, where they forage on worms, bivalves and other invertebrates. Others remain on the mudflats of Roebuck Bay and Eighty Mile Beach. It is thought that at least four million individual shorebirds use the flyway with at least two million of those migrating to Australia (AWSG 2007). Most migrants leave the Region to head north again in March, although some very old or very young birds may remain in Australia during the Austral winter. The Region and islands adjacent to the Region, support internationally significant populations (over one per cent of the flyway population) of at least six species.

Terns and noddies

There are 14 species of terns and noddies that regularly occur in the Region. All but two species, common and white-winged black terns, breed in or adjacent to the Region. The Region supports significant breeding populations of bridled, sooty crested and lesser crested terns and common noddies. Australian lesser noddies may breed on Ashmore Reef, however, this requires confirmation. Caspian terns, fairy terns, gull-billed terns, little terns and white-winged black terns are primarily coastal or inland feeders, interacting with the Commonwealth waters of the Region only occasionally. Other species mainly forage over the continental shelf for squid, fish, molluscs, jellyfish and insects. Terns and noddies are often observed in mixed species feeding aggregations that form when predatory fish push prey to the surface (Nicholson 2002; Surman & Wooller 2003). Bridled terns also regularly forage over floating mats of *Sargassum* in pelagic waters (Dunlop 1997).

Tropicbirds

Small breeding populations of both red-tailed and white-tailed tropicbirds occur in the Region, on the Rowley Shoals and Ashmore Reef. Tropicbirds are predominantly pelagic species, rarely coming to shore except to breed. They forage for fish and squid by plunge-diving. They are usually solitary feeders, and are rarely observed in large aggregations (Dunlop *et al*. 2001). They forage over long distances, moving up to 1500 km away from their breeding sites. Outside the Region, a banded red-tailed tropicbird has been recorded almost 6000 km from where it was first captured (Le Corre *et al*. 2003).

Boobies

The North-west Marine Region supports breeding populations of three species of booby, including large colonies of brown boobies on Ashmore Reef, Adele Island, Bedout Island and the Lacepede Islands. Smaller populations of masked boobies occur on Adele and Bedout islands and a small population of red-footed boobies breeds on Ashmore Reef. Brown, red-footed and masked boobies primarily feed on flying-fish and squid, with red-footed boobies generally eating more squid while masked boobies and brown boobies eat more fish. Brown boobies are specialised plunge divers and are thought to forage closer to land than the other species, which are considered more pelagic. A study of the marine distribution of Christmas Island seabirds found that brown boobies foraged within 250 km of their colony, however red-footed boobies foraged up to 800 km away (Dunlop *et al*. 2001).

Frigatebirds

Two species of frigatebird (greater and lesser) occur in the Region, with large breeding colonies of lesser frigatebirds occurring on several offshore islands. Frigatebirds feed mostly on fish and occasionally on cephalopods (squid and cuttlefish). They forage on the wing, scooping prey from the surface of the water or taking flying-fish from just above the surface. Frigatebirds are also kleptoparasitic, chasing and harassing other seabirds and forcing them to regurgitate their prey.

Procellariiformes

Procellariiformes include albatrosses, petrels, shearwaters and their allies. Ten species of procellariiformes occur regularly in the North-west Marine Region, including one species of albatross, one giant petrel, two storm petrels, three petrels and three shearwater species. Only the wedge-tailed shearwater is known to breed in the Region with large colonies on many offshore islands. Indian yellow-nosed albatrosses, soft-plumaged petrels and Matsudaira's storm-petrels are thought to migrate to the Region during the non-breeding season, while other species such as Wilson's storm-petrels, Hutton's shearwaters and streaked shearwaters may migrate through the Region on their way to other non-breeding areas.

Procellariiformes generally feed on squid, fish and crustaceans, either by taking prey from the surface or pursuit-diving for deeper-living prey species. Wedge-tailed shearwaters have been recorded diving to depths of up to 66 m, although most dives are to depths of less than 20 m (Burger 2001). Storm-petrels feed by scooping minute crustaceans from the ocean surface. Some species will readily follow ships and attend trawlers, foraging on fishery discards. Others may form large mixed species feeding aggregations with other seabirds and predatory fish.

Important areas in the North-west Marine Region

Threatened and migratory species are considered matters of national environmental significance under the EPBC Act. Important areas for threatened and migratory bird species, as well as other seabird species, in the North-west Marine Region are identified below. These sites include offshore islands and coastal areas that support important seabird colonies, but fall under State Government jurisdiction. Some of these areas are already afforded protection through their status as Commonwealth or State marine parks or reserves.

Adele Island – Adele Island supports large breeding colonies of brown boobies and lesser frigatebirds as well as smaller breeding populations of red-footed boobies, masked boobies, lesser crested terns and silver gulls (Serventy *et al*. 1971; DEC 2007a).

Ashmore Reef and Cartier Island – These islands support some of the most important seabird colonies on the North West Shelf, including colonies of sooty terns, crested terns, bridled terns, common noddies and brown boobies as well as smaller populations of little egrets, eastern reef egrets, black noddies, frigatebirds, tropicbirds, red-footed boobies, roseate terns and lesser crested terns (Serventy *et al*. 1971; DEC 2007a).

The reserves are also important staging points for many migratory shorebirds including large flocks of eastern curlews, ruddy turnstones, whimbrels, bar-tailed godwits, common sandpipers, Mongolian plovers, red-necked stints and grey-tailed tattlers. As such, Ashmore Reef National Nature Reserve is included on the Ramsar List of Wetlands of International Importance.

Bedout Island – Bedout Island supports one of the largest colonies of brown boobies in Western Australia, with a population estimated to be over 10 000 breeding pairs (Nicholson 2002; DEC 2007a). The island also supports smaller breeding populations of masked boobies, lesser frigatebirds, common noddies and crested, roseate and sooty terns.

Dampier Archipelago – The islands of the Dampier Archipelago are important nesting areas for wedge-tailed shearwaters, bridled, fairy, roseate and Caspian terns, eastern reef egrets, beach stone-curlews, ospreys and white-bellied sea-eagles.

Lacepede Islands – The Lacepede Islands support some of the largest colonies of brown boobies in Western Australia, with the number of breeding pairs on West Island and Middle Island estimated to be in the tens of thousands. Approximately 2500 pairs of lesser frigatebirds nest on West Lacepede Island, while smaller populations of bridled terns, roseate terns, fairy terns, sooty terns, common noddies, Australian pelicans and silver gulls also breed in the area (Serventy *et al*. 1971; DEC 2007a).

Montebello, Lowendal and Barrow islands – These islands support significant colonies (over 10 000 pairs) of wedge-tailed shearwaters, crested terns and bridled terns. The Montebello Islands support the biggest breeding population (over 6000 pairs) of roseate terns in Western Australia, while small numbers of ospreys, Brahminy kites, white-bellied sea-eagles, eastern reef egrets, Caspian terns, lesser crested terns and beach-stone curlews also breed on the Montebello and Lowendal islands. A large breeding population of silver gulls (over 1000 pairs) breeds on the Lowendal Islands between December and April (Nicholson 1998; Burbidge *et al*. 2000; Nicholson 2002; Surman & Nicholson 2006).

Barrow Island is ranked equal tenth among 147 important migratory bird sites in Australia. Along with the nearby Lowendal and Montebello Islands, Barrow Island is an internationally significant site for grey-tailed tattlers, ruddy turnstones, red-necked stints, sanderlings and greater and lesser sand plovers, supporting more than one per cent of the East Asian–Australasian Flyway population of these species. As well as an important staging post, at least some birds remain on the island throughout the summer non-breeding season and even during the winter.

