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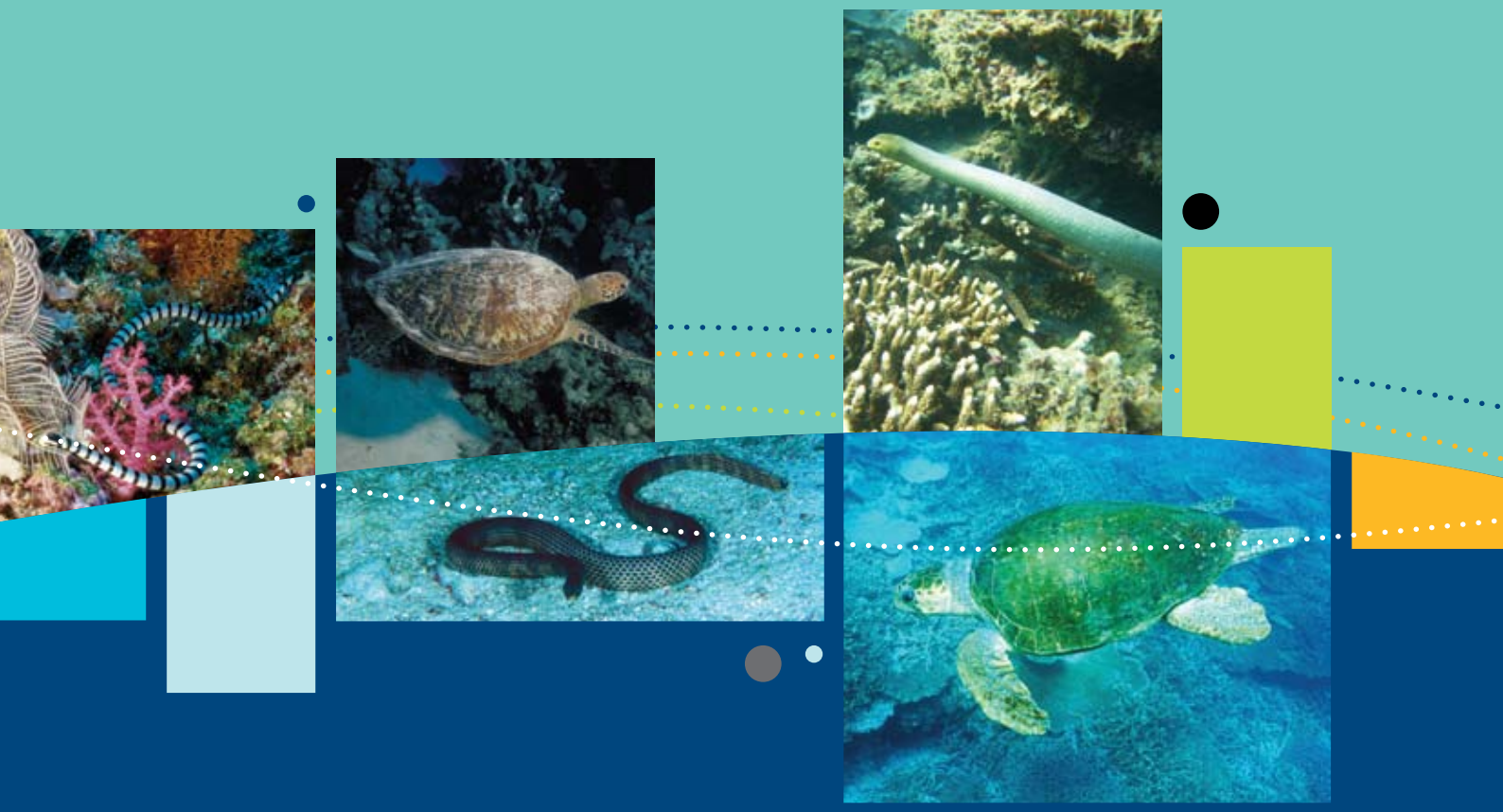

Species group report card – marine reptiles

Supporting the marine bioregional plan for the Temperate East Marine Region

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

Disclaimer

Images:
A Loggerhead turtle swims over Acropora corals – GBRMPA, Banded sea snake – M.Spencer, A Green turtle swims over sand along the edge of reef platform – GBRMPA, Dubois' Sea Snake – GBRMPA, Middleton Reef from air – Director of National Parks, Runic wreck on Middleton Reef – Director of National Parks, Black-browed Albatross – M.Double, Acropora species – R.Chesher Ph.D, Blue Devil – D.Harasti

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SPECIES GROUP REPORT CARD—MARINE REPTILES

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

Report cards

The primary objective of 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
- heritage 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 Temperate East Marine Region

The region supports a range of marine reptile species, namely marine turtle and sea snakes. For marine turtles, four of the seven species found in Australian waters are present. Sea snakes, which are listed under Section 248 of the EPBC Act as protected marine species, are also found in abundance with 20 of the 35 Australian species known, or thought, to occur within the region (Cogger 2000; Tzioumis & Keable 2007). See Table A1, Attachment A for the species list.

The loggerhead and green turtles are most commonly found in the region, with nesting sites dotted along the New South Wales and south-east Queensland coasts. The hawksbill and leatherback species are more likely to be found foraging in the region. Of the 20 sea snake species, most have tropical to subtropical distributions and thus are more commonly encountered in the region's north. Within this distribution, the group are known to utilise a wide variety of habitats, from coral reefs to areas of bare sand and/or mud. Their distribution is thought to be further influenced by seasonal factors (GBRMPA 2011).

This report card considers the four species of marine turtle individually, whilst the sea snakes have been considered due to limited data availability. These species were selected after considering their conservation status, distribution and population structure within the region; life history characteristics; and the potential for the population(s) in the region to be genetically distinct from populations elsewhere.

