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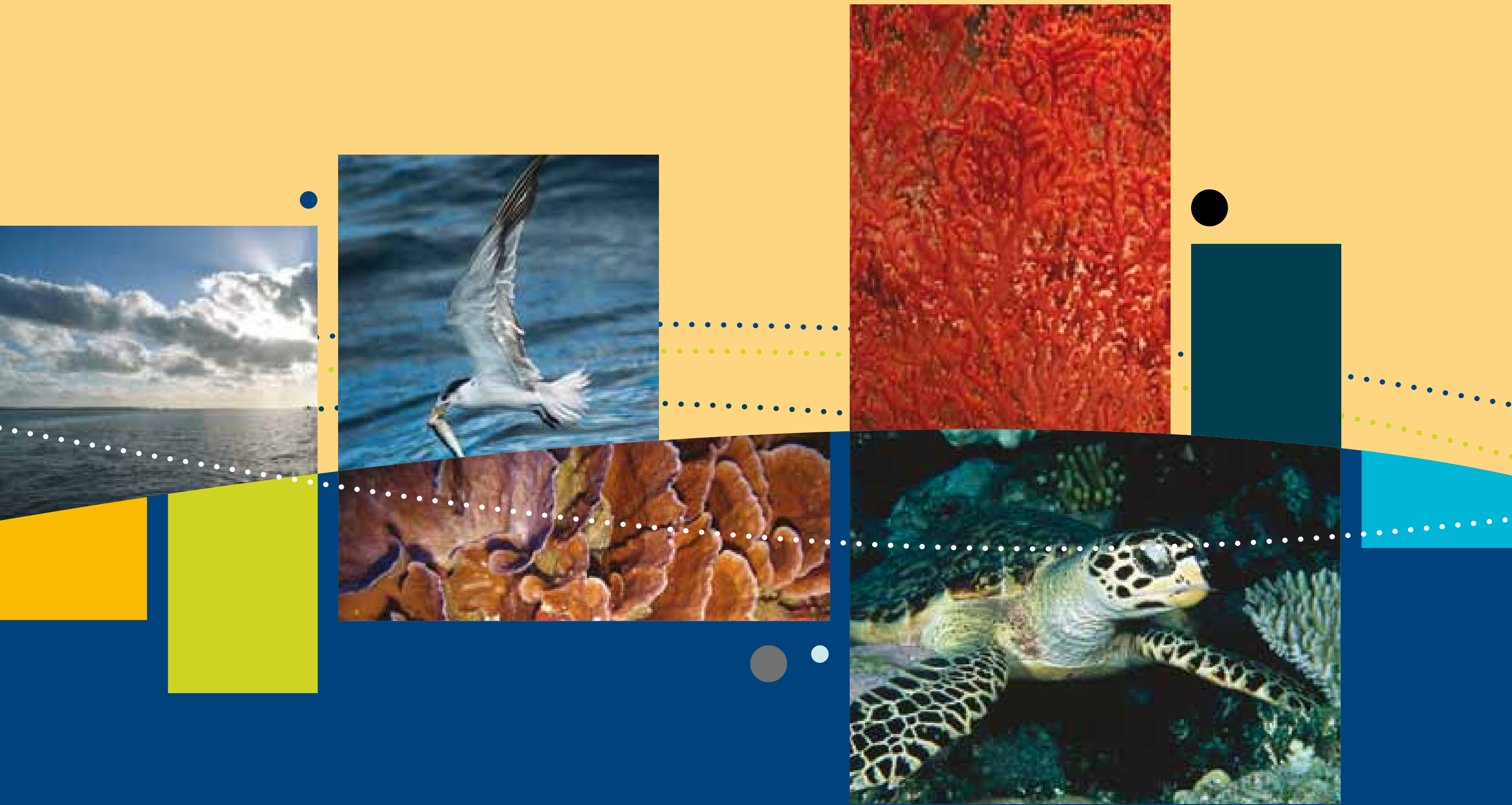

Species group report card – marine reptiles

Supporting the marine bioregional plan for the North Marine Region

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

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

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SPECIES GROUP REPORT CARD – MARINE REPTILES

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

Report cards

The primary objective of the report cards is to provide accessible information on the conservation values found in Commonwealth marine regions. This information is maintained by the Department of Sustainability, Environment, Water, Population and Communities and is available online through the department's website (**www.environment.gov.au**). A glossary of terms relevant to marine bioregional planning is located at **www.environment.gov.au/marineplans**.

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

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

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

Species group report cards

Species group report cards are prepared for large taxonomic groups that include species identified as conservation values in a region; that is, species that are listed under Part 13 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and live in the Commonwealth marine area for all or part of their lifecycle. All listed threatened, migratory and marine species and all cetaceans occurring in Commonwealth waters are protected under the EPBC Act and are identified in the relevant marine bioregional plans as conservation values.

Species group report cards focus on species for which the region is important from a conservation perspective; for example, species of which a significant proportion of the population or an important life stage occurs in the region's waters.

For these species, the report cards:

- outline the conservation status of the species and the current state of knowledge about its ecology in the region
- define biologically important areas; that is, areas where aggregations of individuals of a species display biologically important behaviours
- assess the level of concern in relation to different pressures.

1. Marine reptiles of the North Marine Region

The North Marine Region is an important area for several species of marine reptiles, including marine turtles, sea snakes and saltwater crocodiles.

Six of the seven species of marine turtle in the world are known to inhabit Australian waters, and all six of these species are known to occur in the North Marine Region. All six species of marine turtle are listed under the EPBC Act as vulnerable or endangered, migratory and marine species. Important breeding, nesting and feeding areas for marine turtles are found throughout and adjacent to the region. The region supports globally significant breeding populations of green turtle, hawksbill turtle and flatback turtle. Large immature and adult-sized loggerhead turtles from eastern and western Australian populations are known to forage in the eastern Arafura Sea, the Gulf of Carpentaria and the Torres Strait (Limpus 2009), and have been sighted in Northern Territory coastal waters from Fog Bay to north-east Arnhem Land (Chatto 1998). There are also two significant nesting aggregations of olive ridley turtles adjacent to the region: north-west Arnhem Land (including Melville Island, Bathurst Island, Cobourg Peninsula, the McCluer Island group and Grant Island), and north-east Arnhem Land (including the Sir Edward Pellew Group, the Wessel Islands and Crocodile Islands) (Chatto 1998; Limpus & Miller 2000). Leatherback turtles have also been recorded nesting on the Cobourg Peninsula (Chatto & Baker 2008).

Of the 35 species of sea snake (including sea kraits) known to inhabit Australian waters, 19 species are known to occur in the North Marine Region; a further nine species may occur in the region. All sea snakes are listed under section 248 of the EPBC Act as protected marine species.

The saltwater (or estuarine) crocodile has a tropical distribution that extends across the northern coastline of Australia, where it can be found in coastal waters, estuaries, freshwater lakes, inland swamps and marshes, as well as far out to sea (Webb et al. 1987). High densities of saltwater crocodiles are found adjacent to the North Marine Region in the river systems of Kakadu and the Mary River, and throughout the Gulf of Carpentaria. The saltwater crocodile is listed under section 248 of the EPBC Act as a protected migratory and marine species.

