

A Vulnerability Assessment for the Great Barrier Reef



Marine turtles

Information valid as of June 2014

Summary

Diversity

Six of the world's seven species of marine turtle occur within the Great Barrier Reef World Heritage Area (the World Heritage Area). The green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), loggerhead turtle (*Caretta caretta*) and flatback turtle (*Natator depressus*) nest and forage in the World Heritage Area. Leatherback turtles (*Dermochelys coriacea*) and olive ridley turtles (*Lepidochelys olivacea*) do not have significant foraging populations in the World Heritage Area and neither species nests in this area.



Flatback turtle, *Natator depressus*, covering her nest

Susceptibility

Marine turtles exhibit behaviours and life history traits that make them susceptible to environmental and human-related pressures in the World Heritage Area and throughout their migratory ranges outside of Australian waters. These behaviours and traits include being long-lived (meaning populations are vulnerable if unsustainable numbers of adults experience early mortality); having slow growth rates with delayed sexual maturity; high levels of egg and hatchling mortality; inhabiting a range of habitats during their life stages where they may be exposed to poor water quality and/or incidental capture during fishing operations; migratory (their range crosses international boundaries into areas where they are less protected and highly targeted); and a reliance on beaches for nesting which increases their exposure to land-based threats and rapidly changing environmental conditions.

Major pressures

Climate change; coastal development and the loss and degradation of habitat; declining water quality due to catchment run-off; incidental capture in

commercial crab and net fisheries and bather protection programs; diseases, boat strike; poaching and illegal harvest; traditional collection of eggs and harvest of animals for meat (in Australia and neighbouring countries); feral animal depredation of nests and hatchlings; ingestion of and entanglement in marine debris.

Cumulative pressures

Commonly, pressures that marine turtles are exposed to in the World Heritage Area depend on the species and location. These pressures can vary in severity, spatially and/or over time (perhaps seasonally or during certain biological life stages). Pressures can be acute direct pressures such as deaths from boat strike, or chronic indirect pressures from declining water quality due to catchment run-off. Boat strike is common around entrances to busy ports or areas adjacent to major population centres. These localities may also be important foraging grounds for a particular genetic stock and be impacted by declining water quality from catchment run-off and habitat degradation from increased coastal and marine development. The combination of these pressures over time can cause impacts on marine turtle health, the availability or health of their food and eventually the status of the stock. That same stock may nest at another location where their eggs are harvested at levels that cause further pressure on the stock. These pressures may not seem significant if applied or assessed separately, however research indicates that the combined and cumulative impact of these major pressures present significant concern for the conservation of some species of marine turtles (or stock within a species) that occur in the World Heritage Area.

Management in the Great Barrier Reef

Legislative management tools in force for the conservation of marine turtles in the World Heritage Area include:

- The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- *Great Barrier Reef Marine Park Act 1975* (including the Cairns Area, Hinchinbrook and Whitsundays Plans of Management) and subordinate legislation
- The *Nature Conservation Act 1992* (Qld) and subordinate legislation
- *Fisheries Act 1994* (Qld) and subordinate legislation
- Spatial protection via the Great Barrier Reef Marine Park Zoning Plan 2003 (34 per cent of the Great Barrier Reef Marine Park closed to extractive use), along with the Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004 (Qld) which provides

complementary protection of coastal and some estuarine waters

- Dugong Protection Area regulations under the *Fisheries Act 1994* (Qld), with complimentary provisions under the Great Barrier Reef Marine Park Act, Species Conservation (dugong protection) Special Management Areas and Fish Habitat Areas (under the *Fisheries Act 1994* (Qld), provide subsequent protection for marine turtles and their supporting habitat
- Trawling strip closures under Queensland Fisheries Regulations 1995 compliment habitat protection provided by Marine Park zoning plans
- The Queensland Coastal Plan guides coastal development
- The regulation of land management practices for the improvement of water quality that enters the catchment under the *Great Barrier Reef Protection Amendment Act 2009* (Qld)
- And others (see management table, page 20).

Existing management actions

Management actions in the World Heritage Area aim to be outcomes focused and in part put legislative management tools into effect. They also provide strategic direction or additional guidance to management operations in the Marine Park.

In 2014, a comprehensive strategic assessment of the Great Barrier Reef World Heritage Area and adjacent coastal zone was completed. There are two components to the assessment, a marine component and a coastal component, which were undertaken by the Australian and Queensland governments, respectively.

Recommendations from the marine component of the strategic assessment report informed a separate Program Report for the Great Barrier Reef Region. The Program Report is a detailed description of the GBRMPA's management arrangements and future commitments to protect and manage the Great Barrier Reef. The Program Report details how the GBRMPA's current foundational management will continue to adapt and be strengthened to achieve its responsibilities over the next 25 years.

The *Great Barrier Reef Outlook Report 2014*¹ highlights threats to the Great Barrier Reef and reports marine turtles as being exposed to a range of pressures. Regional and local solutions to these pressures will be guided by the Program Report and strategic direction provided by planning documents to improve conservation outcomes for marine turtles. These planning documents include:

- Reef Water Quality Protection Plan 2013
- Great Barrier Reef Biodiversity Conservation Strategy 2013
- Great Barrier Reef Climate Change Adaptation Strategy and Action Plan 2012–2017
- Queensland Department of Environment and Heritage Protection's Back on Track Actions for Biodiversity documents 2010^{2,3,4,5,6,7,8}

- Raine Island Climate Change Adaptation Plan 2010–2070
- The National Recovery Plan for Marine Turtles in Australia and threat abatement plans under the EPBC Act 1999

A number of other management actions are in place in the World Heritage Area and its catchment. These include:

- The Land and Sea Country Indigenous Partnerships Program — Traditional Use of Marine Resources Agreements. Traditional use of marine turtles south of Cardwell has virtually halted as a voluntary conservation measure initiated by Traditional Owner groups
- Indigenous Land Use Agreements (which can include provisions for agreement on the traditional use of marine resources)
- Targeted compliance and enforcement through the joint Queensland Government and Great Barrier Reef Marine Park Authority (GBRMPA) Field Management Program and Indigenous Eyes and Ears compliance program.
- The Marine Wildlife Strandings Program reports on strandings and causes of mortality of marine turtles in Queensland (and other protected marine species). The program is provided with information from Queensland Fisheries on interactions with the Queensland Shark Control Program and fisheries interactions with species of conservation interest through mandatory logbook reporting under the Fisheries Regulations 2008
- Regular aerial surveys have been able to inform large-scale ecosystem planning and management by identifying areas of high dugong relative abundance
- Queensland Fisheries Regulations 2008 make it mandatory for trawlers to be fitted with satellite-linked vessel monitoring systems to track their movements which increases compliance with zoning plans and Fisheries Regulations
- Mandatory use of turtle exclusion devices in the East Coast Otter Trawl Fishery since 2001
- Public education of management actions through programs such as GBRMPA's Reef Guardians and listing of responsible reef practices for marine turtle protection within the Tourism Operator's Handbook: *Looking after protected species in Queensland: a comprehensive guide for commercial fishers* (Fisheries Queensland)
- Code of practice for the sustainable management of dugong and marine turtle tourism in Australia
- Stewardship, education and awareness programs that enable industry, organisations and individuals to minimise their impacts on the environment, such as the Reef Guardian program.

Great Barrier Reef Outlook Report 2014 assessment: Poor

Vulnerability assessment: high

- The combination of conservative life history traits (including being long-lived, having slow growth rates with delayed sexual maturity and high levels of egg mortality and mortality throughout their sub-adult phases) and the complex behaviour and ecology of marine turtles means they are particularly vulnerable to pressures. These traits also hamper the adaptive capacity of management activities as it can take many decades for population decline or recovery to become evident.
- Marine turtles demonstrate a high degree of fidelity to areas of their birth (natal philopatry), interesting areas and foraging areas.^{9,10,11,12,13} DNA analyses have revealed that marine turtles form discrete genetic stocks. If these stocks become depleted, they will not be 're-colonised' by other turtles from other stock, meaning they face extirpation (localised extinction).
- Although the southern Great Barrier Reef green turtle stock and the eastern Australian loggerhead turtle stock are showing increases in abundance, other stocks are stable, in decline or their status is uncertain. Some genetic stocks within certain species are more at risk than others.
- The northern Great Barrier Reef stock of green turtles is showing signs of a population that may be in decline.¹⁴ Three primary sources of pressure have been identified: a loss of hatchling production from the northern Great Barrier Reef nesting region, including Raine Island and Moulter Cay; the preferential selection of large mature females (traditional take and illegal poaching); and the possible overharvesting of eggs at some locations within the Torres Strait, Papua New Guinea and the Solomon Islands.
- Since 1990, monitoring of the nesting population of the Torres Strait–northern Great Barrier Reef stock of hawksbill turtles indicates there has been an annual rate of decline of three per cent. This decline is considered to be due to unsustainable harvesting of turtles in neighbouring Indo-Pacific countries. If the current rate of decline continues, this stock is expected to decline by more than 90 per cent by 2020 — in other words, in less than one generation for this species.¹⁵
- There are a suite of pressures that impact marine turtles in the World Heritage Area. These pressures may not impact each of the species, or stock within a species, every stage of life, or every location within their range. Generally, however, the greatest impacts threatening marine turtles within the World Heritage Area include:
 - declining nesting effort and reduced hatchling success and survivorship due to disturbance (light and other general sources) from inappropriate coastal development
 - incidental capture in commercial (trawl, longline and set mesh nets, crab pots) and recreational fishing apparatus (crab pots) and apparatus used for bather protection programs
 - boat strike (most significantly in areas adjacent to high-traffic ports or major population centres)
 - ingestion of and/or entanglement in marine debris (for Great Barrier Reef species that forage in northern Australia, entanglement in ghost nets adds another dimension to this pressure that requires a management response¹⁵)
 - where unmanaged, unsustainable traditional and/or illegal take of marine turtles and/or their eggs (mainly green turtles of northern Great Barrier Reef stock (meat and eggs) and hawksbill turtles (mainly eggs, internationally also shell)) within their Australian distributions, but more importantly throughout their international migratory ranges)
 - incidences of disease (with probable links to poor water quality, habitat degradation and climate change)
 - nest depredation by feral and native animals (generally speaking, red fox for southern nesting stocks and feral pigs for northern nesting stocks, although nest depredation by pigs is not occurring at high-density nesting sites within the World Heritage Area).
- Marine turtles are exposed to a range of pressures that may reduce their resilience to current and future impacts of climate change and impede their capacity to adapt to the expected rate of change. These pressures include accelerated rates of climate change; often declining or depleted populations; cumulative impacts of human-related threats; and a reduction of alternative habitats for nesting and foraging.
- Details of these major pressures on specific stocks of marine turtle species within the World Heritage Area are discussed further within this document.



Green turtle, *Chelonia mydas*

Background

Brief description of marine turtles

There are two extant families of marine turtles, Cheloniidae and Dermochelyidae. Both occur in waters of the World Heritage Area. Of the six recognised species of cheloniid turtles, four nest and forage in the World Heritage Area — these are the green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), loggerhead turtle (*Caretta caretta*) and flatback turtle (*Natator depressus*). Despite the capture of adult olive ridley (*Lepidochelys olivacea*) females off Townsville, Queensland, in the process of forming yolks in their ovum^b, this species has not been recorded nesting on Queensland's east coast and are only rarely encountered foraging in these waters.¹⁶

The family Dermochelyidae is represented by a single extant species, the leatherback turtle, *Dermochelys coriacea*. Leatherback turtles are recorded travelling through the Marine Park, but they have not been recorded nesting along the Queensland coast since 1996 and were only ever recorded nesting in very low numbers (maybe one or two females) prior to 1996.¹⁷

There has been monitoring and research on marine turtles that nest and forage in Queensland since the mid-1960s. This has contributed to the understanding of their nesting and breeding behaviour, population dynamics, feeding ecology and migratory behaviour. Similar research and monitoring programs have been conducted around the world, and where data is available it indicates a decline in many populations throughout their range.¹⁸ (Note: this does not apply to the major populations of green turtles around the world which have been shown to be steadily increasing.)¹⁹

Recent mitochondrial DNA analysis has demonstrated that on a global scale there are geographically discrete stocks of marine turtles, and that there is little interbreeding between the widely separated stocks that breed in Australia.^{20,21,22,23} Research indicates that each major grouping of rookeries supports an independent stock of turtle,^{24,25} which can be considered to represent separate management units.²⁶

Although specific biological characteristics differ between marine turtle species, both families share some common morphological features and life history traits. They live almost their entire lives in the marine environment but must surface to breathe. Like all extant turtles and tortoises, they have no teeth and their beaks are covered by keratinised sheathes. Marine turtles' senses provide them with an acute sense of smell, but no ability to taste. Their eyes are well developed with colour vision, and their hearing is restricted to very low frequencies (250–1000 Hz for loggerhead turtles²⁷ and 300–500 Hz for green turtles).²⁸