Marine turtles

Loggerhead turtle

The loggerhead turtle (*Caretta caretta*) is slow growing, taking around 30 years to reach maturity (Chaloupka 1998; Chaloupka & Limpus 1997; Chaloupka & Musick 1997). During their post-hatchling phase, they are carried southward by the East Australian Current to around 30° S (Limpus et al. 1994; Walker 1994), then eastward out to New Zealand, before re-entering the region via the Coral Sea as large immature turtles. Following their oceanic phase, they become carnivorous benthic feeders, primarily predating on benthic invertebrates from a range ofhard and soft-bottom habitats (e.g. rocky and coral reefs, estuaries and seagrass meadows) to depths of 55m (Limpus et al. 1994; Limpus et al. 2005; Preen 1996). In their juvenile stage, they feed on algae, pelagic crustaceans and molluscs (Limpus et al. 1994).

The loggerhead turtle is known to breed along the eastern Australian coast, predominantly on beaches close to and north of Bundaberg, as well as the islands of the southern Great Barrier Reef. The largest of these sites is Mon Repos on the mainland and Wreck Island in the Great Barrier Reef, where several hundred females lay their eggs every year. Some isolated nesting also occurs south of Bundaberg as far as Ballina in New South Wales (DEWHA 2009a; Limpus 1985). Loggerhead turtles forage throughout Queensland and New South Wales waters; particularly large concentrations of foraging turtles have been found in the lagoons of the southern Great Barrier Reef islands (e.g. Heron Island) and the Hervey Bay and Moreton Bay areas (DEWHA 2009a).

Green turtle

The green turtle (*Chelonia mydas*) is a global species that generally live in tropical environments within the 20 °C isotherm, although they are occasionally known to enter temperate waters. As adults, they predominantly forage on seagrass and algae, but are also known to feed on mangroves (Limpus & Limpus 2000) and sponges (Whiting et al. 2000). Green turtles are common throughout north-eastern Australia and seven distinct genetic stocks are recognised within Australia (Dethmers et al. 2006; FitzSimmons et al. 1997). The northern Great Barrier Reef supports the largest population of nesting green turtles, with a smaller breeding population recognised in the southern Great Barrier Reef (DEWHA 2009a). It is individuals from this southern population that are most likely to be found in the Temperate East Marine Region.

During their post-hatchling and juvenile stages, green turtles drift on ocean currents. Like the loggerhead, they travel south on the East Australian Current, leaving the region as is flows eastwards to New Zealand and then into the South Pacific Gyre (Carr & Meylan 1980), which transports them back to Australian waters via the Coral Sea (DEWHA 2009a). Green turtles are much smaller than other marine turtle species when they leave this pelagic phase, and it is presumed that they do not travel as extensively as some other species (DEWHA 2009a; Limpus et al. 2005). Mature turtles move to shallower waters to forage on seagrass and algae, living in coral and rocky reefs, inshore seagrass beds and algal mats (Musick & Limpus 1997; Poiner & Harris 1996; Robins et al. 2002; Whiting et al. 2000).

Hawksbill turtle

The hawksbill turtle (*Eretmochelys imbricata*) has a worldwide tropical and subtropical distribution, and Australia supports the largest remaining stocks of breeding turtles in the Indian Ocean–Western Pacific Ocean region (Limpus 2009a). Hawksbill turtles in Australia comprise two distinct genetic stocks: one in the north-east of Australia and the other in Western Australia (Limpus 2009a). Only the north-eastern stock is considered in this report card. Due to significant timing differences in the breeding seasons across the north-eastern stock, two subpopulations are distinguished for management purposes (Limpus 2009a). Of these subpopulations, the northern Great Barrier Reef population lives adjacent to the Temperate East Marine Region and it is individuals from this subpopulation that are most likely to be found in the region. This subpopulation supports a nesting population of between 100 and 500 females and was one of the pivotal values associated with the World Heritage listing of the Great Barrier Reef. The reef also supports the greatest number of protected foraging hawksbill turtles in the world (Limpus 2009a). Although nesting within the Temperate East Marine Region is rare, foraging individuals are found as far south as northern New South Wales (Tzioumis & Keable 2007).

Hawksbill turtles are highly migratory and mature females have high site fidelity, returning to the same beaches to nest each year. Little is known about the early life phase of the hawksbill turtle. They are rarely recorded in inshore waters during their first five years post-hatching (DEWHA 2009a; Limpus 2009a) and it is presumed that they follow an oceanic, planktonic life during this time. As adults and immature turtles, hawksbills are most frequently encountered in tidal and subtidal coral and rocky reef habitats (Limpus 2009a). They are omnivorous and are thought to feed predominantly on algae, sponges and seagrass (Limpus 2009a).

Leatherback turtle

Distributed worldwide across tropical and temperate seas, the leatherback turtle (*Dermochelys coriacea*) is considered to be in serious decline across the Pacific Ocean basin (Spotila et al. 1996). Although there are no major nesting sites in Australia, the species is known to forage in Australian waters, including in the Temperate East Marine Region, migrating from larger nesting populations in neighbouring countries (Hamann et al. 2007; Limpus 2009b). Leatherback turtles forage throughout the water column, from close to the surface to depths of more than 1200 metres, feeding predominantly on jellyfish and other soft-bodied macroplankton (Gulko & Eckert 2004; Tzioumis & Keable 2007). Mainly pelagic during both its juvenile and adult phases, the leatherback grows more quickly than other marine turtle species and can start breeding at less than 20 years of age (Tzioumis & Keable 2007). Small juveniles seem to disappear for several years, but they may concentrate around upwellings where food sources are abundant.