Of the listed reptiles known to occur and observed to infrequently occur in the North Marine Region, this report card focuses on the saltwater crocodile, and the six species of marine turtle and the 19 species of sea snake known to occur in the region. These species were selected following consideration of their conservation status; distribution and population structure in the region; life history characteristics; and the potential for the populations in the region to be genetically distinct from populations elsewhere.

Flatback turtle

Flatback turtles (*Natator depressus*) are endemic to the northern Australian – southern New Guinea continental shelf, with all breeding occurring on Australian beaches (Limpus et al. 1988). There is a low level of genetic variation within the flatback turtle population (compared to other marine turtle species), and limited gene flow between rookeries has been reported (Dutton et al. 2002). At least four separate stocks are recognised in the continuum of flatback turtle nesting from Exmouth Gulf in Western Australia to south-east Queensland (Dutton et al. 2002; Limpus 2009): the eastern Queensland stock; the Gulf of Carpentaria stock; the western Northern Territory stock and the Western Australia stock (Dutton et al. 2002; Limpus et al. 1993).

Flatback turtles differ from other species of marine turtle in that post-hatchlings do not go through an oceanic dispersal but are believed to follow a surface-water-dwelling life over the continental shelf and remain within pelagic habitats (Limpus et al. 1994a; Walker 1994). A substantial number of medium and high density nesting sites of flatback turtles exist along the Northern Territory coastline (Chatto 1998), north-eastern Gulf of Carpentaria and western Torres Strait.

Flatback turtles forage over soft-bottom habitats across the northern Australian continental shelf and as far north as New Guinea and Indonesia (Limpus 2009). They prefer inshore waters and bays where their feeding ground is the shallow, soft-bottomed seabed, away from reefs (DSEWPaC 2011a). Post-hatchling diet consists mainly of macroplankton, gastropods, siphonophores, pelecypods and cuttlefish. Immature adult and a dult flatback turtles eat mainly sea cucumbers, sea-pens, cuttlefish and jellyfish (Limpus 2009).

Green turtle

The North Marine Region supports at least two genetic breeding stocks of green turtle (*Chelonia mydas*), the Gulf of Carpentaria breeding unit and the north Great Barrier Reef breeding unit (Limpus & Chatto 2004; Limpus 2009). The Gulf of Carpentaria supports two main green turtle rookeries: one in the Wellesley Group (Bountiful Island, and Pisonia and Rocky islands), and one in the eastern Arnhem Land, Groote Eylandt and Sir Edward Pellew Islands area. Low density green turtle nesting also occurs in northern and western Arnhem Land and adjacent islands (Chatto 1998; Hope & Smit 1998; Limpus & Preece 1992). In the Gulf of Carpentaria, nesting occurs year round with a mid-winter peak (Limpus 1995).

It appears that all foraging areas linked to the Northern Territory breeding assemblage lie within the Gulf of Carpentaria (Limpus 2009). For example, research undertaken by the Dhimurru Land Management Aboriginal Corporation in Nhulunbuy, in which turtles were fitted with satellite tracking devices, indicates that most (and possibly all) of the green turtles that nest in north-east Arnhem Land remain in the gulf to feed (Kennett et al. 1998).

Post-hatchling and juvenile green turtles with shell sizes up to 30 centimetres in length are pelagic, drifting on the surface of the water, and are usually associated with driftlines and floating sargassum rafts. When their shells are around 30–40 centimetres in length they move to shallow benthic foraging habitats such as coral and rocky reefs, seagrass beds and algal mats, where they feed primarily on seagrass and algae. Adult green turtles will occasionally eat other items including mangroves (Forbes 1994; Limpus & Limpus 2000; Pendoley & Fitzpatrick 1999), fish-egg cases (Forbes 1994), jellyfish (Limpus et al. 1994b) and sponges (Whiting 2000). Young turtles tend to be more carnivorous than adults (Brand-Gardner et al. 1999; Cogger 2000; Whiting 2000). During their pelagic phase, young green turtles also eat plankton (Cogger 2000).

Hawksbill turtle

Australia's hawksbill turtle (*Eretmochelys imbricata*) is considered to comprise two distinct genetic stocks, one in the north-east of Australia and the other in Western Australia (Limpus 2009). Due to significant differences in the timing of the breeding season across the north-eastern stock, it is considered as two subpopulations for the purposes of management on the basis that interbreeding is highly unlikely (Limpus 2009). These are two of the largest remaining nesting populations of hawksbill turtle in the world (Limpus & Miller 2000). Australian stocks of hawksbill turtles are genetically different from those that breed in neighbouring countries such as Solomon Islands and Malaysia (Moritz et al. 2002). The breeding stock that nests adjacent to the North Marine Region at Arnhem Land is associated with the rookeries of the Torres Strait and the northern Great Barrier Reef (Limpus 2009). Other rookeries near the North Marine Region include Torres Strait and the mainland coast of western Cape York Peninsula north of Cotterell River, and four main sites in Arnhem Land (outer islands of the English Company Islands area; and north-east, north-west and south-east areas of Groote Eylandt). Groote Eylandt is the most significant area for hawksbill turtle nesting in the Northern Territory. Hawksbill turtles breed throughout the year but the peak nesting period in north-eastern Arnhem Land is in winter and early spring (approximately July to October) (Gow 1981; Limpus & Preece 1992; Limpus et al. 2000).

Hawksbill turtle post-hatchlings are believed to follow an oceanic, surface-water-dwelling, pelagic life, although the distribution and biology of this age class is poorly understood in Australian waters (Limpus 2009). Young turtles (with shell sizes around 35 centimetres in length) settle in feeding areas on the continental shelf, foraging in rocky and coral reefs, primarily feeding on sponges and algae (Whiting 2000). They have also been found, less frequently, in seagrass habitats of coastal waters, as well as the deeper habitats of trawl fisheries (Poiner & Harris 1996; Robins et al. 2002). Recovery of flipper tags suggests that hawksbill turtles are highly migratory, as animals tagged in the northern Great Barrier Reef have been recaptured in foraging areas in the southern Gulf of Carpentaria, south-eastern Indonesia and southern Papua New Guinea (Limpus 2009). The species is highly migratory, moving up to 2400 kilometres between foraging areas and nesting beaches (DSEWPaC 2011b). Hawksbill turtles are omnivorous, eating a variety of animals and plants including sponges, hydroids, cephalopods (octopus and squid), gastropods (marine snails), cnidarians (jellyfish), seagrass and algae (Carr & Stancyk 1975; Whiting 2000). During their pelagic phase (while drifting on ocean currents), young hawksbill turtles eat plankton (Meylan 1984). Marine turtles exhibit strong fidelity to foraging areas and nesting beaches.