Much of our understanding of the life cycles of marine turtles in the World Heritage Area is from long-term studies on green and loggerhead turtles. After travelling hundreds to thousands of kilometres to forage, develop and accumulate the energy reserves required for breeding, male and female turtles return to their place of birth to breed and for the females to nest.^{10,11}

Mating usually occurs in the vicinity of the nesting beach some 30 days prior to nesting, after which the males return to their foraging grounds.²⁹ Females come ashore and lay spherical eggs with flexible calcareous shells which contain an embryo developed to the middle gastrula stage (early embryonic stage prior to organ development).³⁰

Within a breeding season, a female may come ashore two to seven times to lay clutches containing 50 (common to flatback turtles³¹) to 120 eggs (common to the large marine turtles).¹⁴ If disturbed during nesting, laying can be abandoned and eggs are either laid later or reabsorbed by the female. The number of eggs in a clutch is a function of the female's size.³² For successful incubation, the eggs must be buried in ventilated, low salinity, high humidity nest sites that are not subject to flooding or erosion and have a temperature range of 25–33°C.¹⁴ Incubation temperatures outside this narrow thermal envelope cause embryonic mortality.³³

The sex of the hatchlings is determined primarily by the temperature of the nest during the middle third of incubation.³⁴ Higher incubation temperatures produce predominantly female hatchlings, while lower temperatures produce predominantly males.^{35,36} The pivotal point^c for sex determination is between 29 and 30°C. Above the pivotal temperature, all hatchlings are female.³⁴

Hatchlings usually emerge at night, approximately 60 days after eggs are laid. The incubation period is a function of nest temperature, with higher temperatures leading to a reduced incubation period.³⁵ There is no parental care of the eggs or hatchlings. When hatchlings emerge from the nest, they orientate towards the brightest horizon line (the ocean). Once they are in the water, they swim at 90 degrees to the surf.³⁷

Once offshore, hatchlings enter oceanic currents and may congregate along the convergence zones of ocean fronts where they spend between five and 15 years foraging on zooplankton.³⁸ In these oceanic convergence zones, they associate with floating seaweed mats and other inanimate material such as marine debris.^{39,40}

^b Known as vitellogenesis which occurs with the enlargement of follicles in the ovaries with yolk in preparation for fertilization.

^c The theoretical temperature that produces a 1:1 ratio of males to females.

After this pelagic life-stage, marine turtles return to take up residence in reefal or inshore foraging areas.⁴¹ The flatback turtle is an exception to this common marine turtle life stage, lacking an oceanic phase to its development. Instead, in eastern Queensland waters the flatback turtle is believed to follow a surface-water dwelling, planktonic life over the continental shelf inside the Great Barrier Reef lagoon.^{42,43}

Species specific information

Green turtle



Green turtle (*Chelonia mydas*) hatchlings emerging from the nest

There are two main breeding populations (or management stocks) of green turtles in the Great Barrier Reef Marine Park: the northern Great Barrier Reef stock and the southern Great Barrier Reef stock.

The northern stock nests on cays and islands of the far northern sector of the Great Barrier Reef and the Torres Strait. Data from turtles recaptured after being tagged suggest most forage in the Northern Territory, Gulf of Carpentaria, Torres Strait, southern and eastern Papua New Guinea and on the east coast of Queensland north of Round Point (which is southward of Lockhart River).¹⁴

The southern stock nests at sites within the Capricorn–Bunker Group of islands and cays, the cays of the Swains reefs, and beaches in the Great Sandy Region of south-east Queensland (which lies outside of the Marine Park). Data from turtles recaptured after being tagged suggest the foraging

range for most of the stock extends along eastern Australia south of 14°S (Princess Charlotte Bay) to central New South Wales and to New Caledonia.

Green turtles within both the northern and southern Great Barrier Reef stocks reach first maturity between 30 and 50 years of age.⁴⁴ This time frame for maturation is the longest of all the marine turtles.

Northern Great Barrier Reef Stock

Raine Island is an outer-shelf coral cay at the northern end of the Great Barrier Reef which supports one of the few remaining large breeding aggregations of green turtles in the world.^{19,13} Of these, the Raine Island aggregation is the largest. As a consequence, it has extremely high conservation value. Both Raine Island and nearby Moulter Cay support about 80 per cent of the breeding population of the northern Great Barrier Reef stock of green turtles. Raine Island has been the primary index beach for monitoring trends in the northern Great Barrier Reef stock since the 1974/1975 breeding season.¹³

Although nesting can occur year round, it mostly occurs between October and March, and reaches its peak in late December to early January. Most green turtles that nest at Raine Island return to breed after four to seven years.¹³ However, no total tagging census of nesting females has been conducted at this site due to the operational constraints of its remote locality and because of the high nesting numbers. The metric used by researchers to gather population data has been a mean nightly tally count.^{d,14}

Population trends are difficult to assess, as nesting turtle numbers fluctuate from year to year as a result of variable climatic conditions driven by the Southern Oscillation Index (SOI).¹³ It appears the climatic variation associated with fluctuations of the SOI may regulate the primary productivity of seagrass meadows and macroalgae that provide the main forage for green turtles. This impacts the rate green turtles can accumulate the fat reserves they need to prepare for migration and breeding.⁴⁵ The El Niño Southern Oscillation precedes increased breeding participation by two years, whereas La Niña conditions reduce breeding participation in the same time frame. This is because heavy rainfall increases disturbance of seagrass meadows. The outflow also reduces the productivity of seagrass and its abundance.^{46,47,48} These effects of SOI fluctuations are consistent across the northern and southern Great Barrier Reef stocks and apply similarly to male and female green turtle migrations.¹⁴

Southern Great Barrier Reef stock

For approximately four decades, Heron Island at the northern end of the Capricorn-Bunker group of islands in the southern Great Barrier Reef, has been monitored annually using an extended season total tagging census.¹⁴ The nesting period and peak for the southern Great Barrier Reef stock of green turtle is the same as that described for the northern stock.¹⁴

^d The average number of females ashore for nesting that are counted during one complete search of the nesting habitat at night. The count is commenced an hour after the tide level enables turtles to swim across the reef to access the entire nesting habitat.

Stock status of northern and southern Great Barrier Reef stocks

A study of six of the world's major green turtle populations has shown that globally green turtle stocks are recovering from previously depleted levels.¹⁹ Within this study, the southern Great Barrier Reef stock has shown small but sustained growth over the past three decades at the rate of about 3.8 per cent per annum.¹⁴ For the northern stock, with Raine Island as the index site, long-term data indicates that although the stock has increased significantly since the mid-1970s, the past two decades have seen a plateau and slight decline to the previously sustained increase in nesting numbers.¹⁹ With the average size (the curved carapace length, measured in centimetres) of nesting females decreasing, and the remigration periods for nesting increasing, the northern stock of nesting females may be showing signs of being in the early stage of decline.^{13,14} There are also concerns regarding declines in nesting and hatchling success at Raine Island.^{13,14}

The population of nesting females in the southern stock is estimated to be 8000 in an average breeding season. Data gathered for this stock shows similar trends, with the average curved carapace length of nesting females decreasing at the Heron Island index site.¹⁴ This suggests that despite steady numbers of nesting females, the proportion of large females in these stocks is decreasing. This may be an early warning sign that indicates the loss of adult turtles from the population. Although these trends take two to four decades to confirm, this trend would be the precursor of a population decline if not abated through management actions.¹⁴

Diet and habitat requirements

Immature and adult green turtles feed in tidal and subtidal habitats including seagrass meadows, coral and rocky reefs and algal turfs on sand, mud flats and rocky foreshores. At approximately 44 centimetres curved carapace length, they recruit to inshore foraging habitats where they become primarily herbivorous, feeding on seagrass, a wide range of algae and mangrove fruits.^{49,50,51} They occasionally feed on macroplankton including jellyfish (*Catostylus mosaicus*), and bluebottles (*Physalia*), dead fish and small crustaceans.¹⁴

Hawksbill turtle



Hawksbill turtle, *Eretmochelys imbricata*

The hawksbill turtles that inhabit the Great Barrier Reef are considered to originate from the Torres Strait–northern Great Barrier Reef genetic stock and the Solomon Islands stock.²⁰ Although not categorically defined by genetic studies, the differential timing of peak nesting for hawksbill turtles that nest in the Northern Territory, compared with those that nest in the Torres Strait and northern Great Barrier Reef, suggest these nesting populations are unlikely to be interbreeding and can be considered as separate stocks.¹⁵

In the Coral Sea region, including the Great Barrier Reef and central to eastern Torres Strait, hawksbill turtles nest year round with a peak around January to February.^{52,53,54} Hawksbill turtles in north-eastern Australia have an unusually long remigration period

for the species: five years between breeding seasons. Less than two per cent of females return to breed at less than three year intervals.⁵⁵ Growth and timing of sexual maturity vary between populations.⁵⁶ Sexual maturity is not reached until after 31 years of age.⁵⁷

A portion of the Torres Strait–northern Great Barrier Reef hawksbill turtle stock that breeds in northern Queensland (northern Great Barrier Reef and Torres Strait) also forages within these same areas, whereas the remainder migrate to and from eastern Indonesia and the Gulf of Papua to forage. Whereas most marine turtle species show a high degree of philopatry (fidelity to natal beaches), a small proportion of the nesting population of hawksbill turtles interchange among adjacent rookeries up to 38 kilometres apart, both between and within breeding seasons.^{55,58}

In more than 70 years of records in the Great Barrier Reef there is only one record of hawksbill turtles nesting south of Princess Charlotte Bay. Emergent hatchlings were observed at Rocky Island (14°14'S, 144°21'E) in January 1997 (E. Gyuris, pers. comm. in Limpus 2009¹⁵).

Stock status

Approximately 4000 female hawksbill turtles are estimated to nest in Queensland; these (together with an estimated 2500 females in eastern Arnhem Land) constitute one of the most significant nesting populations of this species in the world.⁵⁹ Queensland has major nesting sites in central and eastern Torres Strait and the northern Great Barrier Reef. Milman Island, in the northern Great Barrier Reef, has annual numbers of nesting females approximating between 100 and 500,¹⁵ and was selected as the primary index beach for monitoring the long-term variability in the size of the Torres Strait–northern Great Barrier Reef hawksbill turtle subpopulation.

The nesting population was monitored using a one-month, nightly tagging census timed to coincide with the peak nesting period (mid-January to mid-February), starting from the 1990–1991 breeding season through to 2000.^{53,54}

This 10-year study showed an annual rate of decline of three per cent in the nesting population.⁵⁵ The trend was supported by a subsequent eight-year study (spanning 11 years) of a foraging component of the population inhabiting the Howick group of islands, which is also in the northern Great Barrier Reef.⁶⁰ This study found a similar decline occurred between the late 1990s and the late 2000s. However, between 2003 and 2008 the population appeared to stabilise.⁶⁰ Although this study was not able to indicate a long-term trend, it may suggest an encouraging sign that some threatening processes for this stock may be ameliorating.⁶⁰

However, it remains that if the current rate of decline measured at the Milman Island index beach continues, then the Torres Strait–northern Great Barrier Reef hawksbill turtle stock can be expected to decline by greater than 90 per cent by 2020 — that is, in less than one generation for the species.¹⁵ Since 2000 there has been no ongoing monitoring work tracking the hawksbill population nesting on Milman Island.

Mortality for this species comes mostly from pressures outside the Great Barrier Reef Marine Park through the harvest of turtles and eggs for human consumption and the bekko (tortoise shell) harvest in Indonesia. Mortality is also significant through entanglement in ghost nets across their northern Australian foraging range.¹⁵

Diet and habitat requirements

Foraging hawksbill turtles are most frequently encountered in tidal and subtidal coral and rocky reef habitats throughout tropical Australia and in warm temperate areas as far south as the Solitary Islands in northern New South Wales, but they also occur in low density in open seagrass meadows.^{57,61} Hawksbill turtles are omnivorous and feed primarily on sponges and algae and in some localities, seagrass.⁶¹ During 2006 and 2007, Bell⁶² showed that hawksbill turtles within the Howick group of islands fed primarily on red, green and brown algae and were secondarily omnivorous, feeding on sponges, soft corals and a wide variety of invertebrate species.