Sea snakes

Of the 20 species known to, or thought to, occur in the Temperate East Marine Region, sufficient information is available to provide an overview of 12 of the species.

Horned seasnake

The horned seasnake (*Acalyptophis peronii*) occurs in tropical waters from the Coral Sea to Moreton Bay (Covacevich & Couper 1991; Minton & Dunson 1985). It is typically found on sandy substrates (Ehmann 1992; Ineich & Laboute 2002; McCosker 1975) and is active during the day and night (Cogger 2000; Guinea & Whiting 2005). Most sea snakes live within a fairly narrow stratum of the water column (0–100 metres). The horned seasnake eats fish, particularly gobies (Glodek & Voris 1982; McCosker 1975; Voris 1972) and the gregarious *Ptereleotris* species is found in communal burrows, as well as burrow-dwelling shrimp (Ineich & Laboute 2002). It forages on the sandy sea floor, where it removes gobies from burrows and swallows the fish head first (Zimmerman et al. 1994). Female horned seasnakes give birth to up to 10 live young each year (Cogger 2000). Gestation lasts six to seven months and females appear to reproduce every year and give birth between March and June (Fry et al. 2001). The age of sexual maturity, life expectancy and natural mortality are unknown, and there is little information on the relative abundance of the species across the Temperate East Marine Region.

Dubois' seasnake

Dubois' seasnake (*Aipysurus duboisii*) is found in tropical northern Australia (Cogger 2000) from the Coral Sea to Hervey Bay (Limpus 1975). It is most often found in shallow water near protected coral reefs at depths of 3–4 metres (McCosker 1975), but it has also been caught in trawl nets at depths of around 45 metres (Dunson 1975). This species inhabits a variety of substrates including soft muddy bottoms, and sand areas between reef and coral reef fringes (Greer 1997; Guinea 1995). Nothing is known of the population structure of the Dubois' seasnake either in Australia or overseas.

Marbled or spine-tailed seasnake

The marbled or spine-tailed seasnake (*Aipysurus eydouxii*) is found in tropical Australian waters as far south as Fraser Island. It inhabits shallow (depths of less than 100 metres) bays and estuaries, and is commonly associated with soft muddy substrates (Ehmann 1992; Limpus 1975; Storr et al. 1986). It eats only fish eggs (Limpus 1975; Voris 1972). The marbled or spine-tailed sea snake is known to give birth to up to nine young, with gestation time around 6–7 months and birth occurring in September. It appears to reproduce every year (Fry et al. 2001).

Olive seasnake

The olive seasnake (*Aipysurus laevis*) inhabits tropical and subtropical coastal and coral reef waters across northern Australia to southern Queensland (Cogger 2000; Ineich & Rasmussen 1997; Limpus 1975; Storr et al. 1986). The Australian population is split into three genetic regions, with no migration occurring between these distinct populations. The Great Barrier Reef population shows relatively low genetic diversity. The species is found along the lower reef edges and upper lagoon slopes of leeward reefs (McCosker 1975). It is likely that the species is highly dependent on complex reef habitats: they forage by poking their heads into crevices in search of prey, and rarely feed in open water (Lukoschek et al. 2007a). The olive seasnake is the most common sea snake species found in the reefs of eastern Australia and may occur at very high densities of 0.7 to 0.86 individuals per metre of reef edge (Burns & Heatwole 1998, 2000). However, research indicates their populations in the Great Barrier Reef have declined in the last 30 years, with some local extinctions (Lukoschek et al. 2007a). The olive seasnake gives birth to up to 11 young (Fry et al. 2001). In the Rockhampton region (Keppel Island), females are pregnant in the summer months and give birth up until April. Not all females reproduce each year. Individual females may need an intervening non-reproductive summer in which to restore energy reserves before reproducing again (Burns 1985).

Stokes' seasnake

There is little information on the distribution of Stokes' seasnake (*Astrotia stokesii*). The species has been recorded in the tropical coastal waters of Queensland and, during summer months, it extends its range southward into more temperate latitudes (Cogger 2000). Little is known about their specific habitat use, but they have been collected over muddy substrates at depths of 10 metres, as well as coastal tidal pools (McCosker 1975; Sutherland 1983). A strong swimmer, Stokes' seasnake forages on slow-moving fish in holes and crevices on the sea floor and in reefs (Ehmann 1992; Fry et al. 2001; McCosker 1975). Females give birth to 1–5 live young (Ehmann 1992).

Turtle-headed seasnake

The turtle-headed seasnake (*Emydocephalus annulatus*) is found in shallow waters in tropical reef habitats from the Sunshine Coast through to Cape York, often in high densities (Shine et al. 2006). A free-ranging species, it forages at a relatively slow pace, using its sense of smell to locate fish eggs hidden in rock crevices (Guinea 1996). Because this species forages on inert, defenceless prey, it does not depend on speed or good vision (Shine et al. 2006) and is only active during daylight (Shine et al. 2006). The turtle-headed seasnake is one of only three species of sea snake that is a specialist fish egg feeder (McCarthy 1987; Voris 1972). This species gives birth to fully developed live young, with mating occurring in June–July and birth occurring in March–April (Ineich & Laboute 2002; Shine et al. 2006).

Beaked seasnake

The beaked seasnake (*Enhydrina schistosa*) is found in inshore waters such as estuaries and tidal rivers out to the continental shelf waters (Tzioumis & Keable 2007). Research shows it has a high mortality rate, most likely because it is one of the most commonly encountered species. Only around 6 per cent of females reach reproductive age and, of those females that reach maturity, approximately 11 per cent of their eggs are infertile (Heatwole 1997).