Observations by Dunlop *et al*. (1988) indicate that an area to the west of the Montebello Islands may be a minor zone of upwelling in the Region, supporting large feeding aggregations of terns. More recent studies indicate that it is an important feeding area for migratory Hutton's shearwaters and soft-plumaged petrels (C. Surman pers. comm. 2007).

North West Cape and surrounds – There are records of breeding on Serrurier and Airlie islands for Caspian terns, fairy terns, little terns, wedge-tailed shearwaters, ospreys and silver gulls.

Onslow to Dampier Archipelago – Islands between Onslow and the Dampier Archipelago support important nesting sites for wedge-tailed shearwaters, roseate, crested, Caspian and bridled terns, ospreys, eastern reef egrets, beach stone-curlews and white-bellied sea-eagles.

Roebuck Bay and Eighty Mile Beach – Roebuck Bay and Eighty Mile Beach are two of the most important areas in Australia for migratory shorebirds, regularly supporting over 500 000 birds at any one time, with over 850 000 birds using the area annually. The area is an internationally significant site for 20 species, regularly supporting more than one per cent of the East Asian–Australasian Flyway population. Whistling kites, Brahminy kites and red-capped plovers also breed in the area. Both Roebuck Bay and Eighty Mile Beach are included on the Ramsar List of Wetlands of International Importance.

Rowley Shoals – The sand cays at Clerke and Imperieuse reefs and the sand areas exposed at low tides at Mermaid Reef may be important resting and feeding sites for migratory shorebirds. There are also breeding records of red-tailed tropicbirds, white-tailed tropicbirds, little terns and sooty terns on Bedwell Island and Clerke Reef (DEC 2007a).

Scott Reef – Scott Reef is an important staging post for migratory shorebirds and a foraging area for seabirds including roseate terns, lesser frigatebirds and brown boobies.

Shark Bay – Several hundred pairs of wedge-tailed shearwaters breed on the islands of Shark Bay (C.

Surman & L. Nicholson pers. comm. 2007). Bridled terns, Caspian terns, roseate terns, fairy terns, crested terns, silver gulls, Pacific gulls and Australian pelicans have also been recorded breeding in the area (Serventy *et al*. 1971; DEC 2007a).

Known interactions, threats and mitigation measures

All the bird species listed as marine, migratory and/or threatened are protected under the EPBC Act, making it an offence to kill injure, take, trade, keep or move any member of a listed bird species without a permit. However, seabirds may interact with human activities in a number of ways. Potential interactions and threats to seabirds in the North-west Marine Region are listed below.

Commercial fishing

Many seabird species such as bridled terns, common noddies and wedge-tailed shearwaters rely heavily on foraging relationships with predatory fish, such as schools of tuna that herd prey species to the surface. For some species, such as lesser noddies and sooty terns, this is a near obligate relationship. Changes in tuna stock abundance or behaviour could affect populations of these species (Shaw 2000).

Incidental catch (or by-catch) of seabirds during oceanic longline fishing operations is listed under the EPBC Act as a key threatening process. Longline fishing is a particular concern for albatrosses and petrels in higher latitudes (south of 25°S). In the North-west Marine Region, the Western Tuna and Billfish Fishery is known to interact with seabirds through the use of pelagic longlining, however, most of the effort in the fishery occurs south of the Region (DEH 2004). Data from observer programs indicate that interactions with seabirds are rare and all birds caught are released alive (Ward & Curran 2004). The Australian Government has developed a threat abatement plan for the by-catch of seabirds on longlines, which can be found at <www.environment.gov.au/biodiversity/threatened/publications/tap/longline>. This threat abatement plan was reviewed in 2006, and the provisions of the revised plan apply to all longline fisheries managed by the Commonwealth.

In the Region, seabirds also interact with the Northern Prawn Fishery through actively feeding on discards from the fishery (DEH 2003). Such an increase in food availability may affect foraging behaviour, population sizes and reproductive success. The impacts of increasing populations of some species beyond their natural capacity may have implications for the ecosystem as a whole. Studies outside the Region in the Great Barrier Reef indicate that seabirds only eat a small proportion of trawl discards (Hill & Wassenberg 2000), but Blaber *et al*. (1995) found that increased food availability may affect diet, foraging strategies and juvenile survival. Discarded by-catch in the Northern Prawn Fishery is substantial but has been reduced through reduction in effort in the fishery (DEH 2003).

Oil and gas infrastructure

The oil and gas industry is one of the most significant human activities in the North-west Marine Region. Potential effects of oil and gas infrastructure on seabirds include oil spills, the destruction or disturbance of nesting or roosting habitat, disorientation of juvenile birds by lights (Nicholson 2002; Bamford & Bamford 2005), and, rarely, death in gas flares (Bourne 1979; Nicholson 2002). Platforms and other infrastructure associated with the industry can provide new roosting areas; however, the risk of helicopter strike is associated with these structures (C. Surman & L. Nicholson, pers. comm. 2007).

Marine debris and pollution

Injury and fatality to birds and other vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris has been listed as a key threatening process under the EPBC Act. Marine debris includes garbage washed or blown from land into the sea (such as plastic), discarded commercial or recreational fishing gear, and solid non-biodegradable floating materials disposed of by ships at sea. Entanglement in marine debris can lead to restricted mobility, starvation, infection, amputation, drowning and smothering. The ingestion of plastic marine debris can cause physical blockages leading to starvation, or injuries to the digestive system leading to infection or death. The Australian Government is currently developing a threat abatement plan that aims to minimise the impacts of marine debris on threatened marine species. Further information on the impacts of marine debris on threatened species is available at <www.environment.gov.au/biodiversity/threatened/publications/marine-debris.html>.

Seabirds are also susceptible to toxic contaminants such as heavy metals, and synthetic compounds such as organochlorines, which may be absorbed after ingestion of plastic materials. Organochlorines accumulate up the food chain and can cause reduced breeding success, increased risk of disease, altered hormone levels and death (Ryan *et al*. 1988). Similarly, heavy metals originating from agricultural and industrial run-off may be concentrated in top-level predators such as seabirds and are thought to cause decreased reproductive success, behavioural abnormalities and increased mortality (Burger & Gochfeld 2000).

Competition with introduced and other native species

Introduced species are the most significant threat to seabirds at their breeding sites. The black rat (*Rattus rattus*) is the most widely distributed introduced rodent on Australian islands and has been recorded on many islands on the Pilbara and Kimberley coasts (Morris 2002). Black rats prey on eggs and chicks and are thought to be responsible for the extermination of common noddies from Bedout Island and the Lacepede Islands. Eradication programs have been successful on several islands such as Bedout, Middle and West Lacepede islands and Barrow and Middle islands (Morris 2002). Exotic plant species can also affect seabird breeding by reducing nesting habitat, eroding burrowing substrate, giving cover to predators and reducing cover and shade for chicks (WBM Oceanics & Claridge 1997).

However, other native species may also pose a threat to seabirds, particularly at colonies. In the past 50 years, the populations of silver gulls throughout Australia have grown significantly, probably as a result of increased access to anthropogenic food sources (Smith & Carlile 1993). Silver gulls prey on the eggs and nestlings of other seabirds and displace them from preferred nesting sites (Surman & Nicholson 2006). It is estimated that approximately 40 000 silver gulls were resident in the Perth metropolitan area in 1992 (DEC 2007b). Although the species is not yet a major problem in the North-west Marine Region, substantial silver gull population increases in some parts of the Region associated with human activity and industry could have a negative impact upon other seabird breeding populations.