Leatherback turtle

No major breeding sites of leatherback turtles (*Dermochelys coriacea*) have been recorded in Australia (Limpus 2009); however, scattered nesting occurs adjacent to the North Marine Region along the coast of Arnhem Land. For example, low numbers of nesting females have been recorded at Cobourg Peninsula in north-west Arnhem Land (Chatto & Baker 2008), with breeding occurring mostly during December and January. Leatherback turtles were sighted on the Queensland coast of the Gulf of Carpentaria in 1997, along with nesting tracks observed that were possibly made by leatherbacks. Leatherback turtles are occasionally observed on the continental shelf in the Gulf of Carpentaria and near Cobourg Peninsula. It is thought that most leatherback turtles found in Australian waters have migrated from nesting areas elsewhere to feed in the tropical waters of northern Australia (Limpus 1995).

Leatherback turtles are the largest of all marine turtles, weighing up to 500 kilograms and with shells averaging 1.6 metres in length (Limpus et al. 1994a). Their large body size, high metabolism, thick fatty tissue layer and ability to regulate blood flows allows them to use cold water foraging areas (DEWR 2007). This species is primarily pelagic in both the juvenile and adult phases of its life history. Small juveniles seem to 'disappear' for several years but may concentrate around upwellings where food sources are abundant. Large juveniles and adult turtles are found in both pelagic and coastal waters from tropical to cold temperate areas. Foraging occurs throughout the water column, from close to the surface to depths of more than 1200 metres (Gulko & Eckert 2004). Leatherback turtles are carnivorous and feed extensively on colonial tunicates, jellyfish and other soft-bodied invertebrates (Bone 1998; Limpus 1984; Limpus & McLachlan 1979). Leatherback turtles are able to dive comparatively deeply due to a flexible carapace (top shell) and plastron (bottom shell) that are made of cartilage embedded with miniature bones and that resist cracking under pressure, as well as the ability to retain large amounts of oxygen in their blood and muscles (Gulko & Eckert 2004).

Loggerhead turtle

Loggerhead turtles (*Caretta caretta*) are found in the North Marine Region; however, evidence suggests they do not breed in the region or in areas adjacent to the region. Large immature and adult-sized loggerhead turtles from eastern Australian populations are known to forage in the eastern Arafura Sea, the Gulf of Carpentaria and the Torres Strait (Limpus 2009), and have been sighted in Northern Territory coastal waters from Fog Bay to north-east Arnhem Land (Chatto 1998). Loggerhead turtles have also been sighted foraging within the Sir Edward Pellew Group in the south-west corner of the Gulf of Carpentaria (DEWHA 2008). Loggerhead turtle populations from Western Australia are thought to migrate to north-east Arnhem Land and share foraging areas with eastern populations of the species (Limpus 2009).

Loggerhead turtles enter benthic foraging habitats at a larger size than other marine turtles (except for the leatherback turtle). Adults and large juveniles with shell sizes of more than 70 centimetres in length inhabit environments with both hard and soft substrates, including rocky and coral reefs, muddy bays, sand flats, estuaries and seagrass meadows. Loggerheads are carnivorous, feeding primarily on benthic invertebrates in near shore waters to depths of 55 metres. Loggerhead turtles may dig within the substrate, pick items off the substrate or pluck items from the water column. In their juvenile stage, they feed on algae, pelagic crustaceans and molluscs and have also been recorded ingesting flotsam and anthropogenic debris.

Olive ridley turtle

In terms of numbers of annual breeding individuals, olive ridley turtles (*Lepidochelys olivacea*) are the most abundant marine turtle species globally but one of the least abundant in Australian waters. Genetic diversity of olive ridley turtles that breed in Australia has not yet been determined. However, it is believed that nesting stock(s) of olive ridley turtles from Australia are genetically different from stocks in Malaysia, India and the eastern Pacific (Bowen et al. 1998; Dutton et al. 2002).

There are two main nesting aggregations adjacent to the region: north-west Arnhem Land (including Melville Island, Bathurst Island, Cobourg Peninsula, McCluer Island group and Grant Island), and north-east Arnhem Land (including the English Pellew Group, Wessel Islands and Crocodile Islands) (Chatto 1998; DEWHA 2008; Limpus & Miller 2000; Limpus 2009). Australia's nesting population is 500–1000 females annually; most nest in north-west Arnhem Land (DSEWPaC 2011c). Nesting is also known to occur in the Gulf of Carpentaria at Crab Island, Edward River, north of Weipa, in the mouth of the Scrutten River and the Wellesley Islands. Olive ridley turtles nest year round, although most nesting occurs during the dry season from April to November (Chatto 1998; Cogger & Lindner 1969; Guinea 1990; Limpus & Preece 1992). Olive ridley turtles have been sighted foraging in the Joseph Bonaparte Gulf; in Arnhem Land in the north-west (including Cobourg Peninsula, Melville Island and Bathurst Island) and north-east (Wessel Islands); and in the Gulf of Carpentaria, from Blue Mud Bay to Mornington Island.

Olive ridley turtle hatchlings are among the smallest marine turtle hatchlings in Australia (Limpus 2009). There are currently no data on the distribution and diet of post-hatchling olive ridley turtles in the Australian region, but post-hatchlings are thought to drift in offshore continental shelf and oceanic surface waters, feeding on plankton (Bolten 2003). Immature and adult olive ridley turtles are carnivorous, feeding principally on gastropod molluscs and small crabs (Limpus 2009). Australian populations of olive ridley turtles spend a substantial part of their immature and adult lives foraging over benthic habitats of the continental shelf. This is in contrast to the eastern Pacific Ocean olive ridley turtle populations that spend their entire post-hatchling, immature adult and adult phases occupying oceanic pelagic waters. Studies of migration behaviour of adult olive ridley turtles in the Northern Territory reveal that after nesting, olive ridley turtles utilise various foraging areas including coastal, continental shelf and continental slope habitats and have been recorded migrating up to 1050 kilometres from nesting beaches (Whiting et al. 2007). Olive ridley turtles nesting on the same beach can use different foraging areas and are often widely spread from nesting beaches (McMahon et al. 2007; Whiting et al. 2007).

Sea snakes

Most of our knowledge of sea snakes in the North Marine Region comes from trawler bycatch. Of the 19 species known to occur in the North Marine Region, detailed information is available for only six species. These data have provided most of the information on sea snake species diversity, abundance and distribution. The few studies independent of trawling data indicate much is to be learned about sea snake species and their distribution. Porter et al. (1997) found that several species inhabit the bays and estuaries adjacent to the North Marine Region. Observational surveys of surface waters (Limpus 2001) have revealed a healthy and previously unreported population of the surface-dwelling yellow-bellied seasnake (Pelamis platurus). This species is not reported in trawl bycatch.