Loggerhead turtle



Loggerhead turtle, *Caretta caretta*, nesting

Loggerhead turtles that inhabit the Great Barrier Reef occur within the eastern Australian stock which breeds in southern Queensland. Their foraging range encompasses the eastern Arafura Sea, Gulf of Carpentaria, Torres Strait, Gulf of Papua, Coral Sea, and western Tasman Sea to southern New South Wales including the Great Barrier Reef, Hervey Bay, and Moreton Bay. The outer extent of their foraging range includes coastal waters in eastern Indonesia, north-eastern Papua New Guinea (Trobriand Islands and Woodlark Islands), north-eastern Solomon Islands and New Caledonia.^{9,63,64}

In southern Queensland, mating commences in about late October, reaches a peak in November and ceases by about early December. Nesting starts in late October, reaching a peak in late December and ends in about early March. Hatchlings emerge from nests from late December until about May with a peak of hatchling

emergence in February and early March.^{41,65}

Loggerhead turtles in the south-western Pacific Ocean are slow growing, taking about three decades to grow from hatchlings to breeding adults. They recruit from their pelagic stage to inshore foraging grounds with a curved carapace length of about 79 centimetres, where they remain resident for approximately 13 years before breeding.⁶⁶ They demonstrate a strong tendency to return to their breeding locations and foraging grounds.

Stock status

The islands and cays of the Swains Reefs and Capricorn–Bunker group in the southern Great Barrier Reef and mainland beaches of the Bundaberg coast support the only significant nesting by loggerhead turtles in the South Pacific Ocean.^{67,68} Until recently, fewer than 300 loggerhead turtles nested annually in Queensland — a decline of 70–90 per cent from the estimated population of 3500 in 1976–77. There was a decline of 50–80 per cent over 10–15 years up to 1990 in the eastern Australian loggerhead population,⁶⁷ and a decline of approximately 86 per cent by 1999.⁶⁸ Annual monitoring has revealed that since 2001, when the use of turtle exclusion devices on otter trawlers became mandatory, the previous long-term decline in nesting loggerhead turtle numbers has reversed. There is now an increasing trend at all eastern Australian loggerhead turtle index beaches.⁴¹ During the 2009–2010 nesting season, 400 nesting females were recorded nesting at Mon Repos on the Woongarra Coast north

of Bundaberg (C.J. Limpus, pers. comm. 2010), where the greatest nesting aggregation for this stock occurs. This data corresponds to a significant decline in loggerhead turtle numbers coming aboard trawlers since the introduction of turtle exclusion devices were introduced.⁶⁹ However, mortalities from other cumulative human-related pressures continue to threaten the recovery of this formerly depleted stock.⁴¹

Diet and habitat requirements

Large immature and adult-sized loggerhead turtles from the eastern Australian management unit feed in a wide range of tidal and subtidal habitats including coral and rocky reefs, seagrass meadows, and soft-bottomed sand or mud areas.

Adult and large immature loggerhead turtles are carnivorous, specialised for feeding on hard-bodied, slow moving invertebrate prey. In eastern Australian coastal waters, loggerhead turtles feed mainly on gastropod and bivalve molluscs, portunid crabs and hermit crabs.³² They feed less frequently on other invertebrates (including jellyfish, anemones, holothurians, sea urchins) and fish. There are records of this species feeding on about 100 different taxa.^{32,63}

Flatback turtle

Flatback turtles are the only marine turtle endemic to Australian waters. The stock which nests in the Great Barrier Reef is known as the eastern Australian stock. Its breeding period is highly seasonal. Mating occurs before nesting commences in mid-October. Nesting activity reaches a peak in late November to early December, and ceases by about late January. Hatchlings emerge from nests during early December until about late March, with a peak of hatching in February.^{31,42} Females remigrate to nest every two to three years.^{70,71} Alternatively, nesting in the Gulf of Carpentaria–Torres Strait stock occurs all-year round, with a peak mid-year.⁴²

The adult female displays a high degree of fidelity to her chosen nesting beach, with most females returning to the same small beach to lay eggs for successive clutches within and over successive nesting seasons.^{9,70} There is no data on age at maturity for flatback turtles, but compared to other Cheloniid species in Australia they are expected take three or more decades to reach maturity.⁴²

The foraging distribution for the eastern Australian stock extends from Hervey Bay to Torres Strait and possibly into the Gulf of Papua.^{72,73,74} When flatback turtles cease their pelagic life history phase over the continental shelf of the outer Great Barrier Reef, they change to inhabit subtidal soft bottomed inshore habitats, probably without changing their geographical distribution.⁴²

Stock status

There are four Australian stocks of flatback turtles. Of the two that exist in Queensland, one inhabits the Great Barrier Reef and the other the Gulf of Carpentaria. Genetic analysis of the two populations has found them to be independent from each other and from both the other two northern Australian management units.²² Three decades of research and monitoring of the eastern Australian stock at rookeries in the central Great Barrier Reef region (centred on Peak, Wild Duck, Avoid and Curtis Islands) show the population is stable, though conservation dependent.^{75 e}

Diet and habitat requirements

Flatback turtles have rarely been encountered in intertidal seagrass meadows or in coral reef habitats.⁴² Within otter trawl fisheries, flatback turtles have been captured in soft-bottomed waters, mostly between 6–35 metres deep within the Great Barrier Reef and at 11–40 metres depth in Torres Strait.⁷⁴ Females tagged at the southern Great Barrier Reef rookeries have been recaptured throughout the inner shelf area of the Great Barrier Reef from Gladstone northwards to Torres Strait.

Large flatback turtles are carnivorous, feeding principally on soft-bodied invertebrates including soft corals, sea pens, holothurians and jellyfish.⁴²

^e The northern population nesting in the Gulf of Carpentaria has not been extensively monitored. It is thought that excessive depredation of turtle eggs by feral pigs in north-western Cape York Peninsula, previous high mortality through prawn trawling, entanglement in ghost nets and Indigenous hunting will put this population under some pressure, with some suggesting that it is already in decline.⁴²

Olive ridley turtle



Olive ridley turtle, *Lepidochelys olivacea*, with satellite tracking device

There are two main breeding areas for olive ridley turtles in Australia: one in the Northern Territory which supports about 1000 nesting females a year, and the other in the Gulf of Carpentaria with estimates of 100 nesting females a year. There are no records of olive ridley turtles nesting along the east coast of Australia, even though vitellogenic adult females in the process of producing egg yolks have been captured in foraging areas off Townsville, Queensland.¹⁶ No census has been made of the size of the nesting population in Queensland. No Queensland rookeries are managed within National Parks or similar protected habitat.¹⁶ However, a substantial part of their east coast foraging range is contained within the Great Barrier Reef Marine Park and the Queensland Great Barrier Reef Coast Marine Park.

Australian nesting populations of olive ridley turtles are currently considered to be a single management unit and to be genetically distinct from populations nesting in other countries.¹⁶ Nesting appears to be all year round, with a peak in the early dry season from April to June.¹⁶ To date, no growth measurements have been made for olive ridley turtles in Australia.¹⁶

Stock status

From the review by Limpus:¹⁶

"Historically within Australia, research and monitoring of olive ridley turtles has been neglected, primarily because of their "remote" feeding and nesting distribution. It is presumed that the Australian population is small relative to some other countries.

Assuming that the population dynamics of olive ridley turtles is not very different to that of the better studied species and given the estimate of only a few thousand nesting olive ridley turtle females annually, then the Australian population is unlikely to be able to sustain an annual mortality of many hundreds of large immature and adult turtles and large numbers of clutches over the long term.

There is a distinct possibility that the Australian olive ridley turtle population is already in decline and is one of the most threatened species of marine turtle in Australia. With no monitoring of the population in place, it is impossible to determine its current status with certainty."

Diet and habitat requirements

The Australian olive ridley turtle population behaves differently to eastern Pacific populations which use oceanic pelagic waters during the entire post-hatchling, immature and adult life history phases. Research has shown that at least a substantial part of the immature and adult Australian olive ridley population forages over shallow seafloor habitats from northern Western Australia to south-east Queensland.^{76,77} Satellite telemetry studies of post-breeding migrations of adult females have verified this, with the five turtles studied remaining within continental shelf waters.⁷⁶ Until there is data that challenges this finding, it is assumed that adult Australian olive ridley turtles forage on soft bottom, benthic communities on the northern Australian continental shelf.¹⁶ The species has not been recorded living in coral reef habitat or shallow inshore seagrass meadows.¹⁶ Prior to the introduction of turtle exclusion devices in 2001, the species was most frequently captured at 6–35 m depth within the Queensland East Coast Otter Trawl Fishery.⁷⁴

Adult and large immature olive ridley turtles are carnivorous, feeding principally on gastropods, molluscs and small crabs.¹⁶

Leatherback turtle

Leatherback turtles are one of the fastest growing marine turtles. Individuals from the eastern Pacific population are estimated to reach maturity in 13 years.⁷⁸ There are no equivalent studies for leatherback turtles of the south-western Pacific.

Mating has not been recorded for this species in Australian waters. Nesting in south-eastern Queensland formerly commenced in mid-December, reaching a peak in January and ending in about mid-February.⁷⁹

Stock status

No large rookeries for the leatherback turtles occur in Australia. There has been a progressive decline in breeding frequency for leatherback turtles in eastern Australia from low-density, annual nesting between 1973 and 1983 to today where nesting is not recorded.¹⁷ While some Australian nesting has previously been recorded on the mainland coast north of Bundaberg and along the coast of Arnhem Land, the decline in recorded nesting attempts indicates the population that frequents Australian waters is likely to be in decline. This correlates with

recent reports of a significant decline in Pacific Ocean leatherback turtle populations.⁸⁰ The last recorded nesting by a leatherback turtle in Queensland was in February 1996.¹⁷

During the 1980s, leatherback turtles were regularly hooked by drum lines set within the Queensland Shark Control Program in south-east Queensland waters. Such interactions have been rare since 1992, providing further evidence that the number of leatherback turtles entering southern Queensland coastal waters has declined in the past two decades.⁸¹

Australian breeding populations of leatherback turtles have not been included in the global population genetics assessment of marine turtle stocks²² and their genetic relatedness to other leatherback turtles in the south-western Pacific Ocean remains unknown.¹⁷ There is limited census data by which to measure the status of the species within Australian waters. If leatherback turtles that occur in Australian waters are part of south-west Pacific Ocean stocks, then animals in our waters must be in decline in line with the reductions seen in leatherback turtles across the Pacific basin and south-east Asia.¹⁷ As stated by Limpus,¹⁷ if the leatherbacks that breed in Australia are a separate stock, then given the low nesting numbers and poor incubation success, this stock has a low chance of survival.

Diet and habitat requirements

Leatherback turtles are generally regarded as an oceanic species that does not have a juvenile or adult phase where they live in shallow nearshore waters.⁸² However, this species has been regularly recorded foraging in inshore waters less than 3 metres deep in the south-eastern Gulf of Carpentaria, more than 1000 kilometres from the nearest oceanic waters.¹⁷ This suggests its life history strategy may not strictly conform to the oceanic life history pattern generally ascribed to it. It is a widely distributed inhabitant of oceanic waters surrounding Australia,⁸³ but its fine-scale distribution in this region is poorly documented.

Leatherback turtles are carnivorous. In Australian waters it feeds extensively on colonial tunicates such as *Pyrosoma spp.*,⁸⁴ jellyfish such as *Catostylus spp.* and other soft-bodied invertebrates.^{85,86} It will feed at all levels of the water column from the seafloor to the surface.⁸⁶

Geographical distribution

With the exception of the flatback turtle, each of the six species of marine turtles residing within the World Heritage Area is distributed throughout the world's tropical, subtropical or temperate waters.^{87,88}

Flatback turtles have a restricted distribution. It is one of only two marine turtles not having a global distribution (the other being the Kemp's Ridley, which is restricted to the Gulf of Mexico and U.S. Atlantic seaboard, from Florida to New England). All recorded nesting beaches for the flatback turtle are in Australia.⁴² The species forages widely through the northern waters of the Australian continental shelf to as far north as the Gulf of Papua in Papua New Guinea and coastal waters of Indonesian western Papua.⁸⁹ Connected by the Sahul Shelf joining Australia to Papua New Guinea and the eastern islands of Indonesia, the species has been recorded from the coastal waters of Kei in eastern Indonesia.⁹⁰

Population status in the Great Barrier Reef Marine Park

All species of marine turtles found in the Marine Park are listed as threatened under Queensland and Commonwealth legislation and by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species.^f

An analysis of the population status for individual species is discussed within the background information provided above. A summary is provided below:

- Loggerhead turtle:** Eastern Australian stock — breeding female population currently recovering, though highly conservation dependent; previously, stock depleted considerably due to human-related impacts. Stock is highly conservation dependent.
- Green turtle:** Northern Great Barrier Reef stock — increased from mid-1970s. Past 20 years has seen evidence of a population that may be in decline.¹⁴ Stock is highly conservation dependent. Southern Great Barrier Reef stock — evidence of population increase at 3.8 per cent per year for the last three decades. Stock is highly conservation dependent.
- Hawksbill turtle:** Primary index nesting site at Milman Island indicates Torres Strait–northern Great Barrier Reef stock is in decline at around three per cent per year.⁵⁵ At this rate the stock can be expected to decline by greater than 90 per cent by 2020, that is, in less than one generation for the species.¹⁵
- Flatback turtle:** Eastern Queensland stock currently stable but conservation-dependent.