Disturbance at colonies

Human disturbance of seabird breeding colonies can cause breeding failure through modification or destruction of breeding habitat, displacement of breeders, nest desertion by all or part of a breeding population, destruction or predation of eggs, and exposure or crushing of young chicks, particularly in ground and burrow nesting species (WBM Oceanics & Claridge 1997).

Climate change

The long-term effect of climate change on marine species is still speculative, however, seabirds may be affected in a number of ways. An increase in temperatures is likely to lead to earlier nesting, an expansion or shift in ranges southward, the loss of nesting sites and foraging habitat through increases in sea level, and changes in availability and abundance of food resources (Hobday *et al*. 2006). Changes in prey availability will also affect distribution, abundance, migration patterns and community structure of seabird communities. There is already evidence that the ranges of a number of tropical seabird species in Western Australia are expanding south (Dunlop & Goldberg 1999; Dunlop & Mitchell 2001), although the mechanisms driving this range expansion are not clear. There is also evidence that arrival and departure dates for migratory species are changing and that this may be linked to changes in climate (Beaumont *et al*. 2006).

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D6 North-west Marine Region Protected Species Group Report Card – Dugongs

Current at May 2008. See <www.environment.gov.au/coasts/mbp/north-west> for updates.

General information

The dugong (*Dugong dugon*) belongs to the order Sirenia, and is the only remaining species in the family Dugongidae. The dugong is most closely related to the extinct Steller's sea cow (*Hydrodamalis gigas*), which was a member of the same family. Three species of manatee are the only other remaining members of the order Sirenia (Marsh *et al*. 2002).

Dugongs are also known as 'sea cows', and have been found in tropical and subtropical coastal and island waters from East Africa to Vanuatu, between about 26°N and 27°S (Marsh *et al*. 2002). Historically, the distribution was broadly coincident with the tropical Indo–Pacific distribution of its food plants, the seed-producing seagrasses (Husar 1978). Research indicates a decline in dugong numbers globally, however the degree to which their numbers have dwindled and their range has fragmented is not known. Dugong populations outside Australian waters currently consist of relict populations separated by large areas where the species is close to extinction or extinct. (Marsh *et al*. 2002).

Research indicates that a significant proportion of the world's population of dugongs is now found in northern Australian waters between Shark Bay in Western Australia and Moreton Bay in Queensland. Over 10 000 animals have been recorded in Shark Bay (14 906 km^2) alone, compared with a population estimate of 9000 animals in the Red Sea and the Arabian Gulf (72 000 km^2) (Preen 1998). The population of dugongs in Australian waters is estimated to include about 80 000 animals (Saalfeld & Marsh 2004).

Nationally protected species

The dugong is listed under the EPBC Act as a migratory and marine species, making it an offence to kill, injure, take, trade, keep or move dugongs in a Commonwealth area without a permit. Any actions in Australian waters that have, or are likely to have, a significant impact on dugongs are subject to a rigorous referral, assessment and approval process under the EPBC Act.

Currently, dugongs are classified as vulnerable to extinction under the *2006 IUCN Red List of Threatened Species* because they are considered to be at high-risk of extinction in the wild in the medium-term future. Australia supports the largest remaining dugong populations in the world, which are considered to be relatively stable across most of their range in northern Australia. As such, the dugong is currently not listed as a threatened species under the EPBC Act.

The dugong is also listed on Appendix I of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES), and on Appendix II of the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS). As a signatory to CMS, Australia has an international obligation to protect migratory species, their habitats, and their migration routes. Similarly, as a party to CITES, Australia has agreed to control the import and export of an agreed list of species that are endangered, or at risk of becoming endangered, because of inadequate controls

Dugong in Shark Bay. Photo: Kevin Crane, Department of Environment and Conservation, WA.

over the trade in specimens or their products. Further information on CITES and CMS is included in Appendix A.

On 31 October 2007, Australia signed the *Memorandum of Understanding on the Conservation and Management of Dugongs and their Habitats throughout their Range* under the CMS at a meeting in Abu Dhabi, United Arab Emirates. The memorandum of understanding is a non-legally binding arrangement that acknowledges the shared responsibility of signatory states for the conservation and management of dugongs and their habitat. The associated *Conservation Management Plan for Dugong* sets out key priority objectives and actions for the conservation and management of dugong populations across their migratory range and is consistent with plans for other species developed under CMS.

Ecology of protected species in the North-west Marine Region

Dugongs are large grey mammals that spend their entire lives in the sea. Fully grown, they are about 3 m long and weigh 400 kg. They have nostrils near the top of their snouts, and a few bristles near the mouth. Dugongs swim by moving their broad spade-like tail in an up-and-down motion, and by use of their two flippers. They surface only to breathe. For food, they rely on the seagrasses that grow on sandy seafloor regions in shallow warm water. Feeding aggregations tend to occur in some of these areas, though access to inshore feeding areas is only possible when water depth is over 1 m, and some areas may be accessible only at high tide. Where tidal amplitude is low, such as Shark Bay, or where seagrass grows subtidally, daily movements are not dictated by tides (Marsh *et al*. 2002).

It is estimated that dugongs need to eat around 40 kg of seagrass each day (QEPA & QPWS 1999). Research indicates that dugongs selectively forage for seagrass species that are lowest in fibre and highest in available nitrogen and digestibility (*Halophila* spp. and *Halodule* spp.). This allows them to maximize the level of nutrients rather than bulk. Dugongs will resort to eating marine algae when seagrass is scarce, and will delay breeding if there is insufficient food.

Dugongs have a low reproductive rate, long generation time and a high investment in each offspring (Marsh *et al*. 2002). They do not have a specific breeding season, but they do show some seasonality, with mating and calving apparently peaking in the spring and summer months. Females bear their first calf at between six and 17 years of age depending on the quality of food available. Gestation lasts for approximately 13 months and the mother gives birth underwater, usually to a single calf. Calves start eating seagrasses soon after birth but remain with their mother, suckling and following close-by for at least 18 months. The period between successive calving is very variable, ranging from around three to seven years, and is related to the quality of their food (Boyd *et al*. 1999; Kwan 2002). Three separate age classes have been defined for dugongs: newborn and unweaned calves are usually less than 1.8 m in length; juveniles that are independent but sexually immature, generally measure between 1.8–2.4 m; and adults are usually greater than 2.4 m (Husar 1978). Dugongs are believed to have a long life-span. Age determination by tusk examination has estimated a female dugong from Roebuck Bay to have been around 73 years old when she died (IUCN 2006).

Dugongs are highly migratory, which means Australia shares its dugong populations with other countries, including Timor and Papua New Guinea. They are also found in other parts of the Indian and Pacific oceans in warm shallow seas protected from large waves and storms. In Australia, dugongs inhabit the shallow coastal waters of northern Australia from the Queensland/New South Wales border in the east to Shark Bay on the Western Australian coast. In the North-west Marine Region, they occur in Shark Bay; Exmouth Gulf and offshore on the North West Shelf; in and adjacent to Ningaloo Reef; in coastal waters close to Broome and along the Kimberley coast; and on the edge of the continental shelf at Ashmore Reef (Marsh *et al*. 2002).

Dugongs may use certain habitats for different activities. For example, shallow waters appear to be used for calving, and deeper waters may be used in winter as a thermal refuge from cooler coastal waters (Marsh *et al*. 2002). In Shark Bay, South Cove is used for some types of mating behaviour and the Faure Sill is a major feeding ground in spring and summer (Marsh *et al*. 1994).