Trawl data show that the four most commonly encountered species in the bycatch of the Northern Prawn Fishery are olive-headed seasnake (*Disteira major*), elegant seasnake (*Hydrophis elegans*), ornate seasnake (*Hydrophis ornatus*) and spine-bellied seasnake (*Lapemis curtus*) (Fry et al. 2001). These species feed on several species of fish that are associated with areas of open sand in the trawl fields, making them vulnerable to capture. Feeding, in general, occurs during the day when trawlers are active. Females of these species usually outnumber males in the trawl bycatch because they are larger, swim more slowly and possibly prefer the shallower areas of the Gulf of Carpentaria. These sea snakes, like females of the other true sea snakes (family Hydrophiidae), give birth to live young at sea. Breeding occurs during the summer months. A fifth common species, spine-tailed seasnake (*Aipysurus eydouxii*), breeds during the winter months, which coincides with the trawl season. Female sea snakes in the North Marine Region typically take several years to reach reproductive maturity, have few young, but may breed every year (Heatwole 1997). Research trawls indicate the sea snakes move to the southern shallow regions of the Gulf of Carpentaria in the summer months and into deeper water at other times of the year (Redfield et al. 1978). The small amount of ecological data available indicates that sea snakes in the North Marine Region breed in shallow embayments and estuaries along the Queensland and Northern Territory coastlines (Guinea et al. 2004; Redfield et al. 1978).

Saltwater crocodile

The saltwater (or estuarine) crocodile (*Crocodylus porosus*), a member of the *Crocodylidae* family, is the largest species of crocodilian and the largest living reptile on the planet today (Webb et al. 1987). Estimated to live up to 70 years of age, adult males are on average 5 metres long and weigh 450 kilograms, although they can grow up to 8 metres long and weigh more than 1000 kilograms. Females average 3 metres in length and up to 150 kilograms in weight (DSEWPaC 2011d; Webb et al. 1984).

The saltwater crocodile has a tropical distribution that extends to northern Australia, where it currently inhabits coastal areas ranging from Broome in north-west Western Australia, across the Northern Territory, and down the east coast of Queensland to Rockhampton (Webb & Manolis 1989). Saltwater crocodiles can be found in tidal rivers, coastal floodplains and channels, billabongs, swamps up to 150 kilometres inland from the coast, as well as far out to sea (Webb et al. 1987). High densities of saltwater crocodile are found in and adjacent to the North Marine Region, primarily in the Mary River and other river systems throughout Kakadu and the Gulf of Carpentaria (Fukuda et al. 2007).

Studies in Arnhem Land found that saltwater crocodiles nest during the wet season from November to May, with a peak in nesting during January and February (Webb & Manolis 1989). Courtship typically occurs 4–6 weeks before nesting and continues throughout the nesting period (Webb et al. 1987). Preferred nesting habitat includes elevated, isolated freshwater swamps that do not have the influence of tidal movements (Webb et al. 1987). Floating rafts of vegetation also provide important nesting habitat in some areas such as the Finniss River, Northern Territory (Webb et al. 1987).

As opportunistic predators, saltwater crocodiles both actively hunt their prey and employ a sit-and-wait strategy (Cooper & Jenkins 1993). Immature saltwater crocodiles (measuring less than 180 centimetres in length) eat crustaceans, insects, lizards, snakes, fish, birds and mammals, although their diet varies between seasons and depending on their body size (Taylor 1979). Larger crocodiles (measuring more than 2 metres in length) are opportunistic feeders whose diet can include mud crabs, birds, sea turtles, fish, flying foxes, dingoes, cats, dogs, pigs, buffalo, cattle, horses and humans (Webb & Manolis 1989). Rocks and stones ingested by crocodiles may function as gastroliths and aid digestion, as well as serving other functions such as ballast (Webb & Manolis 1989).

Biologically important areas

Biologically important areas are areas that are particularly important for the conservation of the protected species and where aggregations of individuals display biologically important behaviour such as breeding, foraging, resting or migration. The presence of the observed behaviour is assumed to indicate that the habitat required for the behaviour is also present. Biologically important areas have been identified for some EPBC Act listed species found in the North Marine Region, using expert scientific knowledge about species' distribution, abundance and behaviour in the region. The selection of species was informed by the availability of scientific information, the conservation status of listed species and the importance of the region for the species. The range of species for which biologically important areas are identified will continue to expand as reliable spatial and scientific information becomes available.

Biologically important areas have been identified for the flatback, green, hawksbill, leatherback and olive ridley turtle. Behaviours used to identify biologically important areas for marine turtles include internesting and foraging.

Biologically important areas have not yet been identified for the loggerhead turtle, sea snakes or saltwater crocodile in the North Marine Region.

Biologically important areas are included in the North Marine Region Conservation Values Atlas (**www.environment.gov.au/cva**).

2. Vulnerabilities and pressures

Vulnerabilities

Marine turtles

The life history characteristics of marine turtles, including long life spans and late sexual maturity, make them vulnerable to a range of pressures in the marine environment. Population modelling suggests that for species which are long-lived and slow growing, including marine turtles, high survival rates of large juveniles, subadults and adults are necessary for maintaining stable populations (Heppel et al. 2003). Marine turtles spend their life at sea, with females returning to beaches in their natal region to nest as adults (Chaloupka & Limpus 2001; FitzSimmons et al. 1997). While at sea marine turtles are vulnerable to impacts from marine debris as floating plastics can resemble prey items (DEWHA 2009).

During the breeding season females are vulnerable to land-based pressures due to limited mobility, and when they return to the sea, may become disoriented by artificial light sources if nesting sites are adjacent to urban or industrial areas. Hatchlings are also sensitive to light. Sea turtles have life history characteristics, physiology and behavioural traits that are heavily influenced by environmental temperature. This is particularly the case during the egg incubation phase (Spotila & Standora 1985) because successful incubation of sea turtle eggs occurs within a narrow thermal range of 25–33 °C (Miller 1985), and all species of marine turtle have temperature-dependent sex determination.

Due to the migratory nature of marine turtle species, pressures acting on marine turtles in the North Marine Region also have the potential to impact on marine turtle populations in adjacent marine regions.

Sea snakes

Sea snakes are vulnerable to human-induced pressures because of their presence in areas used by the commercial fishing industry in the North Marine Region. Typically sea snakes are slow growing and have few offspring. Larger snakes produce more young in a litter than smaller females that are early in their reproductive lives (Fry et al. 2001). Trawling, because of the mesh size of nets, captures the larger snakes that tend to be more fecund (Fry et al. 2001). The diet of most sea snakes in the region is usually restricted to just a few benthic fish species such as eels and gobies (Fry et al. 2001). This makes them more susceptible to changes in trophic structures compared to a few species, such as the spine-bellied seasnake, that feed on a wide range of benthic, demersal and pelagic species (Fry et al. 2001). Sea snakes are therefore vulnerable to human-induced pressures either through direct impacts, such as trawler bycatch, or through indirect impacts such as habitat destruction and disruption of the trophic structure.

Sea snakes are also vulnerable to oil pollution, as they are susceptible to oil on the sea surface and on the sea floor (AMSA 2010; Watson et al. 2009). Being air breathers and obligate bottom feeders, sea snakes can inhale or ingest oil, its residue and dispersants (Gagnon 2009). No oil spills have been reported to have occurred in the North Marine Region to date.

Sea snakes lack ears and rely on eyesight and vibrations through their body (Hibbard 1975) to identify approaching vessels. For this reason, and due to the high velocity of sound in water, sea snakes lack means of identifying the direction of approaching vessels, and therefore have a high potential for collisions with fast-moving vessels.