^f The IUCN Marine Turtle Specialist Group has recently developed a conservation priorities portfolio framework that allows for the evaluation of risk and threats to marine turtles at various spatial scales. This is designed to help guide research and conservation priorities across biogeographically defined regional management units which are more relevant to marine turtle ecology and the variation in pressures they experience across these spatial areas⁹¹.

- Leatherback turtle:** Very low numbers of leatherback turtles were known to have nested in the World Heritage Area, though no records have been made since February 1996. Population observed in the World Heritage Area is considered to be part of south-west Pacific genetic stock that is in decline.
- Olive ridley turtle:** No nesting occurs in eastern Australia and there is no information for determining the status of the olive ridley turtle population anywhere in the World Heritage Area.

Ecosystem role/function



Green turtles, *Chelonia mydas*, mating on a reef flat

Green turtles play a major role in seagrass ecosystems. They have been found to affect the structure and productivity⁹² as well as the nutrient composition⁹³ of seagrass meadows. Other species, such as loggerhead and hawksbill turtles, as mid to low-order carnivores and omnivores respectively, contribute to sediment production/bioerosion (erosion of substrate) and bioturbation (mixing of sediment by burrowing, feeding or other such behaviours) in inshore, deepwater and coral reef ecosystems.^{32,94} Not only do marine turtles provide nutrient-cycling services within their foraging grounds, but they also transport substantial quantities of nutrients from rich foraging grounds to often nutrient-poor mating and nesting grounds.⁹⁵ For example, in a study on Melbourne Beach, Florida, less than one third of the energy and nitrogen contained in eggs deposited by loggerhead turtles returned to the ocean in the form

of hatchlings.⁹⁵ They also act as bioturbators of beach habitat during nest construction, which is likely to influence habitat composition and the structure and production of ground vegetation.

On a broader ecosystem-level, as higher-order predators, crocodiles, large sharks and killer whales predate upon adult and juvenile marine turtles. These animals provide a vital source of protein. At nesting locations, scavenging and predatory bird species migrate over large spatial areas to exploit protein sources in the form of turtle carcasses, eggs and emergent hatchlings. Large fish (e.g. *Caranx* sp., trevallies) and shark species also feed on turtle hatchlings.¹³

Other studies have demonstrated that as long-lived animals, adult marine turtles are predicted to invest in anti-predator behaviour even when predation risk is relatively low to avoid the reproductive costs of an early death. Several studies suggest predators may influence behaviour and habitat use of adult turtles. For example, in a healthy ecosystem in Australia, green turtles, especially those in good body condition, demonstrate avoidance behaviour of profitable feeding areas in order to be safe from tiger sharks.⁹⁶ Heithaus⁹⁶ hypothesises that if marine turtles modify their foraging habitat use in response to predators, the patterns of effects produced by marine turtles on their communities could be shaped by predators through space and time. Such findings highlight the importance of understanding the connectivity of ecosystem processes when considering a whole-of-ecosystem approach to natural resource management.

Ecosystem goods and services

Ecosystem goods and services category	Services provided by the species, taxa or habitat
<p>Provisioning services (e.g. food, fibre, genetic resources, bio-chemicals, fresh water)</p>	<p>Marine turtles provide a provisioning service for Australian Indigenous people where they provide sustenance, particularly for isolated communities where store-bought food is often very expensive.</p> <p>Quantitative species-specific information on traditional use of marine turtles is lacking.</p>
<p>Cultural services (e.g. spiritual values, knowledge system, education and inspiration, recreation and aesthetic values, sense of place)</p>	<p>Marine turtles are of enormous cultural, spiritual and economic (subsistence) importance to Indigenous people. Through a long association with marine turtles, Indigenous people have developed a detailed body of traditional ecological knowledge which includes information on the natural history and ecology of these animals. Marine turtles have spiritual significance, which is reflected in the stories and accounts of the past in many coastal Indigenous communities. Their spiritual significance fulfils roles in traditional lore on their management and use. Resources such as marine turtles and other traditional foods also reinforce a living culture and demonstrate continuity with tradition and traditional estates as required for establishing native title rights under the <i>Native Title Act 1993</i>.</p> <p>In ceremonies, marine turtles play different roles for many coastal Indigenous people. In some areas the marine turtle forms part of creation stories and can be found in all aspects of spirituality, art and life. The activity of pursuing the turtle itself has great significance and is an expression of continuing a long cultural tradition.</p> <p>The importance of the hunting and butchering of the turtle is also expressed through the social sharing of the animal as food according to traditional kinship protocols. When first given the opportunity, the hunt may also form an important part of a young male's progression from boyhood to manhood.</p> <p>Aesthetic and intrinsic conservation values provide a strong social and economic impetus for the conservation of marine turtles. Nature-based tourism focusing on marine turtles provides significant input into the Australian economy. For many people, marine turtles are iconic and can represent symbols of inspiration or have spiritual value.</p>
<p>Supporting services (e.g. primary production, provision of habitat, nutrient cycling, soil formation and retention, production of atmospheric oxygen, water cycling)</p>	<p>Marine turtles may help to support island and reefal ecosystems by cycling nutrients via the transport of substances from rich feeding grounds to often nutrient-poor nesting sites. They also cycle nutrients within the ecosystems in which they forage.</p> <p>Marine turtles may also play a significant role as bioeroders of ecosystems in which they forage. Hawksbill turtles that feed upon algae and sponges can ingest and digest the substrate on which their food grows upon, transporting it to other locations.</p> <p>Marine turtles also act as bioturbators, as they mix sediment during nest construction. Loggerhead turtles have been observed burrowing for prey in the seafloor and can be considered to act as bioturbators and bioeroders in this process.^{32,94}</p>
<p>Regulating services (e.g. invasion resistance, herbivory, seed dispersal, climate regulation, pest regulation, disease regulation, natural hazard protection, erosion regulation, water purification)</p>	<p>Marine turtles play a significant role in the ecology of reefs and seagrass meadows where they contribute to maintaining species composition and productivity of these habitats as a result of their foraging behaviours.^{92,93} Marine turtles also support coral recruitment through the process of herbivory on epilithic algae in reef habitats.</p>

Pressures influencing marine turtles in the Great Barrier Reef Marine Park

Pressures

Marine turtles are exposed to a range of pressures, both direct and indirect, over the course of their lives. These pressures can impact on the immediate survival of individuals or a population (such as the acute pressure from a cyclone on a nesting beach) or be exerted over the long term (chronic pressure), where different impacts may act cumulatively to affect their survival. Marine turtles can be more exposed to these pressures at different life stages; or seasonally, when endeavouring to meet biological needs of breeding; or habitually as they seek to meet ecological requirements, such as feeding. The different species of marine turtle that occur in the World

Heritage Area may also have varying degrees of sensitivity to pressures due to differences in their life history strategies, behaviour or ecology.

The ecology and life history traits displayed by the six species of marine turtle that occur within the World Heritage Area are complex and varied, and for most of these species knowledge gaps exist that make the task of managing the threats they face difficult. Despite these knowledge gaps, there is a considerable body of information available, and management decisions must take into account reasonable predictions of likely effects of human activities on marine turtles. While information gaps must be addressed for management to be effective in the long term, the precautionary principle must be applied at the same time to take reasonable actions to avoid or minimise potentially serious or irreversible effects. Regularly evaluating the effects of human activities on marine turtles, as well as determining the conservation status of the various populations, are essential for detecting problems early and for allowing management measures to be evaluated and modified.⁹⁷

There are a suite of pressures that impact the six species of marine turtle that occur in the World Heritage Area (also refer to Table 1 below):

- cumulative impacts from habitat loss and degradation as a result of climate change and extreme weather impacts (for example, reduced hatchling success from sea level rise and/or flooding and altered sex ratios from increased nesting beach temperatures); the impact of reduced water quality on foraging resources due to extreme weather events, catchment run-off and coastal development.
- reduced adult reproductive output and hatchling success and survivorship due to disturbance on nesting beaches (light and other general sources) from inappropriate coastal development
- incidental capture in commercial (trawl and set mesh nets, crab pots) and recreational fishing apparatus (crab pots) and apparatus used for bather protection under the Queensland Shark Control Program
- where unmanaged, unsustainable traditional and/or illegal take of marine turtles and/or their eggs (mainly green turtles of northern GBR stock (meat and eggs) and hawksbill turtles (mainly eggs, internationally also shell)) within their Australian distributions, but more importantly throughout their international migratory ranges
- boat strike (mostly in areas adjacent to high-traffic ports or population centres)
- ingestion of and/or entanglement in marine debris (for Great Barrier Reef species that forage into northern Australia, entanglement in ghost nets adds another dimension to this pressure¹⁵)
- disease (with probable links to poor water quality, habitat degradation and climate change)
- nest depredation by feral (and native) animals (generally speaking, red fox for southern nesting stocks and feral pigs for northern nesting stocks).



Turtles can get entangled in floats, lines and other apparatus. Here a leatherback turtle, *Dermochelys coriacea*, in waters off Western Australia has wrapped a float line around its front flipper. Photo courtesy of D. Coughran

Table 1. Greatest impacts on marine turtles in the Great Barrier Reef Marine Park

Level of concern		Cumulative impacts from human-related activities (e.g. coastal development CD; declining water quality WQ; climate change impacts CC)	Mortality from incidental capture in fishing apparatus or nets set for bather safety	Indigenous take (internal or external to the World Heritage Area#)		Boat strike / port dredging	Ingestion of / entanglement in marine debris (can include ghost net entanglement during foraging / migration within and outside of the World Heritage Area)	Disease	Risk of nest depredation (Internal or external to World Heritage Area#)
				Animals	Eggs				
Low or no concern	Moderate concern	CC	ECIFFF, CPF, QSCP, ECTF, TSPF, NPF — low	moderate level of take	low level of take	low	(includes ghost net entanglement in the northern GBR)	low prevalence of disease	Feral pig, dogs* — moderate
				External	External				
High Concern	Unknown	CD WQ CC	ECIFFF, CPF, QSCP	low level of take	low level of take				Red fox, dogs (mainland sites) — low
			ECTF, TSPF — low	External	External				
Loggerhead turtle	Nthn GBR	CD WQ CC	OLL, ECIFFF, CPF, QSCP	low level of take	no take				Red fox, dogs — low
			ECTF, TSPF — low	External					
Hawksbill turtle	Sthn GBR	CC	ECIFFF, CPF, QSCP	very low level of take	low level of take	low	(includes ghost net entanglement in the northern GBR)		Feral pigs
			ECTF, NPF, TSPF — low	External	External				
Flatback turtle		CD WQ CC	ECIFFF, CPF, ECTF, TSPF, NPF, QSCP — low	no take	low level of take	low		low prevalence of disease	Red fox, dogs (mainland sites) — low
			External (feral pigs, dogs, goannas)						
Olive ridley turtle		CD WQ CC	Northern Australia commercial set mesh net, CPF	no take	no take	low	(includes ghost net entanglement in the northern GBR)	no	no
			External	External	External (feral pigs, dogs, goannas)				
Leatherback turtle			NPF, TSPF, ECTF, ECIFFF - low					no	
			QSCP	no take	no take				low
			OLL, ECIFFF, CPF — low						

Adapted from Limpus's Biological Reviews of marine turtles – Limpus^{14,41,15,42,16,17} (respectively in listed order from table above).

Incidental capture: *Fisheries within the Great Barrier Reef Marine Park*: set mesh net component of the East Coast Inshore Fin Fish Fishery (ECIFFF), crab pot fisheries (commercial and recreational) (CPF), Qld Shark Control Program – (QSCP), East Coast Otter Trawl Fishery (ECTF). *Fisheries outside the Great Barrier Reef Marine Park*: oceanic long-line (OLL), Northern Prawn Fishery (NPF), Torres Strait Prawn Fishery (TSPF)

* Risk is low in the World Heritage Area as depredation only occurs at low-density nesting beaches on the mainland east coast in northern Cape York Peninsula.
Listed as 'external' when the species occurring in the World Heritage Area experiences the threat when migrating outside the limits of the World Heritage Area to either nest or forage.

Vulnerability assessment matrix

According to the *Great Barrier Reef Outlook Report 2014*¹, the key pressures reducing the resilience of the Reef ecosystem are a number of commercial and non-commercial uses of the Marine Park, along with habitat loss and degradation due to climate change, coastal development and declining water quality from land-based (catchment) run-off.

The report considered these pressures are the key factors that influence the current and projected condition of environmental, economic and social values of the Great Barrier Reef. These pressures can impact directly and/or indirectly on habitats, species and groups of species to reduce their resilience to future impacts.

Using the vulnerability assessment framework adapted by Wachenfeld and colleagues,⁹⁸ this vulnerability assessment aims to provide an integrated assessment of social, ecological, economic and governance information on the conservation and management of marine turtles within the World Heritage Area.