Dugong movements are believed to be largely related to their searches for suitable seagrass beds, however towards the high latitude limits of their range they have been observed to make seasonal movements to warmer waters (Marsh *et al*. 2002). In Shark Bay, they tend to move to the western shores of the bay in winter and the eastern shores in the summer (Marsh *et al*. 1994). Satellite tracking has enabled the observation of long-distance movements of individual animals up to 600 km. It is thought that long-distance movements are associated with the ephemeral nature of the distribution of their preferred seagrass species (Marsh *et al*. 2002).

Important areas for dugongs in the North-west Marine Region

Dugongs prefer coastal waters; therefore, much of their distribution falls under Western Australian State jurisdiction. However, dugongs are listed as a marine and migratory species under the EPBC Act, making them a matter of national environmental significance. Important areas for dugongs in and adjacent to the North-west Marine Region are identified below. Some of these areas may already be afforded protection through their status as Commonwealth or State marine parks or reserves.

Shark Bay – A number of surveys of dugong populations have been conducted in Shark Bay. Surveys in 1989 and 1994 indicated that the dugong population was fairly stable at around 10 000 animals (Preen *et al*. 1997). A third survey in 1999 estimated that up to approximately 14 000 animals were present in the bay (Gales *et al*. 2004). Relocation of animals into Shark Bay from cyclone-affected areas to the north appeared the most likely explanation of this change (Gales *et al*. 2004).

The Gladstone/Wooramel Delta area on the eastern shore of Shark Bay is thought to be an important feeding area, particularly in the summer months when populations increase to between 3000 and 5000. During the winter months about 170 dugongs use this area (Preen *et al*. 1997). The warmer waters east of Dirk Hartog Island support seagrass banks and are thought to be a refuge frequented by dugongs during the winter months (Preen *et al*. 1997). Preen *et al*. (1997) concluded that the Shark Bay population was significant because of its large size, the low level of human predation and incidental mortality, and the presumed low level of habitat disturbance. This will provide a valuable reference point with which to compare other dugong populations.

Ningaloo Reef and Exmouth Gulf – Surveys in Exmouth Gulf in 1989 and 1994 indicated populations of around 1000 animals in this region (Marsh *et al*. 1994; Preen *et al*. 1997). A survey in 1999 indicated that the population for Ningaloo Reef and Exmouth Gulf had decreased to around 300 (Gales *et al*. 2004). A further survey in 2000 indicated that the population in Exmouth Gulf had decreased to below 100 (Prince 2001). It is thought that the numbers decreased as a result of the destruction of seagrass beds caused by the passage of tropical cyclone Vance through the Exmouth Gulf in March 1999, and relocation of previously resident dugongs responding to this loss of foraging habitat.

Pilbara coastal and offshore region (from Exmouth Gulf to the De Grey River) –Shoreline surveys of this area in the 1980s indicated reasonable concentrations of dugongs. An aerial survey in 2000 estimated the population at around 2000 animals. Knowledge of the extent of seagrass resources and their changes in response to disturbance from tropical cyclones in the area is sparse; however, potential seagrass habitat in deep water meadows and in the shallow waters around Barrow Island and the Montebello Islands has been documented. Dugong feeding trails have been observed between Middle and North Mangrove islands (Marsh *et al*. 2002).

Kimberley coast – Data from this region are sparse; however, small concentrations of dugongs have been observed in seagrass between Cape Bossut and King Sound. Reconnaissance surveys in this area in the mid-late 1980s indicated resident dugong populations at densities similar to the Pilbara (B. Prince, pers. comm. 2007). Unquantified levels of Indigenous hunting of dugongs occur in the west Kimberley region.

Ashmore Reef – Dugongs with calves have been reported at Ashmore Reef and nearby on the Sahul Shelf. The Ashmore Reef area may support a small, but possibly genetically distinct population, with a minimum population estimate of 11 animals (Whiting 1999).

Known interactions, threats and mitigation measures

As well as being listed as a marine and migratory species under the EPBC Act, dugongs are protected in Western Australian State waters under the *Western Australia Wildlife Conservation Act 1950*. The *Wildlife Conservation (closed season for Marine Mammals) Notice 1998* sets limits on human interactions with marine mammals and prevents some activities that interfere with, or result in the taking of marine mammals (Marsh *et al*. 2002).

Dugongs in the North-west Marine Region may be subject to a range of human threats including entanglement in shark-nets, mesh-nets and gill-nets, loss and degradation of critical coastal seagrass habitat, and collisions with boats (DEW 2007). Specific human activities that may pose a threat to dugongs in the region are detailed below:

Habitat loss and degradation

Dugongs are particularly vulnerable to habitat loss because of their dependence on seagrass beds containing their preferred food species (Marsh *et al*. 2002). Seagrass beds are sensitive to natural events such as cyclones and anthropogenic pressures.

Increased sedimentation and turbidity can smother seagrasses resulting in death, disease or a decrease in growth rate and, ultimately, a decline in the total area of seagrass beds. Increased sedimentation can occur from storm and cyclone activity, agriculture, coastal development, land reclamation and mining. Boat traffic and dredging practices also increase sediment suspension in the water column (Talbot & Wilkinson 2001; Hobday *et al*. 2006). Adjacent to the Region, port expansion in the Dampier Archipelago and Cape Lambert area associated with petroleum and iron ore industries also pose a potential threat to seagrass habitat as a result of increased dredging and ship movements (Marsh *et al*. 2002).

Coastal development also poses a threat to seagrass habitat. For example, in Shark Bay, the salt industry has constructed a sea wall to isolate part of Useless Inlet, and proposes to construct additional salt crystallizer ponds. The impacts of the sea wall on seagrasses are unknown, but it is expected that the crystalliser ponds will destroy approximately 40 ha of seagrass. As salt production increases, the industry will require larger vessels to export their product. This will involve dredging shipping channels in the vicinity of the seagrass banks east of Dirk Hartog Island (Marsh *et al*. 2002). This area of warmer waters is thought to be a refuge frequented by dugongs during the winter months (Preen *et al*. 1997).

Aquaculture farms being considered for parts of Shark Bay may also affect dugongs and their habitat through acoustic disturbance, eutrophication, pesticides, boat strikes, and the dragging of moorings on the seabed (Marsh *et al*. 2002).

Climate change

The long-term effects of global warming on marine species are still speculative; however, possible habitat loss and degradation of seagrass habitat in the North-west Marine Region as a result of climate change may affect dugong populations. Seagrass habitat is likely to be affected through increasing carbon dioxide levels, water temperature, UV radiation and storm activity. Changes in rainfall and coastal run-off, coastal salinity, currents and winds, and sea level rise will also have an impact on seagrass beds (Hobday *et al*. 2006).

Cyclones and storms can cause physical damage to the sea floor and seagrass beds. The passage of tropical cyclone Vance through the middle of Exmouth Gulf in 1999 is believed to have caused extensive damage to seagrass beds in that area. This may have been the reason for the decrease in dugong numbers in 2000, by an order of magnitude, from 1000 to 100 animals (Prince 2001). It is expected that climate change will change storm regimes in tropical regions across the globe. An increase in storm activity could result in an increase in turbidity and, in turn, a decrease in ultraviolet radiation levels, leading to smothering of seagrass plants (Hobday *et al*. 2006).

Rainfall and coastal salinity are also related to storm activity. Heavy rainfall during the tropical wet season (spring and summer) and associated with cyclones has the potential to increase sediment loads in coastal areas, through river flooding. In addition, while seagrasses can generally tolerate a wide range of salinity, it is thought that prolonged disturbance may affect community composition. Similarly, research indicates that increased wave exposure and wind speed may cause physical damage to seagrass beds and resuspend sentiments. This may also hinder the ability of seedlings to establish and grow, as pollination and seed dispersal depends on water movement (Hobday *et al*. 2006).