Saltwater Crocodile

Before 1970 the saltwater crocodile was hunted in an unsustainable manner, and populations in the Northern Territory declined to as little as 3000 individuals (DSEWPaC 2011d; Fukuda et al. 2007). The Northern Territory and Queensland governments ordered the killing of saltwater crocodiles to cease in 1971 and 1974 respectively. Saltwater crocodile populations in Australia were officially listed in Appendix 2 of the Convention on International Trade in Endangered Species (CITES) in 1975 (DSEWPaC 2011d; Fukuda et al. 2007; Read et al. 2004). As a result of these and other ongoing protection measures, the total Australian non-hatchling saltwater crocodile population has dramatically risen to approximately 100 000 to 200 000 individuals (Fukuda et al. 2007).

As with all crocodilian species, most pressures impacting on saltwater crocodiles, both direct and indirect, are anthropogenic in origin (Leach et al. 2009). In Australia, the primary pressures on saltwater crocodiles are incidental mortality in fishing nets and habitat destruction (Taplin 1987). However, recent internal Northern Territory Government Department of Regional Development, Primary Industries, Fisheries and Resources papers report that crocodile mortality due to drowning in fishing nets during 2007 and 2008 throughout northern Australia was less than 30 individuals (Leach et al. 2009).

Adult saltwater crocodiles have few natural predators apart from humans and other crocodiles (Webb & Manolis 1989). The species is most vulnerable to mortality at the egg stage, through nest flooding, and at the hatchling (less than 1 year old) stage, through predation (Webb & Manolis 1989). In Arnhem Land, feral buffalo (*Bubalis bubalis*) have destroyed wetland habitat by trampling, grazing and wallowing in mud, thereby increasing drainage and reducing vegetation crucial for nesting (Webb et al. 1984, 1987); however, there has been a reduction in buffalo numbers. Future climate change impacts, including increasing temperatures and rising sea levels, may also impact on nest success, with higher egg mortality; however, as with other crocodilian species, saltwater crocodiles are fairly adaptable and would most likely start nesting higher up or shift their range further south along the Queensland and Western Australian coastlines.

Analysis of pressures

On the basis of current information, pressures have been analysed for the 26 reptile species (six species of turtle, 19 species of sea snake and the saltwater crocodile) discussed in this report card. A summary of the pressure analysis for marine reptiles is provided in Table 1. Only those pressures identified as *of concern* or *of potential concern* are discussed in further detail below. An explanation of the pressure analysis process, including the definition of substantial impact used in this analysis, is provided in Part 3 and Section 1.1 of Schedule 1 of the plan.

Table 1: Outputs of the marine reptile species pressure analysis for the North Marine Region

Pressure	Source	Crocodiles: Saltwater crocodile	Marine turtles: Flatback turtle	Marine turtles: Green turtle	Marine turtles: Hawksbill turtle	Marine turtles: Leatherback turtle	Marine turtles: Loggerhead turtle	Marine turtles: Olive ridley turtle	Sea snakes: Beaked seasnake	Sea snakes: Black-headed seasnake	Sea snakes: Dubois's seasnake	Sea snakes: Dwarf seasnake	Sea snakes: Elegant seasnake
Sea level rise	Climate change	data deficient or not assessed	of potential concern	of potential concern	of potential concern	of potential concern	not of concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern
Changes in sea temperature	Climate change	data deficient or not assessed	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern
Changes in oceanography	Climate change	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Ocean acidification	Climate change	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern
Chemical pollution/ contaminants	Agricultural activities Urban development (urban and/ or industrial infrastructure)	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	not of concern	not of concern	not of concern	not of concern	not of concern
Nutrient pollution	Agricultural activities Urban development	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	not of concern	not of concern	not of concern	not of concern	not of concern
Marine debris	Land-based activities Fishing boats Shipping Vessels (other)	data deficient or not assessed	of concern	of concern	of concern	of concern	of potential concern	of concern	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Noise pollution	Seismic exploration	data deficient or not assessed	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Urban development	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Shipping Vessels (other)	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Onshore and offshore construction	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Light pollution	Onshore and offshore activities	not of concern	of potential concern	of potential concern	of potential concern	of less concern	of less concern	of potential concern	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Physical habitat modification	Dredging and/ or Dredge spoil	data deficient or not assessed	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern
	Offshore construction and installation of infrastructure	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	not of concern	not of concern	not of concern	not of concern	not of concern
	Onshore construction	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	not of concern	not of concern	not of concern	not of concern	not of concern
	Climate change (changes in storm frequency etc)	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Human presence at sensitive sites	Tourism Recreational and charter fishing (burleying) Research	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Extraction of living resources	Commercial fishing (domestic or non-domestic)	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	not of concern	not of concern	not of concern	not of concern	not of concern
	Indigenous harvest	of less concern	of potential concern	of potential concern	of potential concern	not of concern	of less concern	of potential concern	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Bycatch	Commercial fishing	of less concern	of potential concern	of less concern	of less concern	of less concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of concern
	Recreational and charter fishing	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Oil pollution	Shipping Vessels (other)	not of concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern
	Oil rigs	data deficient or not assessed	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern
Collision with vessels	Shipping Fishing Tourism	data deficient or not assessed	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern
Disease	Fishing Shipping Tourism	not of concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Invasive species	Land-based activities	of potential concern	of concern	of concern	of concern	of less concern	not of concern	of concern	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed

Legend: of concern (red); of potential concern (orange); of less concern (green); not of concern (grey); data deficient or not assessed (white)

Table 1 continued: Outputs of the marine reptile species pressure analysis for the North Marine Region

		Species													
		Sea snakes													
Pressure	Source	Fine-spined seasnake	Horned seasnake	Large-headed seasnake	Plain seasnake	Plain-banded seasnake	Olive seasnake	Olive-headed seasnake	Ornate seasnake	Small-headed seasnake	Spectacled seasnake	Spine-bellied seasnake	Spine-tailed seasnake	Stokes' seasnake	Yellow-bellied seasnake
Sea level rise	Climate change	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern
Changes in sea temperature	Climate change	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern
Changes in oceanography	Climate change	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Ocean acidification	Climate change	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern
Chemical pollution/ contaminants	Agricultural activities Urban development (urban and/ or industrial infrastructure)	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern
Nutrient pollution	Agricultural activities Urban development	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern
Marine debris	Land-based activities Fishing boats Shipping Vessels (other)	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Noise pollution	Seismic exploration	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Urban development	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Shipping Vessels (other)	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
	Onshore and offshore construction	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Light pollution	Onshore and offshore activities	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Physical habitat modification	Dredging and/ or Dredge spoil	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern	of potential concern
	Offshore construction and installation of infrastructure	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern
	Onshore construction	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern
	Climate change (changes in storm frequency etc)	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Human presence at sensitive sites	Tourism Recreational and charter fishing (burleying) Research	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Extraction of living resources	Commercial fishing (domestic or non-domestic)	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern
	Indigenous harvest	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Bycatch	Commercial fishing	of potential concern	of concern	of concern	of potential concern	of potential concern	of concern	of concern	of concern	of concern	of concern	of concern	of concern	of concern	of potential concern
	Recreational and charter fishing	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Oil pollution	Shipping Vessels (other)	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern
	Oil rigs	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern	not of concern
Collision with vessels	Shipping Fishing Tourism	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern	of less concern
Disease	Fishing Shipping Tourism	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed
Invasive species	Land-based activities	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed	data deficient or not assessed