Elegant seasnake

The elegant seasnake (*Hydrophis elegans*) occurs throughout the waters of tropical Australia from Shark Bay in Western Australia to Moreton Bay in Queensland (Cogger 2000; Storr et al. 1986). At times, this species moves into freshwater habitats, although it is more commonly found in estuaries (e.g. Burnett River, Queensland). It is also found in the coral reef lagoons and channels of the Great Barrier Reef, where it feeds on elongated bottom-dwelling fish such as catfish and gobies (Fry et al. 2001; Kerford 2005; Limpus 1975; McCosker 1975). Females may reproduce every year in warmer waters (Fry et al. 2001) or every two or three years elsewhere (Ward 2001). Larger females produce up to 30 young in a clutch (Fry et al. 2001).

Spectacled seasnake

The spectacled seasnake (*Hydrophis kingii*) is found across northern Australia, from Broome to New South Wales (Cogger 1975; Limpus 1975). A specialist fish feeder, this species is found over soft sandy and muddy substrates from the surface to depths of 22 metres (Redfield et al. 1978; Trembath 2003). Occasionally, it is also found in reef and inter-reef habitats (Trembath 2003). It is thought to be naturally rare as it has a very low capture rate in commercial fisheries operations (Courtney et al. 2010). The species is also known to have a small clutch size.

Small-headed seasnake

The small-headed seasnake (*Hydrophis mcdowelli*) is restricted to northern Australia, including areas of the Gulf of Carpentaria, the Northern Territory coast and the Temperate East Marine Region (Cogger 2000; Milton 2001). Little is known of this species, as it is rarely encountered in trawls (Courtney et al. 2010). Females appear to reproduce every year but have fewer than four young in each clutch (Cogger 2000). The species forages for fish in holes or soft sediment on the sea floor (Ineich & Laboute 2002; Minton & Dunson 1985).

Olive-headed seasnake

The olive-headed seasnake (*Hydrophis major*) occurs from Shark Bay in Western Australia to Moreton Bay in Queensland (Limpus 1975; Storr et al. 2002). It moves into the Temperate East Marine Region in around August and remains there until January (Ehmann 1992; Limpus 1975). It inhabits sand and mud in lagoons and inshore waters at depths between 3 and 10 metres (Ehmann 1992; Limpus 1975). In northern Australia, females apparently reproduce every year, with clutch sizes varying from 6 to 12 (Greer 1997; Fry et al. 2001). They appear to mature at a younger age than other sea snake species (Milton 2001). Olive-headed seasnakes eat benthic, elongated fish species such as catfish (Fry et al. 2001; McCosker 1975).

Yellow-bellied seasnake

The yellow-bellied seasnake (*Pelamis platurus*) is the only species found throughout the Temperate East Marine Region (Tzioumis & Keable 2007). The only true pelagic sea snake, it is often found in the drift lines between currents. The largest populations exist south of the tropics, where they are commonly found on beaches after storms (Cogger 1975, Cogger 1996). Yellow-bellied seasnakes can attract fish by mimicking an inanimate floating object on the surface (DSEWPaC 2010).

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 Temperate East 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 green and loggerhead turtles. Behaviours used to identify biologically important areas for turtles include nesting, inter-nesting and foraging.

Biologically important areas are included in the Temperate East Marine Region Conservation Values Atlas (**www.environment.gov.au/cva**). Biologically important areas have not yet been identified for sea snakes in the Temperate East Marine Region.

2. Vulnerabilities and pressures

Vulnerabilities

The life history characteristics of marine turtles, including their long life spans and late sexual maturity, make them vulnerable to a range of pressures in the marine environment. Other factors contributing to their vulnerability include the highly migratory habits exhibited by many species and the varied utilisation of multiple habitats across multiple life stages. For example, a juvenile turtle during its oceanic phase is vulnerable to marine debris, particularly the micro-sized plastic pieces that they digest (DEWHA 2009b). During the breeding season, however, females become vulnerable to land-based pressures (e.g. invasive species) due to their reduced mobility and, when they return to the sea, are more vulnerable to becoming disoriented by artificial light sources from urban or industrial areas. Newly hatched individuals also experience heightened vulnerability to light pollution impacts.

For sea snakes, characteristics such as slow growth and small clutch sizes increase their vulnerability to marine pressures. For many species, a specialist diet (i.e. usually restricted to just a few benthic fish species such as eels and gobies (Fry et al. 2001)) is also a source of vulnerability, particularly to pressures that impact on community structure and species abundance.

Analysis of pressures

On the basis of current information, pressures have been analysed for the four individual species of marine turtle, and one family group of sea snakes 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 reptiles pressure analysis for the Temperate East Marine Region

Pressure	Source	Species				
		Green turtle	Hawkbill turtle	Leatherback turtle	Loggerhead turtle	Seasnakes
Sea level rise	Climate change					
Changes in sea temperature	Climate change					
Change in oceanography	Climate change					
Ocean acidification	Climate change					
Changes in terrestrial sand temperature	Climate change					
Chemical pollution/ contaminants	Shipping Vessels (other)					
	Urban development Agricultural activities					
Nutrient pollution	Urban development Agricultural activities					
Marine debris	Shipping Vessels (other) Fishing boats Land-based activities					
Noise pollution	Seismic exploration					
	Shipping Vessels (other)					
	Urban development					
Light pollution	Land-based activities					
	Shipping Vessels (other)					
Physical habitat modification	Dredging Dredge spoil					
	Fishing gear					
Human presence at sensitive sites	Tourism Recreational and charter fishing Research					

Legend of concern; of potential concern; of less concern; not of concern; not assessed