Sea level rise has the potential to increase turbidity in coastal waters through flooding and erosion. It is likely that sea level rise will result in a shift in seagrass distributions landward, with the loss of some deep water seagrass habitat (Hobday *et al*. 2006).

Commercial fishing

Interactions between dugongs and fisheries in the North-west Marine Region may include boat strikes and net entanglements. However, the Western Australian Government has introduced measures to avoid these interactions, including closures in certain areas, the use of by-catch reduction devices and observers on research vessels (Bunting 2002).

The major commercial and recreational fisheries in Shark Bay are prawn and scallop trawls, wet-lining and beach-seining. Neither of the latter two currently threaten dugongs, but there are minimal interactions with trawl nets. Shark Bay has been closed to commercial mesh net fisheries since 1986. Recreational gill-netting is permitted but requires net attendance so is not expected to pose a threat (Marsh *et al*. 2002). Seagrass beds and other areas of sensitive habitat in Shark Bay have been closed to prawn and scallop trawling permanently (EA 2002b; Kangas *et al*. 2006).

Aquaculture operations in Shark Bay have the potential to disrupt seagrass habitat and displace dugongs, however, the conservation of seagrass habitat in Shark Bay has historically been considered a priority for the industry (DoF 2004). Aquaculture in Shark Bay is currently being reviewed by the Western Australian Department of Fisheries. The review will consider the *Shark Bay Management Paper for Fish Resources*, which includes a list of recommendations for aquaculture management to mitigate negative effects on protected species (DoF 2004).

Management of recreational and commercial fishery activities in Ningaloo Marine Park is detailed in the *Ningaloo Marine Park (Commonwealth Waters) Management Plan* (EA 2002a) and the *Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005–2015* (CALM 2005). Prawn trawling is permitted in Exmouth Gulf; however, it is excluded from shallow water areas and the Ningaloo Reef Marine Park. The Western Australian Department of Environment and Conservation frequently reviews measures to protect dugongs and their habitat in the marine park (Marsh *et al*. 2002).

Marine debris

The Australian Government is actively seeking to address threats to marine mammals, including dugongs. Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris is listed as a key threatening process under the EPBC Act. The Australian Government is currently developing a threat abatement plan that aims to minimise the impacts of marine debris on threatened marine species. Further information on the impacts of marine debris on threatened species is available at <www.environment.gov.au/biodiversity/threatened/publications/marine-debris.html>.

Indigenous use and hunting

Under Section 211 of the *Native Title Act 1993* Indigenous people with a native title right can legitimately hunt dugong to satisfy their personal, domestic or non-commercial communal needs. Limited hunting of dugongs still occurs in Shark Bay and along the Pilbara and Kimberley coasts, particularly at One Arm Point. The catch has not been quantified but is not considered to be a significant threat (Marsh *et al*. 2002). Research in the Torres Strait and Cape York areas indicate that high levels of dugong hunting in some areas may have an impact on neighbouring populations (Heinsohn *et al*. 2004). However, movements between major Western Australian populations and those in other northern Australian regions are unlikely (B. Prince pers. comm. 2007).

The Kimberley Land Council has set up a Land and Sea Management Unit to manage the land and sea country in the region. The unit has established partnerships between Traditional Owners, community organisations, governments and industry to manage projects in the Kimberley region, including marine resource management (NAILSMA 2006). The unit manages the Marine Turtle and Dugong Project, which it has established to monitor and manage turtle and dugong populations across Northern Australia.

In 2005, the *Sustainable Harvest of Marine Turtles and Dugongs in Australia – A National Partnership Approach* (DEH 2005) was established to support management of the hunting of turtles and dugongs in order to contribute to the conservation of these species while maintaining traditional cultural practices. Further information is available at <www.environment.gov.au/coasts/publications/turtle-harvest-national-approach.html>.

Boat-related impacts and ecotourism

Recreational fishing and commercial boat-based dugong-watching occurs in Shark Bay. Ecotourism and recreational fishing in these waters is controlled by licensing under the *Conservation and Land Management Act 1984* and the *Western Australia Wildlife Conservation Act 1950*, and guided by a code of conduct developed by the Department of Environment and Conservation, Western Australia. Despite the strict guidelines, tourism vessels have been found to disturb dugongs from foraging or travelling in 37 per cent of observed encounters (Gerrard 1999). There have also been prosecutions for non-compliance, including for separating a mother and her calf, and for approaching a dugong too closely (Marsh *et al*. 2002).

Similarly, in Ningaloo Marine Park there is a high level of shore-based tourist boat activity within the vicinity of seagrass beds. This has the potential to affect dugong habitat as well as increase the risk of dugong boat strikes. The Pilbara coast has one of the highest levels of boat ownership per capita in Australia, and this is likely to increase over time (Marsh *et al*. 2002). There have been reports of boat strikes in this region and along the Kimberley coast.

The effect of boat traffic on the feeding behaviour of dugongs has been studied outside the Region in Moreton Bay, Queensland. The results indicated that dugongs are less likely to continue feeding when boats pass at a distance of 50 m or less. The observed levels of boat traffic reduced feeding time by 0.6–8 per cent, which was not considered a substantial impact. However, an increase in boat traffic may lead to an increase in disturbance to feeding dugongs (Hodgson & Marsh 2007). An increase in boat traffic in the North-west Marine Region may have a similar impact on dugong populations.

Commercial underwater and aerial filming of dugongs occurs in Shark Bay and has the potential to affect dugongs, although this has not been investigated. The impacts of filming from helicopters and light aircraft may be difficult to manage in the absence of any regulatory control over airspace (Marsh *et al*. 2002).

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D7 North-west Marine Region Protected Species Group Report Card – Cetaceans

Current at May 2008. See <www.environment.gov.au/coasts/mbp/north-west> for updates.

General information

The order Cetacea includes more than 80 species of whales, porpoises and dolphins (IWC 2007a), divided into two suborders, the Mysteceti, or baleen whales, and the Odontoceti, or toothed whales. Baleen whales include species such as blue whales, humpback whales and minke whales and are generally characterised by their large size (10–30 m) and keratinous baleen plates that hang from the upper jaw and are used to filter krill, plankton and other prey items from seawater. Toothed whales include dolphins, porpoises, killer whales and sperm whales, and are active hunters, feeding on squid, fish and sometimes other marine mammals. Cetaceans are thought to have evolved from land mammals that adapted to marine life approximately 50 million years ago. Forty-five species of cetacean occur in Australian waters. Of these, 21 occur regularly in the waters of the North-west Marine Region, including eight species of whale and 13 species of dolphin (see Appendix C, Table 1).

Nationally protected species

All whales and dolphins that occur in Australian waters are protected under the EPBC Act through the establishment of the Australian Whale Sanctuary (see below). Ten species that occur in the North-west Marine Region are also listed under the EPBC Act as threatened and/or migratory (Table D7.1). The long-snouted spinner dolphin is also considered a priority species (Bannister *et al.* 1996); however, information on this species is too scarce to assign it to a conservation category (Ross 2006).

The Australian Government has established the Australian Whale Sanctuary to protect all whales and dolphins found in Australian waters. The Australian Whale Sanctuary is in the Commonwealth marine area and includes all of Australia's EEZ including the waters around Australia's external territories such as Christmas, Cocos (Keeling), Norfolk, Heard and Macdonald islands. Within the sanctuary, it is an offence to kill, injure or interfere with a cetacean. Further information on the Australian Whale Sanctuary can be found at <www.environment.gov.au/coasts/species/cetaceans/sanctuary.html>.