For each key pressure in the Marine Park, exposure and sensitivity is assessed in relation to each other to determine a level of potential impact. The potential impact is then reassessed, having considered the level of natural adaptive capacity that marine turtles can exhibit to respond to the pressure and the adaptive capacity that management has, or can apply, to reduce the potential impact from the pressure.

This provides managers and stakeholders with an understanding of the key elements that each pressure can impose on marine turtles to reach a final assessment of the overall residual vulnerability of marine turtles to that particular pressure. This allows for suggested actions to be developed to minimise the impact of the pressures which marine turtles are most vulnerable to.

Although there are inherent difficulties in undertaking a combined assessment for such a complex group of species within the Marine Park, these have been best addressed in the detailed assessment and explanatory notes in Appendix 1. A summary of the assessment of the impacts of pressures is contained in the table below.

Vulnerability assessment matrix summary for marine turtles in the Great Barrier Reef Marine Park

		Exposed to source of pressure (yes/no)	Degree of exposure to source of pressure (low, medium, high, very high)	Sensitivity to source of pressure (low, medium, high, very high)	Adaptive capacity — natural (poor, moderate, good)	Adaptive capacity — management (poor, moderate, good)	Residual vulnerability (low, medium, high)	Level of confidence in supporting evidence (poor, moderate, good)
Pressures	Commercial marine tourism	Yes; locally (with regional significance)	Low	Medium	Moderate	Good	Low	Moderate
	Defence activities	Yes; locally	Low	Low	Moderate	Good	Low	Good
	Commercial fishing	Yes; Reef-wide	Medium	Medium	Moderate	Moderate	Medium	Good
	Recreational fishing	Yes; predominantly south of Cooktown	Medium	Medium	Moderate	Moderate	Medium	Moderate
	Ports and shipping	Yes; locally (with potential for regional significance)	Medium	Medium	Moderate	Moderate	Medium	Moderate
	Recreation (not fishing)	Yes; regionally	Medium	Low	Moderate	Moderate	Medium	Poor
	Traditional use of marine resources[#]	Yes; locally (with potential for regional significance)	High; for northern GBR* stock of green turtle at a stock level	High; for northern GBR* stock of green turtle at a stock level	Moderate	Moderate	Medium	Good
	Climate change	Yes	Very high	Very high	Poor	Poor	High	Poor
	Coastal development	Yes; predominantly south of Port Douglas	High	High	Moderate	Moderate	Medium	Poor
	Declining water quality due to catchment run-off	Yes; predominantly south of Cooktown	High	High	Moderate	Moderate	Medium	Poor

[#] Traditional use within the World Heritage Area is primarily of green turtles and the eggs of green, hawksbill and flatback turtles.

* For the majority of this stock, the Australian foraging range extends from the Northern Territory through the Gulf of Carpentaria and Torres Strait, and south along the eastern Queensland coast to approximately 15°S (just south of Cape Melville).

Key concerns

The effective conservation of marine turtles requires the protection of key habitats and management of key threats. Animals are particularly sensitive to impacts from human-related activities in and adjacent to key habitats. The following impacts are of key concern:

- Due to the difficulty in obtaining accurate population counts across the different life stages of marine turtles, trends in numbers can take many decades to detect. This is a challenge for management because it is extremely difficult to assess whether populations are stable, increasing or declining and to assess the effectiveness of management strategies and actions once implemented. Turtle stocks present today are the result of impacts and actions from 10–50 years ago and more; the effectiveness of management strategies implemented today may not be measurable for another 10–50 years.
- Within the life cycle of a marine turtle, there are certain common biological characteristics which expose them to sources of pressure. These produce high levels of mortality from natural and human-related threats before and after reaching maturity. Although female marine turtles produce high numbers of eggs, the survival rate for an individual to grow from an egg to a breeding adult is very low, possibly less than one in 1000.^{99,100} Mortality

levels must be addressed for all age classes. However, population models have shown that reducing levels of adult mortality is the most important strategy for the long-term survival of marine turtle populations.¹⁰¹

- Marine turtles demonstrate high degrees of fidelity to their areas of birth (natal philopatry), internesting areas and foraging areas. DNA analysis has revealed that marine turtles form discrete genetic stocks (conceptualised as management units). These have been described for the eastern Australian loggerhead, northern and southern green, eastern Queensland flatback and Torres Strait–northern Great Barrier Reef hawksbill turtle stocks. Although work remains to describe the genetic composition of hawksbill turtles that forage in the southern Great Barrier Reef and leatherback and olive ridley turtles that also occur in the World Heritage Area, it is expected that these animals form part of discrete genetic stocks for their respective species. If these stocks become depleted, they will not be ‘re-colonised’ by other turtles from other stock and face localised extinction.
- Although the long-term trend for the northern Great Barrier Reef stock of green turtles has shown a steady increase in nesting numbers, recent decades have seen that trend plateau.¹⁹ Signs indicate that the stock may be in decline.^{13,14} Being so long-lived and with such complex life histories, there are inherent difficulties in predicting with confidence the population status of marine turtles. However, the recorded lower nesting remigration rates and decrease in the mean size of breeding females for this stock is an indication of a population that may well be in the early stages of decline.
- Size class data collected for the southern Great Barrier Reef stock of green turtles is showing similar trends to the northern Great Barrier Reef stock, even though long-term nesting data shows an uninterrupted steady increase for the southern stock. Although the two stocks are exposed to different pressure dynamics unique to their respective geographic ranges, a precautionary approach must be taken with a focus on reducing all pressures that they face (refer above to greatest threats).
- Raine Island in the northern Great Barrier Reef is recognised as the site that supports the largest remaining aggregation of nesting green turtles in the world. There is real concern for this stock based on data that indicates a significant decline in nesting and hatching success at this location. A number of other concerns for marine turtles (and seabirds) that breed on this island have been identified as requiring direct action in order to remediate the problems. A strategic approach to develop practical measures to mitigate the problems facing species which rely heavily on this island habitat is being undertaken through the Raine Island Climate Change Adaptation Plan 2010–2070.
- Research indicates the mortality of adult female green turtles within the northern Great Barrier Reef stock may be unsustainable under current practices.¹⁴ Between 1976 and 2001, research on the population dynamics of this stock using the index sight of Raine Island has found a progressive decline in the size of nesting females.¹³ However, over almost three decades there was no decline in the size of turtles being tagged for the first time.¹³ This decline was recognised as a reduction in the size of ‘experienced turtles’ remigrating to nest on subsequent occasions. During the latter part of this study period, demographics were also showing a population characterised by a very low recruitment rate.¹³ When these characteristics are viewed together, it indicates a population in decline as a result of a loss of adult turtles.¹⁴
- The Indigenous take within the northern Great Barrier Reef stock of green turtles is biased towards large adult, or near adult, females.¹⁰² In the central and eastern Torres Strait, eggs are also harvested (also occurring at smaller rookeries of the inner shelf of the northern Great Barrier Reef). More work is required to reduce the mortality of adult green turtles and to better understand the level of mortality that occurs through Indigenous harvest of this stock. The harvest of green turtles from this stock within the Torres Strait is estimated to be in the order of 4000 individuals per year.¹⁴ The harvest within the northern Great Barrier Reef stock of green turtles is estimated to be in the low hundreds.¹⁴ Given the combined sources of human-related threats impacting the northern Great Barrier Reef stock of green turtle, it will be critical to continue developing and improving collaborative programs with Traditional Owners to ensure the traditional harvest of marine turtles is ecologically sustainable.
- The Indigenous harvest of marine turtle meat and eggs outside of the Great Barrier Reef (in the Torres Strait and/or neighbouring Indo-Pacific countries) requires management for both the northern Great Barrier Reef stock of green turtle and the Torres Strait–northern Great Barrier Reef stock of hawksbill turtles (eggs and shell, and to a lesser extent, meat). In the Torres Strait, this is being undertaken through an extensive ranger program operated by the Torres Strait Regional Authority which implements and supports fifteen community-based dugong and turtle management plans covering the Torres Strait region. This will be reviewed on a five-yearly basis. Community rangers implement the plan’s objectives in communication and education, compliance and enforcement, and research and monitoring of catch. However, it is extremely difficult to influence the level of harvest of the component of the northern Great Barrier Reef stock that forages in neighbouring Indo-Pacific nations.
- Although worthy of consideration, the harvest of loggerhead turtles from the east Australian stock in South West Pacific coastal communities is not considered unsustainable on its own, but contributes to the cumulative impacts experienced by this stock. Conservation outcomes will benefit from greater collaborative efforts between the Australian Government and the Indo-Pacific region to reduce this mortality.
- Studies show marine turtle species in the World Heritage Area exhibit a high degree of fidelity to foraging grounds that they enter as juveniles and to nesting sites that they return to as adults.^{9,10,11} However, the current

state of knowledge on how marine turtles respond to persistent or threshold levels of disturbance within their home range is limited and insufficient to inform management. Such pressures are most prevalent in foraging habitat along coastal areas from Port Douglas south, and include increasing coastal development resulting in habitat degradation or loss and declining water quality due to catchment run-off. Island nesting sites are under pressure from accelerated rates of climate change which, for example, may impact hatching success. These knowledge gaps become more critical with the understanding that these combined pressures may also reduce available alternative habitats for nesting and foraging.

- The eastern Australian population of loggerhead turtles has been severely depleted through a period of high mortality as a result of otter trawling effort that used apparatus detrimental to turtle survival, along with significant mortality of eggs through depredation by feral animals, primarily the red fox (*Vulpes vulpes*). The introduction of the mandatory use of turtle exclusion devices in 2001 and conservation efforts that reduced red fox depredation of nests have virtually eliminated those sources of mortality and resulted in population trends for the east Australian stock showing signs of recovery.⁴¹ However, there remains significant pressure on this stock from mortality due to incidental capture in pelagic long-line fisheries in the South Pacific, harvest and incidental capture in fisheries of neighbouring South West Pacific nations and ingestion of synthetic marine debris. Therefore, management must focus on reducing the level of mortality of loggerhead turtles in our coastal waters to maintain a robust breeding population while solutions are being sought to reduce mortality in oceanic and neighbouring waters.⁴¹
- Green turtle fibropapilloma disease is an infective disease that is currently believed to be caused by a herpes virus.¹⁰³ While the level of green turtle mortality from this disease is unquantified, beach-washed, dead or moribund green turtles are regularly encountered with fibropapilloma disease in southern Queensland.¹⁴ Fibropapilloma disease has been prevalent in green turtles in semi-enclosed waters such as Repulse Bay (and Moreton Bay in south-east Queensland).¹⁴ Other hotspots for the disease are becoming evident in locations in north Queensland, such as Edgumbe Bay near Bowen. The disease is not considered to cause mortality with most infections, but is more commonly an expression of poor health in the animal or its environment.
- Herpes virus has been implicated with fibropapilloma disease tumours in loggerhead turtles.¹⁰⁴ Genetically the fibropapilloma-associated turtle herpes virus is very similar, irrespective of the infected turtle species.¹⁰⁴ The disease incidence in areas adjacent to altered catchments raises concerns that there are associated human-related factors.⁴¹ Fibropapilloma disease occurs at low frequency among loggerhead turtles in Moreton Bay and the southern Great Barrier Reef.⁴¹
- Encroaching coastal development has impacted on available mainland nesting sites for loggerhead⁴¹ and flatback turtles.⁴² Unnatural sources of bright light at some minor nesting sites for these species within the World Heritage Area have caused hatchlings to become disorientated and move inland towards the source of light¹⁰⁵ (this also occurs at the major nesting site for loggerhead turtles at Mon Repos (north from Bundaberg) outside of the World Heritage Area). This results in increased hatchling mortality from becoming lost or entrapped in vegetation, from heat exhaustion, being run over by cars and from increased bird, cat and crab predation.
- Where nesting sites are not protected under the *Nature Conservation Act 1992* (for example, minor mainland nesting sites used by flatback turtles⁴²), work remains to partner with state and local governments to protect these areas through relevant coastal planning processes. Conservation measures also need to be improved for turtle foraging grounds. Further research into the feeding ecology of marine turtles is needed to inform protection of important inshore foraging habitat under both the state *Marine Parks Act 2004* (Qld) and the *Great Barrier Reef Marine Park Act 1975*.
- The hawksbill turtle population of northern Australia was severely depleted by more than two centuries of harvest to supply the tortoise shell (or bekko) trade. The primary index beach for the Torres Strait–Northern Great Barrier Reef stock at Milman Island shows an annual rate of decline of three per cent for the nesting population. This is likely to be due to unsustainable harvesting of turtles in neighbouring Indo-Pacific countries. If this current rate of decline continues, then the Torres Strait–northern Great Barrier Reef hawksbill turtle stock can be expected to decline by more than 90 per cent by 2020, that is in less than one generation for the species.¹⁵ Major pressures within Australian jurisdictions include unsustainable harvest of eggs in the Torres Strait (and some hunting for meat) and entanglement of immature hawksbill turtles in ghost nets across their northern Australian foraging range. Remaining pressures on this species need to be reduced or eliminated for this stock to recover.¹⁵
- The effective conservation of marine turtles requires the protection of key habitats. Key nesting habitats are mostly known for those species that nest within the World Heritage Area, but information identifying other key habitats for each species is lacking. Key habitats include foraging, mating, nesting and internesting areas, and migratory pathways. Animals may be particularly sensitive to human activities in and adjacent to key habitats. The Queensland Parks and Wildlife Service is working to identify key habitats from information collected on a continuous basis over the past 20-40 years. Many key habitats occur outside the World Heritage Area or outside of Australia. Therefore, collaboration between Queensland, Australian and foreign governments and international agencies is required to ensure a holistic approach to the conservation of marine turtles that nest within the World Heritage Area.