Table 1: Outputs of the marine reptiles pressure analysis for the Temperate East Marine Region

Pressure	Source	Species				
		Green turtle	Hawkbill turtle	Leatherback turtle	Loggerhead turtle	Sea snakes
Extraction of living resources	Commercial fishing (domestic)					
	Commercial fishing (non-domestic)					
	Recreational and charter fishing					
	Indigenous harvest					
Bycatch	Commercial fishing (domestic)					
	Recreational and charter fishing					
	Illegal, unregulated and unreported fishing					
Oil pollution	Shipping Vessels (other)					
	Oil rigs					
Collision with vessels	Shipping Tourism Fishing					
Invasive species	Shipping Fishing vessels Land-based activities					
Changes in hydrological regimes	Climate change					

Legend of concern; of potential concern; of less concern; not of concern; not assessed

Sea level rise—climate change

Rising sea levels were assessed as *of concern* for the loggerhead turtle and *of potential concern* for the green turtle. Global sea levels have risen by 20 centimetres between 1870 and 2004 and predictions estimate a further rise of 5–15 centimetres by 2030, relative to 1990 levels (Church et al. 2009). Longer term predictions estimate increases of 0.5 to 1 metre by 2100, relative to 2000 levels (Climate Commission 2011). Sea level rise is likely to impact on turtle breeding success through an increased risk of tidal inundation or destruction of turtle nests, the selection of suboptimal nesting sites and an increased risk of nest destruction by other nesting turtles associated with higher nesting densities (Fuentes et al. 2009; Hamann et al. 2007; Poloczanska et al. 2009). It is expected that the effects of sea level rise will be particularly marked in regions of extensive coastal development, such as eastern Australia, where developed areas act as a barrier to the landward movement of beaches or hinder natural accretion of beach material and the evolution of beach morphology (Poloczanska et al. 2009). For example, predictions for several key turtle rookeries adjacent to the region (e.g. the Capricorn Bunker group) estimate they will experience a loss of up to 38 per cent of the available nesting area (Fuentes et al. 2009).

Changes in sea temperature—climate change

Changes in sea temperature were assessed as *of concern* for the loggerhead turtle and *of potential concern* for the remaining turtle species and sea snakes. 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 temperatures have the potential to impact on marine turtles in a number of ways, including causing a shift in distribution that may either increase or decrease the species range (Danvenport 1997; Hawkes et al. 2009; Milton & Lutz 2003), alterations to life history characteristics (e.g. growth rates, age at maturity and reproductive periodicity) (Balazs & Chaloupka 2004; Chaloupka & Limpus 2001; Fuentes et al. 2009) and reduced prey availability (Chaloupka et al. 2008). For example higher mean annual sea surface temperatures in core loggerhead foraging areas correlate with trends towards smaller annual nesting populations 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 in the Temperate East Marine Region, these impacts can have serious repercussions, resulting in a range of population effects.

Sea snakes have a particularly intimate relationship with water temperatures because they depend on the water temperature for their body heat while foraging (Guinea 1995; Heatwole 1981). Despite this relationship, little is known about the thermal requirements and tolerances of individual species of sea snakes and how they will respond to increasing water temperatures (Hamann et al. 2007). It is known that one wide spread species—*Pelamis platurus* does not survive at temperatures higher than 36 °C (Dunson & Ehlert 1971; Graham et al. 1971; Heatwole 1981). In tropical reef habitats, surface waters already approach this temperature, and cooler oceanic water remains a few metres below. In addition to the potential direct impact on survival, other indirect impacts such as the availability of prey species and seasonal movements for either breeding or feeding may have further consequences for populations of sea snakes in the region (Fuentes et al. 2009; Hamann et al. 2007).

Changes in oceanography—climate change

Changes in oceanography were assessed as *of potential concern* for all four marine turtle species. Oceanographic changes in the region will be primarily driven by the East Australian Current. Studies indicate this major boundary current has been strengthening, pushing warmer, saltier water up to 350 kilometres further southward along the east coast (Ridgway & Hill 2009). Associated circulation effects will also arise from expected changes to the El Niño–Southern Oscillation. A range of potential consequences for ocean circulation patterns arising from these changes include: alterations to current locations and directions; changes to upwelling events; and increased thermal stratification and eddy activity (Chin et al. 2010). For turtles, these changes may have implications for hatchling dispersal, migration and feeding. For example, dispersal of loggerhead and green turtle hatchlings from the Great Barrier Reef occurs via offshore currents, and any changes in currents may affect post-hatchling migration and distributions for these species (Boyle 2006; Hamann et al. 2007).

Changes in terrestrial sand temperatures—climate change

Changes in terrestrial sand temperatures, particularly increases in temperatures, were considered to be *of concern* for the loggerhead turtle and *of potential concern* for the green turtle. Higher sand temperatures increase the female bias in the sex ratio of turtle hatchlings, potentially leading to a female bias in mature populations (Fuentes et al. 2009). A rise in sand temperatures may also compromise egg incubation, reducing hatchling success and survival (Fuentes et al. 2009). There is evidence that turtles are responding to these pressures in a highly adaptive manner; for example, by shifting nesting periods to correspond to lower temperatures (Poloczanska et al. 2009). This response highlights the difficulties associated with predicting the environmental outcomes of climate change and developing effective management responses.

Chemical pollution/contaminants—shipping; vessels; urban development; agricultural activities

Chemical pollution/contaminants are *of potential concern* for all turtle species, except for the impact of land-based chemical pollution/contaminants on leatherback turtles, which is *of less concern*. Chemical pollution can enter the marine environment via a wide range of vectors, including poorly treated or untreated municipal and industrial wastewater; pesticide and fertiliser run-off from agriculture; spills and other ship-related releases; and mining. The region is highly exposed to possible vectors for chemical pollutants, including significant shipping, fishing, and extensive urban development and agricultural activities occurring adjacent to the region.