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

Marine turtles

Sea level rise–climate change

Sea level rise is *of potential concern* for flatback, green, hawksbill, leatherback and olive ridley turtles. Global sea levels have risen by 20 cm between 1870 and 2004 and predictions estimate a further rise of 5–15 cm by 2030, relative to 1990 levels (Church et al. 2009). Longer term predictions estimate increases of 0.5 – 1.0 metre by 2100, relative to 2000 levels (Climate Commission 2011). As with many predicted impacts associated with climate change, it is difficult to predict exactly how this pressure will affect the North Marine Region. However, rates of sea level rise in the region generally appear to be moving in accordance with global predictions (Hyder Consulting 2008).

The implications of sea level rise for turtles are considerable. They include an increased risk of tidal inundation or destruction of turtle nests, an increased selection of suboptimal nesting zones, and an increased risk of nest destruction by other nesting turtles associated with higher nesting densities (Hamann et al. 2007 in Fuentes et al. 2009a; Poloczanska et al. 2010). Collectively these impacts have the potential to reduce a turtle population's reproductive success. For example, across the key rookeries used by the northern Great Barrier Reef green turtle population, a loss of up to 38 per cent of the available nesting area from inundation as a result of sea level rise has been predicted (Fuentes et al. 2010). Currently concerns exist regarding the impacts on several key turtle rookeries adjacent to the North Marine Region, including the rookeries on Raine Island and the Capricorn Bunker group (Fuentes et al. 2010).

It has also been suggested that sea level rise will impact on foraging by decreasing growth rates in benthic plants such as seagrasses, thus reducing foraging areas (Poloczanska et al. 2010). It is not expected that these impacts will be as immediate as those associated with inundation.

Changes in sea temperature–climate change

Changes in sea temperature are *of potential concern* for flatback, green, hawksbill, leatherback, loggerhead and olive ridley turtles. Sea temperatures have warmed by 0.7 °C between 1910–1929 and 1989–2008, and current projections estimate ocean temperatures will be 1 °C warmer by 2030 (Lough 2009). Increasing sea temperature have the potential to impact on marine turtles in a number of significant and varied ways, including by causing a shift in distribution that may either increase or decrease species range (Davenport 1997; Hawkes et al. 2009; Milton & Lutz 2003); alterations to life history characteristics, such as growth rates, age at maturity and reproductive periodicity (Balazs & Chaloupka 2004; Chaloupka & Limpus 2001; Hamann et al. 2007 in Fuentes et al. 2009a); and reduced prey availability (Chaloupka et al. 2008 in Fuentes et al. 2009a). For example, a negative correlation has been identified between the slowly increasing mean annual sea temperature in the core foraging areas for loggerhead turtles and the size of annual nesting populations during the following summer in eastern Australia (Chaloupka et al. 2008). In contrast, green turtle breeding has been positively linked to El Niño cycles, and warmer sea temperatures could have a positive effect on growth, breeding rates, and breeding frequency (Hamann et al. 2007). For all marine turtle species found in the North Marine Region these impacts can have serious repercussions, resulting in a range of population effects.

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

Marine debris is *of concern* for flatback, green, hawksbill, leatherback and olive ridley turtles and *of potential concern* for loggerhead turtles. Marine debris is defined as any persistent, manufactured or processed solid material that has been disposed of, or abandoned, in the marine and coastal environment (UNEP 2005). This includes a range of material from plastics (e.g. bags, bottles, ropes, fibreglass, insulation) to derelict fishing gear and ship-sourced, solid non-biodegradable floating materials (DEWHA 2009).

Marine turtles in the North Marine Region are vulnerable to ingestion of marine debris. The internal structure of marine turtles' throats prevents regurgitation of swallowed items, trapping items in the gut where they decompose, leaking gases into the body cavity and thereby causing the animal to float and ultimately die. White plastic debris (e.g. plastic bags) is of most concern to marine turtles as they mistake the debris for jellyfish, a key prey species (Derraik 2002). Young turtles are especially vulnerable, possibly because they drift within convergence zones (e.g. rips, fronts and drift lines formed by ocean currents) where high densities of marine debris are known to accumulate. In a recent study by Boyle and Limpus (2008), synthetic materials accounted for up to 46 per cent of total stomach content in green turtle post-hatchlings. Given that hatchlings are not able to compensate intake of non-nutritional items, such levels of ingestion of marine debris would result in reduced energy and nitrogen uptake. In addition to the direct impacts of plastic ingestion, research also indicates that toxins in the materials are being absorbed by marine turtles, with unknown but potentially adverse effects on their demography (Bjorndal et al. 1994).

Marine turtles in the North Marine Region are also vulnerable to entanglement and drowning in derelict fishing nets. Large amounts of derelict fishing net are washed up on beaches of Queensland, the Northern Territory and Gulf of Carpentaria (Limpus 2009). The number of marine turtles drowned in the Gulf of Carpentaria from ghost net entanglement is unquantified but appears to be many hundreds of turtles annually (Limpus 2009). Records indicate, since 1989, at least 1 122 marine turtles have been impacted by plastic debris in Australia either through entanglement or ingestion. Of these animals, 88.7 per cent (996) were entangled and 11.2 per cent (126) had ingested plastic debris (Ceccarelli 2009).

Noise pollution–seismic exploration

Noise pollution is assessed as *of potential concern* for flatback, green, hawksbill, leatherback, loggerhead and olive ridley turtles. Data are limited on the potential impacts of noise pollution on marine turtles. However, marine turtles can detect low frequency noise and are influenced by it. Green and loggerhead turtles have shown behavioural responses to tests on the effects of air gun seismic arrays used in seismic surveying (McCauley et al. 2000). While seismic surveys, which produce noise pollution in the water, are unlikely to cause the death of turtles, they may impact on the foraging, internesting, courting or mating behaviour of turtles. There are clear avoidance responses in all species at ranges of one to several kilometres; it is likely that the sounds are audible and may mask important communication or perceptual cues at much greater ranges (Cummings & Brandon 2004).

Light pollution–offshore activities

Light pollution from offshore activities is *of potential concern* for flatback, green, hawksbill and olive ridley turtles. Light pollution is defined as excessive or obtrusive artificial light that is distinct from natural light (Salmon 2003). For marine turtles, light pollution adjacent to nesting beaches is a particular issue as it causes alterations in critical nocturnal behaviours, such as the selection of nesting sites and the movement of adult females and emerging hatchlings from the beach to the sea (Limpus 2009). The impacts of these changes include a decrease in nesting success, beach avoidance by nesting females and disorientation leading to increased mortality due to predation, collision with vessels or vehicles, or dehydration (Limpus 2009; Lorne & Salmon 2007; Witherington & Martin 1996).