- Climate change has the potential to impact on many stages in the life cycle of marine turtles.^{33,106} Sea level rise may negatively impact on nesting sites through inundation and unfavourable changes to island geomorphology. Increased air temperatures have the potential to raise the incubation temperatures of clutches, skewing sex ratios across generations. It can also lead to embryonic mortality if maximum threshold temperatures are experienced during incubation. Aside from climatic models developed by Fuentes and colleagues,¹⁰⁷ there is limited information on how sensitive marine turtles will be to finer scale impacts of climate change. Information suggests that in combination with other cumulative impacts, a precautionary and strategic approach is required to enhance marine turtle resilience to these potential impacts. The challenge for all agencies charged with responsibility for managing marine turtles in the World Heritage Area will be to develop consistent and complementary approaches.
- There is a high probability that projected increases in air temperature of 1.9 to 2.6°C by 2050¹⁰⁸ will result in sand temperatures during the Austral summer reaching the upper end of, or exceeding, the thermal envelope for successful egg incubation at most current marine turtle rookeries in the World Heritage Area.³³
- The extreme weather events of 2010–2011 in Queensland (widespread flooding and Tropical Cyclone Yasi) applied significant additional pressure on green turtles, particularly the southern Great Barrier Reef stock that forage within the World Heritage Area south of Cape Flattery where most impacts were experienced. These events, along with the previous two years of higher than average rainfall on Queensland's eastern seaboard, have caused the significant decline of seagrasses that green turtles forage upon (L. McKenzie, pers. comm. 2011). This decline in seagrass distribution and abundance may take three to five years under ideal conditions to regenerate and is dependent on a number of factors including a return to more normal seasonal rainfall patterns that will correspondingly reduce impacts of high-turbidity run-off, low salinity and higher concentrations of land-based pollutants (L. McKenzie, pers. comm. 2011).
- Green turtles dominating marine turtle strandings in 2011 are from the southern Great Barrier Reef green turtle stock and small immature animal cohort that have less than 65 centimetres curved carapace length (Queensland marine animal strandings program, unpub. data, 2011). Although this will impact the breeding potential for this cohort into the future, the population is expected to be able to absorb increased mortality due to greater abundance in this size class (relative to productive mature females which to date have proven more resilient to reductions in seagrass). Considering the population of the southern Great Barrier Reef stock of green turtle has been increasing over the past 40 years,¹⁹ it is unlikely the current levels of mortality due to extreme weather impacts pose any stock-level threat to green turtles in the World Heritage Area (C.J. Limpus, pers. comm. 2011). However, the cumulative impacts on green turtle stocks in the World Heritage Area, including recent extreme weather events, determine the conservation dependency of these stock to which state and Commonwealth governments are currently providing a strategic response.

Management of marine turtles in the Great Barrier Reef Marine Park

Management agencies with responsibilities for managing these species or impacts on these species within the Great Barrier Reef World Heritage Area and the statutory and non-statutory tools that influence the conservation management of these species

Legislation or policy	Object as it applies to the species	Tools for Conservation	Who administers it
World Heritage Convention	<ul style="list-style-type: none"> • Four natural heritage criteria with associated conditions of integrity. Criteria focus on (i) geological processes and phenomena, including the evolution of the earth; (ii) ongoing ecological and biological processes; (iii) linked aesthetic components of the natural world; (iv) the biological diversity and habitats of threatened species • Natural heritage criteria iv states that the natural heritage asset must contain the most important and significant natural habitats for in situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation 	<ul style="list-style-type: none"> • Provides State Parties to the convention with definitions of natural and cultural heritage, measures for the protection of natural and cultural heritage; the means of administration and obligations of the Convention; funding arrangements, educational programs and reporting obligations 	United Nations Educational, Scientific and Cultural Organization (UNESCO)
Convention on Biological Diversity (CBD)	<ul style="list-style-type: none"> • The three main objectives of the convention are: <ul style="list-style-type: none"> • the conservation of biological diversity • the sustainable use of the components of biological diversity • the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources. 	<ul style="list-style-type: none"> • Provides State Parties to the convention with global principles, objectives and obligations for the conservation of biodiversity • Guides Australia's strategic planning to achieve national priority actions for biodiversity conservation through a range of objectives and targets for each 	United Nations Environment Programme — CBD Secretariat
International Union for the Conservation of Nature (IUCN) — Red List of Threatened Species (v. 2010.2)	<ul style="list-style-type: none"> • Establishes the conservation status of species based on the assessment of their global population and trends • Species listed as critically endangered: <ul style="list-style-type: none"> • <i>Eretmochelys imbricata</i> • <i>Dermochelys coriacea</i> • Species listed as endangered: <ul style="list-style-type: none"> • <i>Caretta caretta</i> • <i>Chelonia mydas</i> • Species listed as vulnerable: <ul style="list-style-type: none"> • <i>Lepidochelys olivacea</i> • Species listed as data deficient: <ul style="list-style-type: none"> • <i>Natator depressus</i> — previously listed as vulnerable. Review being undertaken by the IUCN Marine Turtle Specialist Group. 	<ul style="list-style-type: none"> • Assessment information used to formulate management direction • GBRMPA to provide input and advice to processes of assessment and review as required 	International Union for the Conservation of Nature (IUCN) through the Marine Turtle Specialist Group

<p>Convention on International Trade of Endangered Species of wildlife fauna and flora (CITES)</p>	<ul style="list-style-type: none"> • All marine turtle species that occur in the Great Barrier Reef Marine Park are listed within Appendix I of the convention 	<ul style="list-style-type: none"> • GBRMPA forms part of the Council of Parties that contributes to review and assessment of management provisions established for signatory nations under the conventions • Species listed on Appendix I of the convention are threatened with extinction — the convention prohibits international trade in specimens of these species except when the purpose of the import is not commercial, for instance for scientific research 	<p>United Nations Environment Programme — CITES Secretariat</p>
<p>Convention on Migratory Species (CMS)</p>	<ul style="list-style-type: none"> • Provides a basis for forming international agreement on the protection, conservation and management of migratory species • All marine turtle species that occur in the Great Barrier Reef Marine Park are listed as marine migratory species under the convention 	<ul style="list-style-type: none"> • The Parties to the convention agree to: <ul style="list-style-type: none"> a) promote, co-operate in and support research relating to migratory species b) endeavour to provide immediate protection for migratory species included in Appendix I c) endeavour to conclude Agreements covering the conservation and management of migratory species included in Appendix II • Animals listed as migratory in appendices of the convention are considered as matters of national environmental significance under the EPBC Act and are protected under the Act. 	<p>United Nations Environment Programme — CMS Secretariat</p>
<p>National Recovery Plan for Marine Turtles in Australia 2003</p>	<ul style="list-style-type: none"> • Outlines actions that managing agencies need to take to assist with the recovery of marine turtles in Australia. The plan identifies GBRMPA as the lead management agency for recovery initiatives in the Great Barrier Reef Marine Park • Aims to reduce impacts on Australian stocks of marine turtles and hence promote their recovery in the wild 	<ul style="list-style-type: none"> • GBRMPA to provide input and advice to processes of review • Action plan describes the conservation status, key threats and existing conservation measures for a large number of species and makes recommendations for further actions. Identifies lead agencies to undertake those actions 	<p>Department of the Environment</p>
<p><i>Environment Protection and Biodiversity Conservation Act 1999</i> (EPBC Act) and Environment Protection and Biodiversity Conservation Regulations 2000</p>	<ul style="list-style-type: none"> • Legislative framework for environmental protection in Australia • Provides means of assessment of 'actions' within Australian marine and terrestrial environments • Under this legislation it is illegal to harm, interfere with or disturb marine turtles except for traditional use (as pursuant to the <i>Native Title Act 1993</i>) • Legislative role includes the listing and regulation of threatened and protected species and communities, preparing 	<ul style="list-style-type: none"> • Species listed as endangered: <ul style="list-style-type: none"> • <i>Dermochelys coriacea</i> • <i>Caretta caretta</i> • <i>Lepidochelys olivacea</i> • Species listed as vulnerable: <ul style="list-style-type: none"> • <i>Chelonia mydas</i> • <i>Eretmochelys imbricata</i> • <i>Natator depressus</i> • Listed threatened species and ecological communities are recognised as a matter of national environmental significance. Consequently, any action that is likely to have a 	<p>Department of the Environment</p>

	<p>recovery plans for threatened and protected species, identifying key threatening processes and, where appropriate, developing threat abatement plans and recovery plans</p> <ul style="list-style-type: none"> • See comments above regarding species listed as migratory, as listed by appendices of the convention. 	<p>significant impact on listed threatened species and ecological communities under the EPBC Act are subject to referral and assessment under the Act</p> <ul style="list-style-type: none"> • An action affecting marine turtles that would otherwise be in breach of the EPBC Act could be deemed to be a 'controlled action' and require a greater scrutiny of environmental impact assessment and, if approved, conditions for control of the action • Threat abatement plans guide industry regulation and outline the research and management actions required to address these threats: <ul style="list-style-type: none"> • Threat abatement plan for the impacts of marine debris on vertebrate marine life (2009) • Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (2005) • Threat abatement plan for predation by European red fox (2008) • Assessment and export approval processes for all fisheries with an export component (Wildlife Trade Operation) that must consider interactions with threatened species • Penalties for non-compliance • Processes of review 	
<p><i>Great Barrier Reef Marine Park Act 1975</i> and Great Barrier Reef Marine Park Regulations 1983</p>	<ul style="list-style-type: none"> • Provides for biodiversity conservation through zoning, permits and plans of management that collectively enable management of human activities in the Great Barrier Reef Marine Park • Regulation 29, Table 29 of the Regulations provides a list of protected species including all marine turtles • The Regulations establish provisions for the Cairns, Whitsundays and Hinchinbrook plans of management 	<ul style="list-style-type: none"> • Plans of management regulate activities within the Marine Park relating to marine turtle conservation and other protected species • Activities within the Marine Park are managed spatially via zoning provisions within the Act • Under the Regulations, the agency must not grant a permit to enter, use, or carry on an activity in the Marine Park unless an assessment has been made of the impact that entry, use or activity is likely to have on the Marine Park • Penalties for non-compliance • Processes of review 	<p>Great Barrier Reef Marine Park Authority</p>
<p>Great Barrier Reef Marine Park plans of management (subordinate to the Great Barrier Reef Marine Park</p>	<ul style="list-style-type: none"> • A multiple-use marine protected area management tool that protects biodiversity by regulating activities within high-use regions of the Marine Park • Regulations for marine turtle (and 	<ul style="list-style-type: none"> • Plans of management outline the values, issues and strategies for the conservation of turtles in management areas. Prohibits taking of marine turtles (as defined under the Great Barrier Reef Marine Park 	<p>Great Barrier Reef Marine Park Authority</p>