A major chemical spill is expected to have impacts similar to, or possibly exceeding, those of an oil spill (GBRMPA 2009). The impacts of smaller and more gradual influxes of chemicals (e.g. agricultural run-off) are harder to ascertain (Muusee et al. 2006). Individuals foraging in nearshore areas have a higher risk of being exposed to land-based pollution (Hermanussen et al. 2006). Studies indicate that turtles bioaccumulate and biomagnify chemicals, meaning these compounds can reach elevated concentrations in individuals, with potentially negative consequences (Muusee et al. 2006).

A number of management measures are in place to respond to this risk, including the *National plan to combat pollution of the sea by oil and other noxious and hazardous substances* and the International Convention for the Prevention of Pollution from Ships (MARPOL), both of which are implemented through the Australian Maritime Safety Authority. Although these measures mitigate the risk of a significant pollution event, its potential cannot be removed entirely.

Nutrient pollution—urban development; agricultural activities

Nutrient pollution is *of potential concern* for green, hawksbill and loggerhead turtles. Nutrient pollution, known also as eutrophication, refers to an increase in the rate of supply of organic matter into an ecosystem, particularly nitrogen, phosphorus and silica. These are derived from a number of sources, including industrial outfalls, aquaculture operations, effluent from vessels and agricultural run-off. Their impacts are mediated by a range of factors, including the mixing characteristics of the water, water temperature and available light. Eutrophication is considered a threat to coastal marine environments, leading to an increased frequency of harmful algal blooms, loss of ecosystem integrity and changes to biodiversity.

Algal blooms have been associated with substandard diets in turtles, which may hamper growth and development and reduce breeding success (Arthur et al. 2006). It is also suggested that these blooms are associated with toxins that may cause fibropapilloma, a type of tumour. Given the likely increase in nutrient pollution associated with the growth in coastal development, experts consider this pressure to be of increasing concern to turtle populations that are already compromised.

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

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

Marine debris is recognised nationally as a key threatening process and marine turtles are particularly susceptible to its effects. Records indicate that, since 1989, at least 1122 marine turtles have been impacted by plastic debris through entanglement or ingestion. Of these, 88.7 per cent (996 animals) were entangled and 11.2 per cent (126 animals) had ingested plastic debris (Ceccarelli 2009). Ingestion occurs when debris is mistaken for prey, and white plastic debris (e.g. plastic bags) is of most concern because it resembles jellyfish, which are a key prey item for turtles (Derraik 2002). The internal structure of a turtle's throat prevents the regurgitation of swallowed items, trapping them in the gut where they decompose and produce gases in the body cavity, which cause the animal to float and ultimately die. 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 accumulate. In a study by Boyle & Limpus (2008), synthetic materials accounted for up to 46 per cent of total stomach content in green turtle post-hatchlings. As hatchlings cannot compensate the intake of non-nutritional items, their energy and nitrogen intake is reduced. In addition to the direct impacts of plastic ingestion, research also indicates that toxins within the materials are absorbed by the animals, with unknown but potentially negative effects on their populations (Bjorndal et al. 1994).

Marine debris data for the region is limited; however, key factors for the introduction and spread of debris are present within the region (Katsanevakis 2008). These include high levels of commercial shipping, major current systems (i.e. the East Australian Current), active fisheries (recreational and commercial) and significant coastal urban development. Despite the paucity of marine debris information, there are some very clear indications that debris is having a negative impact on turtles across the region. For example, of 30 marine turtle stranding events in 2007, 23 per cent were attributed to marine debris (UQ News Online 2008).

Light pollution—land-based activities; shipping; vessels (other)

Light pollution is *of potential concern* for green and loggerhead turtles. Light pollution along, or adjacent to, nesting beaches can alter nocturnal turtle behaviour, particularly the selection of nesting sites and the passage of adult females and emerging hatchlings from the beach to the sea (Limpus 2008a, Limpus 2008b). The impacts of these changes in behaviour include a decrease in nesting success, beach avoidance by nesting females, and disorientation leading to increased mortality through predation, road kill and dehydration (Limpus 2008a; Lorne & Salmon 2007; Witherington & Martin 2000).

Given the particular sensitivity of turtles during nesting events, light pollution originating from coastal developments (e.g. towns, factories, ports) currently poses the most serious risk. The impacts of light pollution were considered to be adequately managed, as the majority of nesting sites occur within managed zones (Limpus 2008b). For example, at Mon Repos Conservation Park, a 1.5 kilometre radius darkness zone was thought to offer sufficient protection. However, lighting from nearby towns is now so extensive that it results in a brightly illuminated dome of sea spray, which remains visible more than 3 kilometres out to sea. This increased light visibility is already negatively influencing hatchling behaviour at Mon Repos (Limpus 2008b). The Queensland Department of Environment and Resource Management coordinates successful programs that aim to educate local councils and the public about the impacts of light pollution on turtle populations; however, it remains a significant pressure on the sustainability of turtle nesting and hatchling populations.

Shipping and other vessels may also cause light pollution offshore, particularly in regions of high vessel traffic, such as along key shipping routes. Hatchlings become easy prey when they are drawn to the vessel hull and may be subject to predation.

Physical habitat modification—dredging/dredge spoil; fishing gear

Physical habitat modification caused by dredging activities is a pressure *of potential concern* for green and loggerhead turtles, and sea snakes. Dredging is an excavation activity that artificially deepens and widens harbours and waterway channels. Dredging occurs extensively along the south-east Queensland and New South Wales coast.