There are few existing light pollution issues in the North Marine Region; however, light pollution originating from offshore activities poses a potential threat to marine turtles. An emerging issue is light pollution originating from shipping, particularly in the Arafura Sea area where shipping routes are busy, and the volume of shipping traffic is likely to increase (Darwin Port Corporation 2010). Further issues arise when ships anchor, as anecdotal evidence suggests that hatchlings are drawn to the anchored vessels due to their lights, and become trapped along the hull and exposed to high levels of predation.

Extraction of living resources–Indigenous harvest

Indigenous harvest of marine turtles and/or their eggs is *of potential concern* for flatback, green, hawksbill and olive ridley turtles. The Indigenous harvest of marine turtles has occurred for millennia, with turtles being taken for their meat and to make a range of products that includes leather, cosmetics, jewellery and other ornaments (Limpus 2009). Indigenous harvest continues across the North Marine Region under provisions outlined in section 211 of the *Native Title Act* 1993, which preserves the right of native title holders to continue traditional hunting activities for personal, non-commercial purposes. Green turtles tend to be preferentially taken for meat, and eggs of most species are harvested. In two surveys of an 11 km beach at Nanydjaka, 87–95% of eggs laid by all four marine turtle species in that area were taken (Limpus 2009).

There are no data on the levels of marine turtle harvest across northern Australia (Limpus 2009), but it is likely that marine turtle harvest varies widely across communities and geographic areas adjacent to the region.

Bycatch–commercial fishing (domestic)

Incidental capture as bycatch in domestic commercial fisheries is *of potential concern* for flatback, loggerhead and olive ridley turtles. Globally, bycatch of turtles is considered to be one of the most significant threats to their ongoing survival (Lewison et al. 2004). Records from other regions of Australia indicate that all six marine turtle species are caught as bycatch (Chaloupka & Limpus 2001; Limpus 2009). Bycatch interactions typically result in the death of individuals from drowning.

Turtles are particularly vulnerable to trawl, gillnet and longline fishing gear. All three gear types are used across the North Marine Region, thus exposing northern Australian turtle populations to a high level of bycatch risk. In the past decade the introduction of turtle excluder devices in several key trawl fisheries has resulted in a significant reduction of bycatch levels. Monitoring programs are beginning to see the outcomes of this management strategy, with reports indicating a marked improvement in affected turtle populations (DoF 2007).

Invasive species–land-based activities

Invasive species are *of concern* for flatback, green, hawksbill and olive ridley turtles. An invasive species is one occurring beyond its accepted normal distribution as a result of human activities, and which threatens valued environmental, agricultural or other social resources. Egg predation by invasive species is a significant issue for marine turtle populations. Of particular concern to populations in the North Marine Region is egg predation by feral pigs and dogs, which could potentially have significant adverse impacts on marine turtle stocks, as it has in the East Marine Region and North-west Marine Region on loggerhead turtles (Limpus & Limpus 2003; Limpus & Parmeter 1985; Tisdell et al. 2004). Pigs destroy up to 90 per cent of marine turtle nests on western Cape York (Limpus et al. 1993). Uncontrolled predation, particularly by feral pigs, is therefore a significant issue for marine turtles in the North Marine Region, especially in the western Cape York Peninsula area.

Sea snakes

Changes in sea temperature–climate change

Changes in sea temperature are assessed as *of potential concern* for sea snakes. True sea snakes depend on water temperature for their body heat (Guinea 1995; Heatwole 1981). Even dark-coloured sea snakes can only raise their body temperature by about 3 °C by basking on the sea surface. However, little is known of the thermal requirements and tolerances of sea snakes and how increased temperatures will affect their behaviour and ecology (Hamann et al. 2007). In tropical reef habitats surface waters approach the maximum tolerance temperature (36 °C) for sea snakes (Dunson & Ehlert 1971; Graham et al. 1971; Heatwole 1981). Cooler oceanic water remains a few metres below. These daily thermoclines are predicted to deepen as water bodies warm and the shallow waters of the North Marine Region potentially become excessively heated throughout the water column. There is little information on the thermal sensitivity and tolerances of any sea snake species in the wild and their response to such changes in sea temperature. Predicted changes are thought to affect the availability of their food species and alter their seasonal movements for either breeding or feeding (Fuentes et al. 2009b; Hamann et al. 2007).

Ocean acidification–climate change

Ocean acidification is assessed as of potential concern for sea snakes. Driven by increasing levels of atmospheric CO_2 and subsequent chemical changes in the ocean, acidification is already underway and detectible. Since pre-industrial times, acidification has lowered ocean pH by 0.1 pH units (Howard et al. 2009). Furthermore, climate models predict this trend will continue, with a further 0.2–0.3 unit decline by 2100 (Howard et al. 2009).The effects of ocean acidification on sea snakes are unknown. Such a change in sea water chemistry may lead to metabolic changes in young and adult sea snakes, and trophic changes associated with the availability of food species and their habitats. However, without further data any predicted changes remain unknown (Hamann et al. 2007).

Physical habitat modification–dredging

Physical habitat modification from dredging is assessed as *of potential concern* for sea snakes. At the local and regional level, physical habitat modification associated with dredging for port construction and maintenance is *of potential concern* for sea snakes in the North Marine Region. The development that exists along the shores adjacent to the North Marine Region is associated with port infrastructure for transporting minerals by ship, and for delivering supplies to mines and small communities. Dredging the sea floor is required during the construction of ports and any subsequent maintenance of shipping or barge channels.

No data are available on the impact of these activities on sea snakes in the North Marine Region. However, potential impacts include physical entrainment in equipment, removal of habitat of prey species, increased turbidity impacting on species that rely on vision for feeding, and the covering of foraging habitat with dredge spoil. Data on sea snakes from elsewhere indicate that, once removed from an area, sea snakes will take a considerable time to recolonise the area, if they do so at all (Burns & Heatwole 1998; Lukoschek et al. 2007).

Bycatch–commercial fishing (domestic)

Bycatch from commercial fishing is assessed as *of concern* for 11 sea snake species and *of potential concern* for 8 sea snakes species (see Table 1 for more details). This pressure is associated with commercial fishing activities in trawl fisheries, and particularly in the Northern Prawn Fishery (Redfield et al. 1978; Ward 2000; Wassenberg et al. 1994). In 2009, 7369 sea snakes were reported in logbook records as caught in the Northern Prawn Fishery (Wilson et al. 2010). Being air breathers, sea snakes need to surface at least every 20 minutes or so when actively foraging (Heatwole 1999). As a consequence, many more survive being captured in trawl nets when the tow time is short (Heales et al. 2008). Openings in the top of the nets are successful in reducing the bycatch of sea snakes (Milton 2001; Milton et al. 2009). Such bycatch reduction devices also reduce the amount of non-target species caught in the net and prevent crushing of sea snakes among the catch. Closures of inshore areas, seagrass habitats and embayments such as Caledon Bay, Blue Mud Bay, Bickerton Island, five bays on Groote Eylandt, areas south of Vanderlin Island and south of the Wellesley Islands, and Arnhem Bay (AFMA 1998) have reduced the impact on some sea snake species. Pressure on sea snakes by commercial fishing has also been reduced through technological innovations such as bycatch reduction devices which, if adopted and installed appropriately, reduce the mortality of captured sea snakes by 50 per cent (Heales et al. 2008; Milton et al. 2009).