In addition, as a signatory to the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS), Australia has an international obligation to protect migratory species, their habitats and their migration routes. Similarly, as a party to the *Convention on the International Trade in Endangered Species of Wild Fauna and Flora* (CITES), Australia has agreed to control the import and export of an agreed list of species that are endangered, or at risk of becoming endangered, because of inadequate controls over trade in them or their products. Further information on CITES and CMS is included in Appendix A.

Australian snubfin dolphin. Photo: Guido Parra, University of Queensland.

Table D7.1 Cetaceans listed as threatened or migratory under the EPBC Act that are known to occur in the North-west Marine Region

Species	Conservation Status	Conservation Plans and Policies
Humpback whale (*Megaptera novaeangliae*)	Vulnerable, Migratory Listed under CITES (Appendix I) & CMS (Appendix I)	• *Interaction Between Offshore Seismic Exploration and Whales – EPBC Act Policy Statement 2.1* (DEW 2007) • *Review of the Conservation Status of Australia's Smaller Whales and Dolphins* (Ross 2006) • *Recovery Plans for Australia's Threatened Whales 2005–2010: Humpback; Southern Right; Blue, Fin and Sei* (DEH 2005) • *Australian National Guidelines for Whale and Dolphin Watching* (Australian Government 2005) • *The Action Plan for Australian Cetaceans* (Bannister *et al.* 1996)
Antarctic minke whale (*Balaenoptera bonaerensis*	Migratory Listed under CITES (Appendix I) & CMS (Appendix II)	
Bryde's whale (*Balaenoptera edeni*)	Migratory Listed under CITES (Appendix I) & CMS (Appendix II)	
Fin whale (*Balaenoptera physalus*)	Vulnerable, Migratory Listed under CITES (Appendix I) & CMS (Appendix I & II)	
Blue whale (*Balaenoptera musculus*)	Endangered, Migratory Listed under CITES (Appendix I) & CMS (Appendix I)	
Sperm whale (*Physeter macrocephalus*)	Migratory Listed under CITES (Appendix I) & CMS (Appendix I & II)	
Indo-Pacific humpback dolphin (*Sousa chinensis*)	Migratory Listed under CITES (Appendix I) & CMS (Appendix II)	
Spotted bottlenose dolphin (*Tursiops aduncus*)	Migratory Listed under CITES (Appendix II) & CMS (Appendix II) – Arafura/Timor Sea population only	
Killer whale (*Orcinus orca*)	Migratory Listed under CITES (Appendix II) & CMS (Appendix II)	
Australian snubfin dolphin (*Orcaella heinsohni*)	Migratory Listed under CITES (Appendix I as *Orcaella brevirostris*) & CMS (Appendix II as *Orcaella brevirostris*)	

Ecology of protected species in the North-west Marine Region

Cetaceans found in the North-west Marine Region include truly pelagic species such as Antarctic minke whales, and spinner and striped dolphins that spend the majority of their time in the Commonwealth waters of the Region, as well as species such as Australian snubfin dolphins and Indo-Pacific humpback dolphins that are predominantly found in Western Australia State waters close to the coast. Sperm whales, false killer whales and short-finned pilot whales may be found around areas of upwelling and canyons on the continental shelf.

Many species are thought to be resident in the Region throughout the year. Resident populations of bottlenose and Indo-Pacific humpback dolphins are known from the Montebello Islands and the population of bottlenose dolphins in Shark Bay is a popular tourist attraction, as well as the subject of long-term behavioural studies (Mann *et al.* 2000; Watson-Capps & Mann 2005; Bejder *et al.* 2006). Family pods of female and juvenile sperm whales are likely to reside in the warm tropical waters of the Region throughout the year, while male sperm whales migrate south to feed in the waters of the Antarctic. While specific areas for sperm whales have not been identified in the Region, historical whaling records show they were commonly encountered offshore in the southern parts of the Region (Townsend 1935; WCS 2006). The Australian snubfin dolphin (formerly known in Australian waters as the Irrawaddy dolphin) is also thought to be resident in shallow seagrass habitats in and adjacent to the Region. This species is newly described and may be endemic to Australian waters (Beasley *et al*. 2005).

The Region is an important migratory pathway between feeding grounds in the Southern Ocean and breeding grounds in tropical waters for several cetacean species. Blue whales, fin whales, dwarf and Antarctic minke whales may travel through the Region on their way to breeding grounds, which are thought to be in deep oceanic waters around the Indonesian archipelago, but have yet to be discovered. The North-west Marine Region is particularly important for the Western Australian population of humpback whales whose known breeding and calving grounds are between Broome and the northern end of Camden Sound (Jenner *et al*. 2001; DEH 2005).

Humpbacks migrate north from their Antarctic feeding grounds around May each year, reaching the waters of the North-west Marine Region in early June. Immature individuals and lactating females arrive first, followed by non-pregnant mature females and adult males, with pregnant females arriving last. Breeding and calving takes place between mid-August and early September when the southern migration starts. Females with calves are the last to leave the breeding grounds, stopping to rest in Exmouth Gulf and Shark Bay. The western Australian population of humpbacks (known as the Group IV population) is genetically distinct from the eastern Australian population, with very little exchange between the two, even in their Antarctic feeding grounds (Baker *et al*. 1993).

Humpbacks are thought not to feed while visiting the Region, however, other baleen whales may feed on tropical krill species, such as *Pseudeuphausia latifrons*, while in the Region. Toothed whales and dolphins are significant predators of cephalopods (squid, octopus and cuttlefish), fish and crustaceans (krill, amphipods and copepods) with some species diving to take deep water prey at depths of more than 1500 m. Others move to feed offshore at night when deep-living organisms, usually schools of fish, migrate to the surface. Killer whales have been known to attack humpback whales, particularly calves, and may be attracted to the Region during the humpback breeding migration, although records of killer whale attacks on humpbacks are rare (Flórez-González *et al*. 1994).

Mixed species feeding aggregations are known to occur among common, bottlenose, Risso's and rough-toothed dolphins as well as melon-headed and pilot whales. Groups of spinner and spotted dolphins also commonly associate with tuna and seabirds. To the south of the Region, blue, fin and possibly sei whales aggregate to feed in the Perth Canyon. Similarly, Australian snubfin and Indo-Pacific humpback dolphins share similar habitat preferences in inshore waters (Parra 2006).

Important areas for cetaceans in the North-west Marine Region

Threatened and migratory species are considered matters of national environmental significance. Important areas in the North-west Marine Region are identified for species listed as threatened or migratory under the EPBC Act. A number of areas in or adjacent to the Region are of particular importance for cetacean species listed as threatened or migratory, including:

Shark Bay – An important resting area for migrating humpbacks, particularly for females and calves on their southward migration. Resident populations of bottlenose dolphins.

Exmouth Gulf – An important resting area for migrating humpbacks.

Wallaby Saddle – Possible aggregation area for sperm whales (DEWHA 2008).

Montebello and Barrow islands – Resting area for migrating humpbacks. Resident populations of common bottlenose and Indo-Pacific humpback dolphins.

Roebuck Bay – Important feeding area for Australian snubfin dolphins and other inshore dolphin species (Thiele 2008).

Quondong Point – Appears to be a migratory waypoint and high density area for northbound humpback whales as well as false killer whales, pygmy blue whales and a number of dolphin species (DEWHA 2008).

Kimberley coast north of Broome – The Kimberly coast from Broome to north of Camden Sound is the main calving area for the west Australian population of humpback whales. High concentrations of humpbacks are observed in Camden Sound and Pender Bay between

June and September each year. Shallow coastal waters and estuaries along the Kimberley coast, particularly Beagle and Pender bays on the Dampier Peninsula and tidal creeks around Yampi Sound and between Kuri Bay and Cambridge Bay are important areas for Australian snubfin dolphins and Indo-Pacific humpback dolphins.