<p>Regulations 1983)</p>	<p>dugong) conservation are found in:</p> <ul style="list-style-type: none"> • Cairns Area Plan of Management Part 1, Div. 2, subdiv.3 • Whitsundays Plan of Management Part 1, Div.2, subdiv. 5 • Hinchinbrook Plan of Management Part 1, Div.3, subdiv.4 	<p>Zoning Plan 2003)</p> <ul style="list-style-type: none"> • Provisions for enforcement have penalties for non-compliance • Plans of management are reviewed regularly in line with changes to management requirements, legislation and national guidelines • Penalties for non-compliance • Processes of review 	
<p>Great Barrier Reef Marine Park Zoning Plan 2003</p>	<ul style="list-style-type: none"> • A multiple-use marine protected area management tool that protects biodiversity by regulating activities within the Great Barrier Reef Marine Park • The Representative Area Program that provided the basis for the Zoning Plan spatial planning decisions, described 70 broadscale habitats, or bioregions, and as such provides the basis for ecosystem-based management in the Marine Park 	<ul style="list-style-type: none"> • Spatial management of activities within the Great Barrier Reef based on protection of habitat type representative areas • 34 per cent of the Marine Park is dedicated as Marine National Park (green) or Preservation (pink) zones in which no extractive activities are permitted • Restricted Access Special Management Areas can be created for the protection of marine turtles and their habitats under special circumstances • Special Management (Dugong Protection) Areas (spatial restrictions on commercial mesh netting) also provide subsequent protection for marine turtles (e.g. Hinchinbrook Island Area Dugong Protection Area) • Penalties for non-compliance • Processes of review 	<p>Great Barrier Reef Marine Park Authority</p>
<p><i>Fisheries Act 1994</i> (Qld) and Fisheries Regulation 2008</p>	<ul style="list-style-type: none"> • Provides the legislative framework and regulatory controls for managing fisheries in all Queensland waters and Commonwealth waters subject to the Offshore Constitutional Settlement for the state of Queensland 	<ul style="list-style-type: none"> • Marine turtles listed as Species of Conservation Interest (SOCI) • Net attendance rules in set mesh net fisheries (must be in attendance at all times) • Rules (N₁, N₂, N₄, N₁₁, S regulations) for net operation and apparatus parameters designed to limit interactions with Species of Conservation Interest, including marine turtles • Species of Conservation Interest logbook reporting requirements • Penalties for non-compliance • Review of the Act in 2011 	<p>Queensland Government</p>
<p>Fisheries (East Coast Trawl) Management Plan 1999 (Qld)</p>	<ul style="list-style-type: none"> • East Coast Trawl Management Plan provides for the management of fishery • Accredited Wildlife Trade Operation under <i>Environment Protection and Biodiversity Conservation Act 1999</i>, managed by Fisheries Queensland 	<ul style="list-style-type: none"> • Management plan regulates the use of bycatch reduction devices such as turtle exclusion devices, equipment used, the amount of effort in the industry through licensing and entitlements/quotas, and spatial management provisions • Commonwealth Regulations requires reporting on 	<p>Queensland Government</p>

		<p>management arrangements and conditions of the Wildlife Trade Operation through an annual status report</p> <ul style="list-style-type: none"> • Reports on interactions with Species of Conservation Interest including marine turtles. Data is gathered through logbooks • <i>Looking after protected species in Queensland — a comprehensive guide for commercial fishers</i> published to assist fishers in interactions with marine turtles and other protected species 	
East Coast Inshore Fin Fish Fishery management arrangements	<ul style="list-style-type: none"> • Regulations are established under the <i>Fisheries Act 1994</i> (Qld) and Fisheries Regulation 2008 • Accredited Wildlife Trade Operation under <i>Environment Protection and Biodiversity Conservation Act 1999</i>, managed by Fisheries Queensland 	<ul style="list-style-type: none"> • Published guidelines for commercial operators in the East Coast Inshore Fin Fish Fishery to provide commercial fishers with a summary of management arrangements • Commonwealth regulations require reporting on management arrangements and conditions of the Wildlife Trade Operation through an annual status report • Reports on interactions with Species of Conservation Interest including marine turtles. Data is gathered through logbooks and verified through an observer program • <i>Looking after protected species in Queensland — a comprehensive guide for commercial fishers</i> published to assist fishers in interactions with marine turtles and other protected species • Review of the fishery under <i>Environment Protection and Biodiversity Conservation Act 1999</i>. Review completed February 2012. New Wildlife Trade Operation with conditions issued; valid to 2015 	Queensland Government
Queensland crab fisheries	<ul style="list-style-type: none"> • Regulations are established under the <i>Fisheries Act 1994</i> (Qld) and Fisheries Regulation 2008. 	<ul style="list-style-type: none"> • Commercial operators limited to up to 50 pots, traps and dillies • Recreational fishers limited to five pots, traps and dillies • Offshore blue swimmer or spanner crab fishers attach 10 to 15 pots or dillies to a trotline attached to a single buoy 	Queensland Government
Queensland Shark Control Program	<ul style="list-style-type: none"> • Community education and policy under <i>Fisheries Act 1994</i> (Qld) • 30 nets at localities in Mackay, Rainbow Beach, Sunshine Coast, and the Gold Coast • More than 350 drumlines at localities across Cairns, Townsville, Mackay, Capricorn Coast, Gladstone, Bundaberg, Rainbow Beach, Sunshine Coast, 	<ul style="list-style-type: none"> • Permitted program under the Great Barrier Reef Marine Park Regulations 1983 • Nets designed to capture sharks greater than two metres in length. Nets are 186 metres long. Most nets have a depth of six metres and a mesh size of 500 millimetres • Five remaining shark nets in 	Queensland Government

	North Stradbroke Island and the Gold Coast. ¹⁰⁹	<p>the Great Barrier Reef: five off Mackay beaches</p> <ul style="list-style-type: none"> • Drumline arrays consist of up to six or more shark hooks with fresh bait suspended individually from large plastic floats. (Roughly one net = six drumlines) • Equipment checked every second day, weather permitting • Other measures employed to reduce interactions with threatened species • Processes of review 	
<i>Nature Conservation Act 1992 (Qld) and Nature Conservation (Wildlife) Regulation 2006; and Nature Conservation (Wildlife Management) Regulation 2006</i>	<ul style="list-style-type: none"> • Legislative framework for the conservation of nature in Queensland • Protecting native wildlife and its habitat • Providing for the ecologically sustainable use of protected wildlife and areas • Provides a list of threatened and protected species in Queensland • Provides for the protection of marine turtles. Under this legislation it is illegal to harm, interfere with or disturb marine turtles except for traditional use • Provides legislative requirement for the development of conservation plans 	<ul style="list-style-type: none"> • <i>Caretta caretta</i>, <i>Lepidochelys olivacea</i> and <i>Dermochelys coriacea</i> listed as endangered • <i>Chelonia mydas</i>, <i>Eretmochelys imbricata</i>, <i>Natator depressus</i> listed as vulnerable • Section 332 of the Wildlife Management Regulation prohibits tampering with a protected animals' place of breeding being used to incubate or rear the animal's offspring • Penalties for non-compliance • Processes of review 	Queensland Government
<i>Marine Parks Act 2004 (Qld) and Marine Parks Regulation 2006</i>	<ul style="list-style-type: none"> • The object of this Act is to provide for the conservation of the marine environment by: <ul style="list-style-type: none"> • declaring marine parks • establishing zones, designated areas and highly protected areas within marine parks • developing zoning and management plans • recognising the cultural, economic, environmental and social relationships between marine parks and other areas • applying the precautionary principle 	<ul style="list-style-type: none"> • Aims to involve all stakeholders cooperatively • Coordination and integration with other conservation legislation • Penalties for non-compliance • Processes of review 	Queensland Government
Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004 (Qld)	<ul style="list-style-type: none"> • A multiple-use marine protected area management tool that protects biodiversity by regulating activities within the Great Barrier Reef Coast Marine Park • The Representative Area Program that provided the basis for the Zoning Plan spatial planning decisions, described 70 broadscale habitats, or bioregions, and as such provides the basis for ecosystem-based management in the Marine Park 	<ul style="list-style-type: none"> • Spatial management of activities within state waters of the Great Barrier Reef based on protection of representative bioregions • Penalties for non-compliance • Complements spatial management zones and certain regulatory provisions established under the Great Barrier Reef Marine Park Zoning Plan 2003 	Queensland Government

<p><i>Strategic assessment of the Great Barrier Reef World Heritage Area and adjacent coastal zone</i></p>	<p>Assessment under the EPBC Act that provides the opportunity to achieve both conservation and planning outcomes at a much larger scale than can be reached through project-by-project assessments</p> <p>Two complimentary strategic assessments – a marine component undertaken by the GBRMPA and a coastal zone component undertaken by the Queensland Government</p>	<p>The two strategic assessments contain recommendations and inform separate Program Reports for the Great Barrier Reef Region. The Program Reports are a detailed description of the GBRMPA's and Queensland Government's management arrangements and future commitments to protect and manage matters of national environmental significance, including the outstanding universal value of the Great Barrier Reef World Heritage Area over the next 25 years</p>	<p>Australian and Queensland governments</p>
<p>Reef 2050 – Long-term Sustainability Plan</p>	<p>The Reef 2050 Long-term Sustainability Plan will inform future development by drawing together the marine and coastal components of the comprehensive strategic assessment, providing an over-arching framework to guide protection and management of the Great Barrier Reef World Heritage Area from 2015 to 2050</p>	<p>It will target identified areas of action from the strategic assessments and seek to address gaps for future management of the Great Barrier Reef World Heritage Area</p>	<p>Australian and Queensland governments</p>
<p><i>Great Barrier Reef Biodiversity Conservation Strategy 2013</i></p>	<ul style="list-style-type: none"> • Identifies all six marine turtle species as species at risk in the Marine Park • Grades the level of risk marine turtles are exposed to via a vulnerability assessment process 	<ul style="list-style-type: none"> • The Biodiversity Conservation Strategy outlines a framework for action with three strategic objectives aimed at building or maintaining ecosystem resilience and protecting biodiversity: <ol style="list-style-type: none"> 1. Engaging communities and foster stewardship 2. Building ecosystem resilience in a changing climate 3. Improving knowledge • Objectives are comprised of program-level outcomes with key actions and contain targets for measuring success • Implementation of the strategy will be undertaken through a multi-agency, multi-stakeholder collaborative approach. 	<p>Great Barrier Reef Marine Park Authority</p>
<p><i>Great Barrier Reef Climate Change Adaptation Strategy and Action Plan (2012–2017)</i></p>	<ul style="list-style-type: none"> • Establishes a strategic approach to developing resilience within Great Barrier Reef ecosystems to enable them to adapt to climate change impacts • The adaptation strategy outlines the approach and objectives that will guide GBRMPA and its partners in addressing key climate change challenges over coming decades. It includes a program of activities for the next five years (<i>Great Barrier Reef Climate Change Action Plan 2012–2017</i>). These activities build upon the outcomes and lessons from the first <i>Climate Change Action Plan (2007–2012)</i>. 	<ul style="list-style-type: none"> • Resilience analysis identifies ways to reduce human impacts and disturbances, and conserve the Great Barrier Reef's biodiversity and ecological processes 	<p>Great Barrier Reef Marine Park Authority</p>

<p><i>Reef Water Quality Protection Plan 2013</i></p>	<ul style="list-style-type: none"> • An overarching framework to achieve a sustainable future for the Great Barrier Reef and the industries in the Reef's catchment by improving water quality that flows into the Reef lagoon 	<ul style="list-style-type: none"> • Improve water quality that flows into the Reef by targeting priority outcomes, integrating industry and community initiatives and incorporating new policy and regulatory frameworks. 	<p>Joint Australian and Queensland government initiative</p>
<p>Land and Sea Country Indigenous Partnerships Program</p>	<ul style="list-style-type: none"> • Expand the Traditional Use of Marine Resource Agreement (TUMRA) program across the Reef catchment • Strengthen communications between local communities, Great Barrier Reef managers and stakeholders and build a better understanding of Traditional Owner use of the Great Barrier Reef Marine Park 	<ul style="list-style-type: none"> • Expansion of the program — this will complement management of dugongs and green turtles and other species of conservation and cultural significance • Enhanced compliance to address illegal activities in high risk areas that threaten cultural and natural heritage values and culturally important species • Engaging with communities to empower traditional owners in the context of sea country management • Providing grants and sponsorships to increase the knowledge and skills base of traditional owners and enable them to better manage sea country • Strengthening communications and knowledge sharing between Traditional Owners, management agencies and the broader community 	<p>Great Barrier Reef Marine Park Authority (funded by the Commonwealth Department of the Environment)</p>
<p>Marine Wildlife Stranding Program</p>	<ul style="list-style-type: none"> • Collects and reports on stranding and mortality information of threatened marine wildlife species within Queensland 	<ul style="list-style-type: none"> • Provides critical information to aid and inform research and management initiatives • Processes of review 	<p>Queensland Government (jointly funded by the Great Barrier Reef Marine Park Authority through the Field Management Program)</p>
<p>Back on Track Biodiversity Action Plans</p>	<ul style="list-style-type: none"> • The Back on Track species prioritisation framework identifies priority species for conservation management, regional threats, and suggested recovery actions • All six species of marine turtle that occur in the World Heritage Area are identified as critical priorities for conservation management in various parts of the Marine Park 	<ul style="list-style-type: none"> • Identifies regionally appropriate management actions to mitigate the risks to these species • Processes of review 	<p>Queensland Government (with regional natural resource management groups and other stakeholders for implementing identified management actions)</p>
<p><i>Great Barrier Reef Protection Amendment Act 2009 (Qld)</i></p>	<ul style="list-style-type: none"> • A framework for reducing the levels of dangerous pesticides and fertilisers found in the waters of the Great Barrier Reef by 50 per cent in four years 	<ul style="list-style-type: none"> • Mix of strict controls on farm chemicals and regulations to improve farming practices 	<p>Queensland Government</p>
<p><i>Coastal Protection and Management Act 1995 (Qld)</i> and Coastal Protection and Management Regulation 2003</p>	<ul style="list-style-type: none"> • Provides the legislative framework and Regulations for the coordinated management of the diverse range of coastal resources and values in the coastal zone. This framework includes provisions that establish the Queensland Coastal Plan 	<ul style="list-style-type: none"> • Queensland Coastal Plan provides guidelines for effective protection and management of the coastal zone 	<p>Queensland Government</p>