Saltwater crocodile

Invasive species–land-based activities

Invasive species are *of potential concern* for the saltwater crocodile. In Arnhem Land, feral animals such as buffalo can destroy wetland habitat by increasing drainage and reducing vegetation (Webb et al. 1984, 1987). Since the 1970s, disturbance of floodplain habitats by feral buffalo has been greatly reduced following eradication campaigns, with a resultant improvement in nesting habitat for crocodiles (Leach et al. 2009). However, more recently it has been reported that there are increasing numbers of buffalo and pig, which have the potential to negatively impact on nesting vegetation (Leach et al. 2009). There is also anecdotal evidence that saltwater crocodile habitat is affected by the invasion of freshwater wetlands by introduced plants such as *Mimosa pigra,* which can reduce the availability of nesting habitat (Leach et al. 2009). As a combined consequence of this invasive plant species and several feral animal pressures, crocodile habitat and available nesting areas may be reduced, thereby potentially impacting on the population.

3. Relevant protection measures

The six species of marine turtle are listed as vulnerable or endangered, migratory and marine species under the EPBC Act. The management of marine turtles is difficult because of their complex ecology. For example, the size and status of marine turtle populations is difficult to quantify because most of their lives are spent in the marine environment; hatchlings disperse throughout entire oceans; individuals follow their own migratory path; they are highly migratory, crossing domestic and international boundaries; only females return to their natal beach to nest; and not all females nest each year. Additionally, they are long-lived and slow to mature, they occupy different habitats at different stages of their life, and are subject to a wide range of impacts at different life stages.

All species of sea snake are listed under section 248 of the EPBC Act as marine species. When within state or Northern Territory waters, the species are also protected under relevant state and territory wildlife protection acts.

The saltwater crocodile is listed under section 248 of the EPBC Act as a protected migratory and marine species. It is also listed on Appendix I of CITES in all countries other than Australia, Papua New Guinea and Indonesia, where it is listed on Appendix II (Ross 1998). The Australian population of the species was transferred to Appendix II in 1985 following a proposal (Webb et al. 1984) to pursue sustainable use through ranching, which aims to save wild populations and their habitat by placing a commercial value on wild stocks (Webb & Vardon 1996). In 1994 the Australian population was given an unqualified Appendix II listing under CITES to allow the incentive-driven conservation program to extend beyond ranching to limited wild harvest.

Under the Act it is generally an offence to kill, injure, take, trade, keep or move listed marine, migratory or threatened species on Australian Government land or in Commonwealth waters without a permit.

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

EPBC Act conservation plans and action plans

- Recovery plan for marine turtles in Australia (Environment Australia 2003)
- Threat abatement plan for the impacts of marine debris on vertebrate marine life (DEWHA 2009).

International measures

Australia is a signatory to the following international agreements for the conservation of marine reptiles:

- Convention on International Trade in Endangered Species of Wild Fauna and Flora 1975 (CITES)—**www.cites.org**
- The Bonn Convention: Conservation of Migratory Species (CMS)—**www.cms.int**
- Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA MoU) —**www.ioseaturtles.org/**

For more information on conservation listings under the EPBC Act, and related management objectives and protection measures, visit:

- **www.environment.gov.au/epbc/protect/species-communities.html** (listed threatened species)
- **www.environment.gov.au/epbc/protect/migratory.html** (listed migratory species)
- **www.environment.gov.au/coasts/species/marine-species-list.html** (listed marine species)
- **www.environment.gov.au/cgi-bin/sprat/public/sprat.pl** (species profile and threats database)

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ATTACHMENT 1: MARINE REPTILE SPECIES OCCURRING IN THE NORTH MARINE REGION

Table A1: Marine reptile species known to occur in the North Marine Region

Species (common name/ scientific name)	Conservation status
Crocodiles	
Saltwater crocodile *Crocodylus porosus*	Migratory, marine
Marine turtles	
Leatherback turtle, leathery turtle *Dermochelys coriacea*	Endangered, migratory, marine
Loggerhead turtle *Caretta caretta*	Endangered, migratory, marine
Olive ridley turtle, Pacific ridley turtle *Lepidochelys olivacea*	Endangered, migratory, marine
Flatback turtle Natator depressus	Vulnerable, migratory, marine
Green turtle *Chelonia mydas*	Vulnerable, migratory, marine
Hawksbill turtle *Eretmochelys imbricata*	Vulnerable, migratory, marine
Sea snakes	
Beaked seasnake *Enhydrina schistosa*	Marine
Black-headed seasnake *Hydrophis atriceps*	Marine
Dubois's seasnake *Aipysurus duboisii*	Marine

Species (common name/ scientific name)	Conservation status
Dwarf seasnake *Hydrophis caerulescens*	Marine
Elegant seasnake, bar-bellied seasnake *Hydrophis elegans*	Marine
Fine spined seasnake *Hydrophis czeblukovi*	Marine
Horned seasnake *Acalyptophis peronii*	Marine
Large-headed seasnake *Hydrophis pacificus*	Marine
Olive seasnake *Aipysurus laevis*	Marine
Olive-headed seasnake *Disteira major*	Marine
Ornate seasnake, ornate reef seasnake *Hydrophis ornatus*	Marine
Plain seasnake *Hydrophis inornatus*	Marine
Plain-banded seasnake *Hydrophis vorisi*	Marine
Small-headed seasnake *Hydrophis mcdowelli*	Marine
Spectacled seasnake *Disteira kingii*	Marine
Spine-bellied seasnake *Lapemis hardwickii*	Marine
Spine-tailed seasnake *Aipysurus eydouxii*	Marine
Stokes' seasnake *Astrotia stokesii*	Marine
Yellow-bellied seasnake *Pelamis platurus*	Marine

Table A2: Marine reptile species known to occur in the North Marine Region on an infrequent basis

Species (common name/ scientific name)	Conservation status
Black-banded robust seasnake *Hydrophis melanosoma*	Marine
Black-ringed seasnake *Hydrelaps darwiniensis*	Marine
Large-scaled sea krait, brown-lipped sea krait *Laticauda laticaudata*	Marine
Leaf-scaled seasnake *Aipysurus foliosquama*	Marine
Northern mangrove seasnake *Parahydrophis mertoni*	Marine
Slender seasnake *Hydrophis gracilis*	Marine
Slender-necked seasnake *Hydrophis coggeri*	Marine
Turtle-headed seasnake *Emydocephalus annulatus*	Marine
Wide-faced sea krait, yellow-lipped sea krait *Laticauda colubrina*	Marine

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