Browse Island – Offshore waters surrounding Browse Island support a larger number of cetacean species than any other area on the Western Australian coast, including large pods of oceanic dolphins, pygmy killer whales, false killer whales, melon-headed whales, minke whales and pilot whales (Jenner & Jenner 2007). Upwellings around Browse Island are likely to be a feeding area for blue whales migrating to Indonesia. Unconfirmed sightings of humpback whales feeding have also been reported from waters around Browse Island. This observation is significant as humpbacks are currently known to feed only in Antarctic waters, but further investigation is necessary (DEWHA 2008).

Scott Plateau – Historically a sperm whale aggregation area. Possible breeding and feeding area for beaked whales (DEWHA 2008).

Known interactions, threats and mitigation measures

All cetaceans in the North-west Marine Region are protected within the Australian Whale Sanctuary under the EPBC Act, making it an offence to kill, injure, take or interfere with (defined as 'harass, chase, herd, tag, mark or brand') a whale or dolphin in Commonwealth waters. However, cetaceans in the Region may interact with human activities in a number of ways. Specific human activities that may pose a threat to cetaceans in the Region are detailed below:

Whaling

Commercial whaling had a significant impact on the western Australian population of humpback whales in the early 20th century. Two whaling stations operated intermittently in the North-west Marine Region between 1912 and 1955. Norwegian whalers operated the Norwegian Bay whaling station on Point Cloates between 1912 and 1916 and again between the early 1930s and World War II. In 1949, the station was reopened by the Nor' West Whaling Company and operated until 1955. The Australian Government operated a whaling station at Babbage Island near Carnarvon between 1950 and 1955. It is estimated that between the whaling stations at Carnarvon, Point Cloates and the Cheyne's Beach Whaling Company at Albany, 18 000 whales were killed and processed between 1949 and 1963 (Egan 1995).

When the International Whaling Commission banned humpback whaling in 1963, it is estimated that the western Australian population of humpbacks had been reduced to about 800. However, recent information on illegal Soviet whaling up until the 1970s (Clapham *et al*. 2005) could mean that the figure was probably much lower by 1985 when the commission imposed an international moratorium on all commercial whaling. In 1999, the western Australian humpback population was estimated at between 8000 and 14 000 and increasing at a rate close to the biological maximum of just above 10 per cent annually (DEH 2005).

Whaling is not currently a threat to most species; however, Antarctic minke whales and fin whales, which are thought to migrate through the Region, are still targeted by the Japanese scientific whaling program with 856 minke whales and 10 fin whales killed during the 2005/06 season. Fifty fin whales, 50 humpback whales and 935 minke whales are proposed to be taken annually in the JARPA II scientific whaling program starting in the summer of 2007/2008. However the humpback take has since been suspended. No fin whales and only 551 minke whales were taken during the first season. Humpback whales are expected to be included in the program in the future and it is likely that western Australian animals will be among those targeted. As populations recover, pressure may increase for the moratorium on commercial whaling to be lifted.

Outside the Region, sperm whales, short-finned pilot whales and some dolphin species (e.g. spinner, spotted, striped, rough-toothed) are hunted in Japan, Indonesia and Sri Lanka. The large-scale movements of these species mean that the Australian populations may be killed outside of Australian waters.

Commercial fishing

Interactions between cetaceans and fisheries in the North-west Marine Region may include depredation of catch (i.e. the removal of hooked fish or bait from longlines), feeding on discarded by-catch, entanglement in gear, or injury or death through incidental capture or boat strikes.

The Western Tuna and Billfish Fishery (DEH 2004), which encompasses the whole of the North-west Marine Region, reports that depredation, or the removal of hooked fish or bait from longlines, is a growing problem in the fishery. Killer whales, false killer whales, short-finned pilot whales and rough-toothed dolphins are all known to depredate longlines, increasing the risk of injury or capture. In addition, there are anecdotal reports of instances where animals robbing longlines have been shot by fishers. Research into possible mitigation measures, such as avoiding areas of high biological productivity, retaining offal, acoustic deterrents and the use of quieter engines is underway (AFMA 2005).

Dolphins actively feed on discards from the Northern Prawn Fishery (DEH 2003), part of which extends into the north-eastern part of the Region. Floating discards are scavenged by species including dolphins. Discarding in areas of regular trawling may affect dolphin and shark populations as discards concentrate in smaller areas within the foraging range of the scavengers. Provisioning of animals is an issue of concern and the impacts of increasing populations of some species beyond their natural capacity may have implications for the ecosystem as a whole. However, as a result of a reduction in effort to protect prawn stocks, discards have also been reduced (DEH 2003).

Interactions with dolphins are a serious issue for the Pilbara Fish Trawl Interim Managed Fishery, which operates almost entirely in the Region (DoF 2006). In 2005, before the implementation of mitigation measures, 56 interactions with dolphins were reported, 52 of which were deaths. In the first half of 2006, a further 23 dolphin interactions were reported in the fishery, 21 of which were deaths (DEW 2007). A by-catch action plan for the fishery is currently being developed (DoF 2006) and mitigation measures such as 'pingers' and by-catch reduction grids are being trialled. In 2006, by-catch reduction grids became mandatory for all trawl operators in the Pilbara Fish Trawl Managed Fishery. Further information on dolphin interactions with the fishery is being collected through an observer program and the use of underwater cameras.

Australian snubfin and Indo-Pacific humpback dolphins are vulnerable to gill-nets targeting barramundi and other fish species in the river and estuarine parts of their range. The overfishing of their prey species is also expected to be an increasing problem for these species (Ross 2006).

Rough-toothed, spinner and spotted dolphins are known to form feeding associations with yellowfin tuna (*Thunnus albacares*). As such, purse seine netting by tuna fleets, particularly in the eastern tropical Pacific Ocean, has been a major threatening process for these species. However, purse seine fishing is not currently a significant problem in the North-west Marine Region, as no fisheries in the Region currently use this fishing method.

Aquaculture and pearling

Aquaculture activities and equipment may be a source of interaction with cetaceans, particularly smaller species of whales and dolphins, often with negative impacts. Some types of aquaculture may negatively affect the marine environment through the introduction of exotic species, diseases, antibiotics and medicines, increased deposition of organic and faecal matter, and disruption of benthic communities. Cetaceans may also become entangled in aquaculture installations (Watson-Capps & Mann 2005). Outside of the Region, 29 dolphins died between 1990 and 1999 after becoming entangled in tuna feedlots at Port Lincoln, South Australia (Kemper & Gibbs 2001). In a study of the impact of aquaculture on cetaceans in Shark Bay, adjacent to the Region, Watson-Capps & Mann (2005) showed that dolphins may avoid aquaculture installations resulting in displacement from preferred habitat.

Tourism

Whale-watching is a growing industry in Australia and around the world. In Australia between 1994 and 1998, the industry grew by an average of 15.9 per cent per year (Hoyt 2001). In 1998, there were 89 commercial whale-watching operations in Western Australia, including two 'swim-with-dolphins' operations. The population of bottlenose dolphins at Monkey Mia in Shark Bay, adjacent to the North-west Marine Region, has been habituated to human interactions through food provisioning since the 1960s and attracts visitors from all over the world. Almost 90 per cent of Shark Bay's 100 000 annual visitors come to see the dolphins (Mann & Kemps 2003).