The impacts of dredging on reptiles are two-fold: direct mortality of individuals and indirect mortality arising from habitat modification. Direct mortality in turtles is well established from stranding records, and turtles killed in this manner have extensive and characteristic injuries (Greenland et al. 2004; Haines & Limpus 2001). The Port of Brisbane and turtle specialists with the Queensland Environmental Protection Agency have introduced deflection devices on dredge vessels, which have reduced interaction rates in this area (GBRMPA 2011; Port of Brisbane 2006). These organisations also consider issues such as timing of activities

and on-board processes (e.g. use of jet pumps). No data is available for sea snakes, but it is believed that they are also subject to physical entrainment and death from the dredging equipment.

For turtles, the direct impact of localised habitat change is considered insignificant because of the relative size of affected areas. However, dredging removes existing bottom sediments, leaving newly smoothed channels. Anecdotal reports suggest that turtles use these channels for resting, which may place them in the path of high vessel traffic and increase their exposure to vessel strike injuries (Mark Hamann, pers comm, 2011).

For sea snakes, the indirect impacts of dredging are more complex. Noise and vibration from the equipment, reduction in foraging habitat, removal of habitat for prey species and increased turbidity may have negative impacts on this species group. Of these, increased turbidity and impacts on prey species may have the most serious implications. Most sea snakes visually identify potential feeding sites, so turbidity may hamper their hunting abilities. As sea snakes are specialist feeders, small changes to the abundance or presence of prey species can be detrimental. Data is limited, but available information suggests that, once removed from an area, sea snake populations take considerable time to recolonise and, in some instances, populations never re-establish (Burns & Heatwole 1998; Lukoschek et al. 2007b).

Extraction of living resources—commercial fishing (non-domestic)

Marine turtles are fully protected in Australian waters, but because they roam internationally, population declines may be due to unsustainable fishing in other parts of the species' range. This pressure is *of potential concern* for green and hawksbill turtles. Evidence indicates that fishing occurs in neighbouring South Pacific countries (Meylan & Donnelly 1999), with green and hawksbill turtles preferentially taken for their meat and shells, respectively, and sold in markets (e.g. Daru and Koki markets in Papua New Guinea). Long life spans and late sexual maturity make these species vulnerable to continued harvesting, which impacts on populations both within and beyond the region (Dethmers et al. 2010).

Bycatch—commercial fishing (domestic)

Turtle bycatch in domestic commercial fisheries operations is *of concern* for green, leatherback and loggerhead turtles, and *of potential concern* for sea snakes. Globally, bycatch is considered to be one of the most significant threats to turtles' ongoing survival (Lewison et al. 2004). Turtles are particularly vulnerable to trawl, gillnet and longline fisheries gear, and bycatch interactions typically result in the death of individuals from drowning. All three gear types are used across the region, and records indicate that all four turtle species are caught (Limpus 2008a, Limpus 2008b). While the population effects of this mortality are unknown for some species, for others (such as the loggerhead and green turtles), it has been attributed to population declines (Limpus 2008a; Limpus 2008b).

The introduction of turtle excluder devices (TEDs) in several key trawl fisheries (such as the Queensland East Coast Otter Trawl Fishery) has significantly reduced bycatch levels. Monitoring programs are just beginning to see the outcomes of this management strategy, with reports indicating a marked improvement in affected turtle populations in the region (Limpus 2008b). Despite their success, TEDs are not universally used; for example, New South Wales trawl fisheries (e.g. New South Wales Otter Trawl Fishery) are not required to use these devices. For other fisheries, such as longline operations, where TEDs cannot be applied, bycatch continues to be considered a high risk. For example, in the Eastern Tuna and Billfish Fishery, green and leatherbacks turtles are the most frequently caught species.

For sea snakes, bycatch from the Queensland trawl fisheries is the main pressure impacting on the species in the Temperate East Marine Region (Cogger 2000). In particular, the redspot king prawn fishery records significant sea snake bycatch (Courtney et al. 2010). This fishery has the potential to impact on all species, especially the spectacled and small-headed seasnakes. Very little is known about either species other than they are slow to mature, have few young and do not survive well in trawl nets.

Bycatch—illegal, unregulated and unreported fishing

Illegal, unregulated and unreported (IUU) fishing is *of potential concern* for all turtle species. IUU fishing encompasses a complex range of fisheries activities, but generally refers to fisheries operations that violate the governing laws and conventions of that fish stock. The Food and Agriculture Organization of the United Nations' *International plan of action to prevent, deter and eliminate illegal, unreported and unregulated fishing* (UN FAO 2001) provides a full definition. While not explicitly targeting turtle species, IUU fisheries operations create significant collateral damage to ecosystems. By their nature, such operations do not respect national and international actions designed to reduce bycatch and mitigate the incidental mortality of marine animals such as marine turtles (Agnew et al. 2009). Although IUU fishing is not a significant issue within the region, it is likely to occur in waters adjacent to the region and may be contributing to declines of turtle populations within the Temperate East Marine Region.

Oil pollution—shipping; vessels (other)

Oil pollution is *of potential concern* for all marine reptile species. Australia has a strong system for regulating industry activity that is the potential source of oil spills and this system has been strengthened further in response to the Montara oil spill. While oil spills are unpredictable events and their likelihood is low based on past experience their consequences, especially for threatened species at important areas, could be severe. The effects of oil pollution are complex and governed by the form and chemistry of the oil itself, as well as environmental factors such as wind speed and water temperature. Marine reptiles are affected by exposure when

surfacing to breathe, contaminated food supplies, fouling of nesting beaches and absorption of oil through the skin (AMSA 2010a; Gagnon 2009; Watson et al. 2009). Physical contact may result in a range of impacts including burns, damage to internal organs and toxicity resulting in reduced hatchling success and deformities in developing embryos (AMSA 2010b).

Mortality from these impacts can have serious effects on populations. For example, the recent accident involving the cargo ship *Pacific Adventurer* sent more than 250 tonnes of fuel oil into the ocean near Moreton Island, a core turtle ground. The efforts of a strong volunteer network along the Sunshine Coast ensured that the impacts of this spill on nesting turtles and emerging hatchlings were minimised (SEQ Catchments 2010). Without this effort, turtle mortality would have been considerably higher. Other recent spills, such as the Montara oil spill, have resulted in known sea snake deaths (AMSA 2010a; Gagnon 2009; Watson et al. 2009).

After a spill, oil can mix with water to create a thick, sticky emulsion that forms lumps known as tar balls. Oil from other sources (e.g. fishing vessels) also forms these sticky balls. Tar balls are very persistent and can travel hundreds of miles, dispersed by currents. Post-hatchlings are thought to be attracted to these items, possibly confusing them with prey, and are known to frequently ingest them with lethal outcomes (Boyle & Limpus 2008).

Collision with vessels—shipping; tourism; fishing

Collision with vessels is *of concern* for all turtle species except leatherbacks. Boat strikes are a common cause of death and injury in marine turtles, and turtles' poor hearing and vision hamper their ability to avoid boats. Turtles are most vulnerable to boat strike when they are in shallow waters, or basking or breathing at the surface. Coastal development and associated recreational boating activities are expected to increase the exposure of turtles to this pressure in the region (Limpus 2008a, Limpus 2008b, Limpus 2009a). Adult turtles are particularly vulnerable, and the loss of breeding individuals compounds the impact of this pressure on turtle populations (Limpus 2008a). Some very effective mitigation measures are in place, such as the 'Go slow' zones in the Moreton Bay Conservation Park; however, experts remain concerned about the impact of boat strikes on turtle populations within the region.

Invasive species—shipping; fishing vessels; land-based activities

Invasive species, particularly the European red fox and the feral pig, are *of potential concern* for loggerhead and green turtles in the region. Both foxes and pigs have had impacts on turtle stocks, particularly the eastern loggerhead population (Limpus & Limpus, 2003; Limpus & Parmeter, 1985; Tisdell et al. 2004). In the case of Mon Repos, a key nesting site for the loggerhead turtle, predation has seriously impacted on the recruitment of females to the population, drastically reducing overall stocks (Limpus & Limpus 2003). A Queensland Government fox eradication program has successfully reduced fox impacts to negligible levels in key sites (i.e. Mon Repos); however, uncontrolled predation remains an issue.

3. Relevant protection measures

The 24 marine reptile species discussed in this report card are listed as endangered (leatherback and loggerhead), vulnerable (green and hawksbill) and marine listed under section 248 (all sea snakes) of the EPBC Act. Under the EPBC Act it is an offence to kill, injure, take, trade, keep, or move a 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; port 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

- *The action plan for Australian reptiles* (Cogger et al. 1993)
- *Recovery plan for marine turtles in Australia* (EA 2003)
- *Sustainable harvest of marine turtles and dugongs in Australia: a national partnership approach* (DEH 2005)
- *Threat abatement plan for the impacts of marine debris on vertebrate marine life* (DEWHA 2009b).

International measures

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

- Convention on International Trade in Endangered Species of Wild Flora and Fauna (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 the following sites:

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

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ATTACHMENT 1: MARINE REPTILES OCCURRING IN THE TEMPERATE EAST MARINE REGION

Table 1: Listed marine reptile species known to occur in the Temperate East Marine Region

Species (common name/scientific name)	Conservation status
Marine turtles	
Green turtle (*Chelonia mydas*)	Vulnerable, migratory, marine
Hawksbill turtle (*Eretmochelys imbricata*)	Vulnerable, migratory, marine
Leatherback turtle or leathery turtle (*Dermochelys coriacea*)	Endangered, migratory, marine
Loggerhead turtle (*Caretta caretta*)	Endangered, migratory, marine
Sea snakes	
Beaked seasnake (*Enhydrina schistosa*)	Marine
Black-ringed seasnake (*Hydrelaps darwiniensis*)	Marine
Blue-lipped sea krait (*Laticauda laticaudata*)	Marine
Colubrine sea krait, banded sea krait or yellow-lipped sea krait (*Laticauda colubrine*)	Marine
Dubois' seasnake (*Aipysurus duboisii*)	Marine
Elegant seasnake (*Hydrophis elegans*)	Marine
Horned seasnake (*Acalyptophis peronii*)	Marine
Laboute's seasnake (*Hydrophis laboutei*)	Marine
Little file snake (*Acrochordus granulatus*)	Marine
Marbled or spine-tailed seasnake (*Aipysurus eydouxii*)	Marine
Olive seasnake (*Aipysurus laevis*)	Marine

Species (common name/scientific name)	Conservation status
Olive-headed seasnake (*Hydrophis major*)	Marine
Plain-banded seasnake (*Hydrophis vorisi*)	Marine
Small-headed seasnake (*Hydrophis mcdowelli*)	Marine
Spectacled seasnake (*Hydrophis kingii*)	Marine
Spotted seasnake (*Hydrophis ornatus*)	Marine
Stokes' seasnake (*Astrotia stokesii*)	Marine
Turtle-headed seasnake (*Emydocephalus annulatus*)	Marine
White-bellied mangrove snake (*Fordonia leucobalia*)	Marine
Yellow seasnake (*Hydrophis spiralis*)	Marine
Yellow-bellied seasnake (*Pelamis platurus*)	Marine





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