Interactions with the dolphins have been managed by the West Australian Government since 1986 and feeding has been restricted to 2 kg of fish per dolphin per day since 1989 (Mann & Kemps 2003). Feeding was further restricted in 1995 after several negative effects of provisioning were observed. Some calves became dependent on human provisioning and failed to learn to forage effectively for themselves. Some mothers were distracted from defending their calves from predators, and habituation to humans and human activities increased the chance of entanglements or injuries. In addition, death of calves whose mothers were provisioned was almost twice as high as calves whose mothers were not provisioned (Mann *et al*. 2000). Changes to the feeding policy have reduced death rates among provisioned calves, however further research has shown that provisioning may still affect maternal care (Mann & Kemps 2003).

More generally, repeated disruption to breeding, social, feeding or resting behaviour can have deleterious effects on reproductive success, health, distribution and ranging patterns, or access to preferred habitat (Bejder & Samuels 2003). Bejder *et al*. (2006) showed a decline in dolphin abundance in Shark Bay during a period of increased exposure to tourist vessels. They suggested that the dolphins were shifting habitat to avoid vessel disturbance. Similarly, Van Parijs & Corkeron (2001) found that noise from boat traffic affected group cohesion among Indo-Pacific humpback dolphins and that mother-calf pairs were particularly sensitive to disturbance. With increasing numbers of humpback whales migrating through the Region, there is likely to be increasing interest in this species from commercial and recreational whale-watching operations.

In response to concerns regarding the impact of the growing cetacean-watching industry, the Australian Government and all State and Territory governments jointly developed the *Australian National Guidelines for Whale and Dolphin Watching 2005*, which can be found at <www.environment.gov.au/coasts/publications/whale-watching-guidelines-2005.html>. These guidelines apply equally to commercial and recreational whale-watching and have the dual aims of:

- minimising harmful impacts on whales, dolphins and porpoises; and
- ensuring that people have the best opportunity to enjoy and learn about the whales, dolphins and porpoises found in Australian waters.

Additional management measures such as regulations, permits, licenses and management plans may apply to areas that are particularly important to the survival of cetacean species or areas that support a substantial whale or dolphin-watching industry. Authorisation from the relevant State, Territory or Australian government is also required to approach cetaceans closer than outlined in the guidelines, for scientific or educational purposes, or for commercial filming.

Oil and gas industry

The oil and gas industry is one of the most significant human activities in the North-west Marine Region. Several aspects of oil and gas exploration and development have, or are likely to have, impacts on cetaceans in the Region. In particular, the use of seismic survey techniques has raised concern over the potential negative effects on whales. Seismic hydrocarbon surveys involve the use of high-energy noise sources operated in the water column to determine the composition of rock strata beneath the seafloor. Research has shown that migrating humpback whales exhibit a startle response to seismic survey sounds and will move to avoid a seismic vessel at a distance of around 3 km. Resting mothers with calves are particularly sensitive and will show an avoidance response at approximately 7–12 km from the seismic source (McCauley *et al*. 2000). Such avoidance behaviour could result in displacement from resting areas, migration routes or feeding or breeding areas. Baleen whales such as humpback, blue and fin whales may be especially vulnerable to negative effects from seismic surveys because their acoustic range operates in the same low frequency. Studies on the relationship between military sonar operations and whale strandings indicate that beaked whales may also be particularly sensitive to acoustic trauma (Frantzis 1998). It is possible that extremely close encounters may cause damage to ears.

Seismic operations are regulated by the Australian Government's *Interaction Between Offshore Seismic Exploration and Whales, EPBC Act Policy Statement 2.1* (see <www.environment.gov.au/epbc/publications/seismic.html>). The guidelines outline standard management procedures for conducting seismic surveys in areas and at times when the likelihood of encountering cetaceans is low, as well as procedures that aim to reduce interference with cetaceans when the likelihood of encounters are moderate to high. Other actions that are likely to interfere with whales may also require permits under the EPBC Act.

Shipping

Shipping in the North-west Marine Region is dominated by traffic from the ports of Dampier, Port Hedland and, to a lesser extent, Broome. Dampier and Port Hedland are the largest tonnage ports in Australia and are being expanded to accommodate an anticipated increase in iron ore and oil and gas exports (DPI 2006). Ship strikes are likely to affect the larger cetaceans in the Region, in particular, humpback whales whose migratory path intersects major shipping routes from both Dampier and Port Hedland ports (Western Australian Government 2006). In 2005, the International Whaling Commission established a Ship Strike Working Group to examine the extent of ship strikes and possible mitigation measures. Since then, one ship strike of a sub-adult humpback whale has been reported from the Region (IWC 2007b). Worldwide, fin whales are killed by ship strike more than any other species (Laist *et al*. 2001), probably because of their surface-feeding behaviour. The coastal nearshore distribution of Australian snubfin dolphins and Indo-Pacific humpback dolphins also makes these species extremely vulnerable to interactions with vessel traffic.

Marine debris

The injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris is listed as a key threatening process under the EPBC Act. Entanglement in marine debris such as discarded fishing gear can lead to restricted mobility, starvation, infection, amputation, drowning and smothering. The ingestion of plastic and other marine debris can cause physical blockages leading to starvation, or injuries to the digestive systems of cetaceans leading to infection or death. Cuvier's beaked whales are thought to be particularly susceptible to ingestion of anthropogenic marine debris because of their suction foraging technique. Outside of the Region, an autopsy on a stranded Bryde's whale found almost 6 m^2 of plastic in the whale's stomach (more information is at <www.environment.gov.au/coasts/publications/cetacean-poster.html>).

The Australian Government is currently developing a threat abatement plan that aims to minimise the impacts of marine debris on threatened marine species. Further information on the impacts of marine debris on threatened species is available at <www.environment.gov.au/biodiversity/threatened/publications/marine-debris.html>.

Water pollution

Toxic contaminants such as heavy metals and synthetic compounds (e.g. organochlorines) may enter the marine environment through soil erosion and agricultural and industrial run-off. Organochlorines are commonly used in insecticides and, while usually only found at very low concentrations in seawater, they can accumulate up the food chain to toxic levels (EA 2002). Organochlorines are soluble in fat and heavy doses may be passed to offspring through mothers' milk. Concentrations of organochlorines and other toxic contaminants have been found in marine mammals throughout the world, including sperm whales off Tasmania and dolphins off South Australia (Evans *et al*. 2004; Correll *et al*. 2004). It is thought that organochlorines and other toxins may have deleterious effects on the immune, endocrine and nervous systems of cetaceans and may contribute to mass mortality events and strandings. Species with an inshore distribution such as Australian snubfin dolphins and Indo-Pacific humpback dolphins may be particularly vulnerable to changes in water quality.

Climate change

The long-term effects of global warming on marine species are still speculative, however it is predicted that both habitat and food availability will be affected by increasing ocean temperatures, changing ocean currents, rising sea levels and reductions in sea ice. Such changes may affect current migration routes, feeding areas and calving grounds, rendering current habitat unsuitable. Similarly, changes to climate and oceanographic processes may lead to decreased biological productivity and different patterns of prey distribution and availability (DEH 2005).

Threats to cetaceans listed as endangered or vulnerable are addressed in the objectives of the *Recovery Plans for Australia's Threatened Whales* (DEH 2005). The objectives of the recovery plans are:

- the recovery of populations of whales utilising Australian waters so that each of the five species can be considered secure in the wild;
- a distribution of each species of whale in Australian waters that is similar to the pre-exploitation distribution; and
- to maintain the protection of each species of whale from human threats.

To achieve these objectives, the recovery plans recommend the implementation of programs to measure population abundance and trends; to better define the characteristics of calving, feeding and migratory areas; to manage and monitor threats to important habitat and prey availability; and to monitor climate and oceanographic change. More information on the recovery plans for humpback, blue, fin and sei whales can be found at <www.environment.gov.au/coasts/species/cetaceans/protecting.html#plans>.

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