<p><i>Sustainable Planning Act 2009</i> (Qld) and Sustainable Planning Regulation 2009</p>	<ul style="list-style-type: none"> • Establishes process for land use planning and development assessments. Identifies state legislation that may be triggered by development assessments and the process by which developments must be assessed against each piece of legislation • Establishes the framework for developing regional plans 	<ul style="list-style-type: none"> • Coastal development generally requires impact assessment and a development approval under the <i>Sustainable Planning Act 2009</i> • Regional plans developed under the Act operate in conjunction with other state planning instruments, usually taking precedence over them • Regional plans must conform to policies established within the Queensland Coastal Plan • Regional plans identify: <ul style="list-style-type: none"> • desired regional outcomes • policies and actions for achieving these desired regional outcomes • the future regional land use pattern • regional infrastructure provision to service the future regional land use pattern • key regional environmental, economic and cultural resources to be preserved, maintained or developed 	<p>Queensland Government</p>
<p>Queensland Coastal Plan (prepared under the <i>Coastal Protection and Management Act 1995</i>)</p>	<ul style="list-style-type: none"> • The Queensland Coastal Plan has two parts: State Policy for Coastal Management; and the Coastal Protection State Planning Regulatory Provision (following the suspension of the State Planning Policy 3/11 — Coastal Protection). 	<ul style="list-style-type: none"> • Coastal activities not defined as development under the <i>Sustainable Planning Act 2009</i> are considered under the State Policy for Coastal Management (currently under review following the change in government) • The suspended State Planning Policy 3/11 provided policy direction and assessment criteria to direct land use planning and development assessment decision making under the <i>Sustainable Planning Act 2009</i>. The Coastal Protection State Planning Regulatory Provision now offers much less specific guidance 	<p>Queensland Government</p>
<p>Queensland Wetlands Program</p>	<p>Long-term conservation and management of wetlands WetlandInfo – a synthesis of information on wetlands and their management</p>	<p>Process for setting desired outcomes and management goals for classified wetlands Rehabilitation guidelines</p>	<p>Queensland Government</p>
<p>Environmental Protection (Water) Policy 2009 (Qld)</p>	<p>A statutory policy established under the <i>Environmental Protection Act 2009</i> (Qld) Achieving water quality fit for purpose which includes protection of aquatic ecosystems</p>	<p>Establishes Water Quality Improvement Plans as key planning mechanisms to improve the quality of Queensland waters. Provides a framework for developing environmental values, management goals and water quality objectives Application through planning, assessment, permits, licensing and conditions</p>	<p>Queensland Government</p>
<p>State Planning Policy 4/10 for Healthy</p>	<p>Made under the <i>Sustainable Planning Act 2009</i></p>	<p>Mangroves and saltmarshes can be identified as areas of high ecological value and hence</p>	<p>Queensland Government</p>

Waters	To ensure that development for urban purposes, including community infrastructure, is planned, designed, constructed and operated to manage stormwater and waste water in ways that protect environmental values specified in the Environmental Protection (Water) Policy 2009	water objectives are set to achieve their ecosystem protection Establishes standards and best practice	
Stormwater Guideline – Environmentally Relevant Activities	The guideline includes criteria to help protect receiving water environmental values from potential environmental impacts arising from poor stormwater quality and altered stormwater flow	Section 1—Guidance material for applicants applying for an approval to carry out a relevant activity Section 2—Assessing compliance with stormwater and erosion sediment control conditions	Queensland Government
State Planning Policy 4/11 Protecting Wetlands of High Ecological Significance in Great Barrier Reef Catchments	Made under the <i>Sustainable Planning Act 2009</i> Seeks to ensure that development in or adjacent to wetlands of high ecological significance in Great Barrier Reef catchments is planned, designed, constructed and operated to prevent the loss or degradation of wetlands and their environmental values, or enhances these values	The SPP provides direction on the following wetland protection issues relevant to the <i>Sustainable Planning Act 2009</i> : • how planning instruments can protect environmental values in wetlands of high ecological significance (HES wetlands) in Great Barrier Reef catchments • how particular development can achieve the relevant policy outcomes for protecting wetland environmental values	Queensland Government
Water Quality Guidelines ^{41,42}	Water quality for the protection of aquatic ecosystems	Trigger values for protection of aquatic environments	GBRMPA Queensland Government
Water Quality Improvement Plans	Between 2002 and 2009 many plans were developed along the Great Barrier Reef catchment. Environmental values and water quality objectives of Water Quality Improvement Plans (or Healthy Waterways Plans) are now being scheduled into legislation under the <i>Environmental Protection (Water) Policy 2009</i>	Key matters to be addressed in a Water Quality Improvement Plan include identifying: • waters to which the plan applies • issues affecting water dependent ecosystems, drinking water and natural flows • waterway uses and values (otherwise known as 'Environmental Values') • management goals and Water Quality Objectives to protect identified environmental values • ways to protect the environmental values for the water • ways to monitor and assess the effectiveness of the protection	Community driven through Natural Resource Management bodies Townsville City Council Voluntary practice uptake for improvements
Regional Natural Resource Management Framework (Qld)	The framework is intended to be a clear and concise statement of the regional Natural Resource Management (NRM) arrangements in Queensland needed to build, align and harness effort and investment for NRM outcomes. It encompasses the scope of business, guiding principles, enduring objectives, participants, processes and relationships	The function of the Queensland Regional NRM Framework is to: • integrate and align NRM effort at the landscape level • define how priorities are set for future Queensland Government NRM investment in regions • assist with negotiating arrangements with the Australian Government	

		<ul style="list-style-type: none"> • identify opportunities for improving NRM arrangements 	
Regional Natural Resource Management plans	<p>There are 54 natural resource management regions across Australia based on catchments or bioregions</p> <p>Each region is supported by a non-government natural resource management body supported by Commonwealth and State governments</p> <p>Regional natural resource management bodies focus on on-ground activities that protect, improve and restore waterways and rangelands by addressing weeds and pests, and improving soil, vegetation and water quality at a river catchment or other landscape level</p>	<p>Natural Resource Management Plans are community-based plans to identify regional objectives and priorities based on community values and the best available knowledge, facilitate partnerships, stimulate action, attract investment and provide land managers with tools and information to help them manage what is valued in the region</p>	Regional Natural Resource Management bodies
Government policies, guidelines, codes of practice and programs	<ul style="list-style-type: none"> • Best environmental practices for recreational Reef visitors to minimise their impacts when observing nesting turtles or visiting permitted nesting sites • Reef Guardians program to educate and build stewardship capacity on marine pollution and fishing best practice • Great Barrier Reef Marine Park Authority dredging and spoil disposal policy • Tourism Operators Handbook outlines a range of Responsible Reef Practices — a tool developed to educate tourism industry staff about minimising the impacts of their operations on species and habitats • Code of Practice for the Sustainable Management of Dugong and Marine Turtle Tourism in Australia (Department of the Environment) • Looking after protected species in Queensland — a comprehensive guide for commercial fishers (Queensland Government) • East Coast Trawl Fishery code of fishing ethics on the capture of marine turtles (Queensland Government) • Best environmental practices on the correct disposal of waste 	<ul style="list-style-type: none"> • Industry and public education tools to promote and develop stewardship actions in the Great Barrier Reef Marine Park • Codes of practice guide operations in order to reduce impacts • Reviewed in line with best practice 	Great Barrier Reef Marine Park Authority (Where identified, Queensland Government, Department of the Environment)

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Appendix 1. Vulnerability assessment matrix

	Pressures									
	Commercial marine tourism	Defence activities	Commercial fishing	Recreational fishing	Ports and shipping	Recreation (not fishing)	Traditional use of marine resources	Climate change	Coastal development	Declining water quality due to land-based run-off
Exposed to source of pressure (yes/no)	Yes; locally (with potential community-level significance if unmanaged). No exposure of olive ridley and hawksbill turtles.	Yes; locally.	Yes; Reef-wide.	Yes; predominantly south of Cooktown for the southern GBR green turtle stock, loggerhead, hawksbill and flatback turtles.█	Yes; locally (with potential for regional significance).█	Yes; regionally.█	Yes; regionally (with stock-level significance) within the northern GBR green turtle and Torres Strait–northern GBR hawksbill turtle stocks.	Yes; climate change is likely to affect the six marine turtle species differently.	Yes; predominantly south of Port Douglas for the southern GBR green turtle stock, loggerhead and flatback turtles.█	Yes; predominantly south of Cooktown for the southern GBR green turtle stock, loggerhead and flatback turtles.█
Degree of exposure to source of pressure (low, medium, high, very high)	Low. Exposure at a local scale could be high where tourism operators seek to observe marine turtles nesting. This would provide a level of disturbance which could be significant if not managed. However, this is not the case and exposure to this pressure is considered to be low and/or well managed.	Low. Marine turtles are not thought to be significantly impacted by defence activities in the Great Barrier Reef as defence operations avoid key sites and manage their activities so as to limit interactions with protected species, including marine turtles. However, mortality, injury and disturbance	Medium Previous commercial harvest seriously depleted Great Barrier Reef stocks of hawksbill, loggerhead and green turtles. Use of turtle exclusion devices in Queensland since 2001 has reduced the threat that otter trawling has on Great Barrier Reef populations of marine turtles. The Eastern Tuna and Billfish Fishery is a federally regulated fishery that operates outside the Marine Park but is known to have a bycatch of marine turtles. ⁴¹	Medium. There is mortality and injury to marine turtles being recorded from: <ul style="list-style-type: none">drowning of juvenile marine turtles in rectangular crab pots with 'funnel type' entrancesingestion of and entanglement in discarded fishing gearincreased boating traffic along the Great Barrier Reef coast causing more boat strikes on marine turtles. Although	Medium. Marine turtles are most exposed to port and shipping activities and infrastructure developments at the local level, though such impacts have the potential to have population-level impacts in the long term. Demand for increased or expanded port facilities along Queensland's coast will result in loss of habitat that marine turtles rely on — most significantly seagrass habitat that green turtles from the	Medium. Especially important if disturbances occur at critical stages in the life history of marine turtles, such as nesting. Many sites are protected under the Queensland <i>Nature Conservation Act 1992</i> . However, 10–20 per cent of flatback, loggerhead and green turtle rookeries (mostly minor sites) remain unprotected and more exposed to this source of pressure ^{14,41,42} Recreational boating	High. The Torres Strait–northern GBR stock of hawksbill turtles and the northern GBR stock of green turtles can be considered as having a high degree of exposure to the harvest of eggs both within the Marine Park and adjacent jurisdictions. The northern GBR stock of green turtles is also exposed to the significant harvest of turtles for meat. The harvest is most	Very High. Climate-driven processes are having an impact on the ecology and biology of marine turtles and the habitats on which they rely. However, these impacts will affect the species that occur in the World Heritage Area differently. It will also affect different stocks of species differently. There are numerous aspects of climate change which are likely to pose a threat to marine turtles. Those of major concern are the links between sea temperature rise, foraging area dynamics and reproductive	High. Projected increases in the human population and the associated increase in coastal developments impact on the populations of marine turtle species that nest and forage in the World Heritage Area. The exposure of marine turtles to coastal and marine development pressures will vary between species and at different life history phases. Major and minor rookeries of	High. Discharge and run-off into the Great Barrier Reef lagoon affects water quality that influences the ecosystem health of the Great Barrier Reef. This has many direct and indirect impacts on marine turtles and the habitats and ecosystem processes they rely upon. Marine debris has been identified as a hazard for marine turtles. Although most debris located on the offshore islands of the Great Barrier Reef is found to come from vessels, increased catchment run-off may contribute to increases of marine

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		<p>of marine turtles have occurred in the Great Barrier Reef in recent times as a result of defence activities.</p>	<p>There are also records of marine turtle bycatch within longline fisheries operating in the north and south Pacific. Quantifiable certainty and level of post-release mortality is not available as reporting and observer coverage is low.⁴¹</p> <p>There is remaining mortality through set mesh nets and equipment used in the fishery and the Queensland Shark Control Program (although not a commercial fishery, it is a contracted operation). However, available data indicates the number of animals drowned is low.¹¹⁰ Mortality due to entanglement in crab pot fisheries is significant at about 13 per cent of marine turtle strandings and mortalities.¹¹⁰</p> <p>In the very north of the Great Barrier Reef there have been mortalities in ghost nets, but this is predominantly</p>	<p>immediate mortality due to boat strike is most attributable to large, high-speed vessels, injury from high-speed small vessel strike is likely to cause injury and delayed mortality. However, immediate mortality does also occur from small vessel strike.¹⁴</p> <p>Most of the mortality from these pressures is being recorded for animals within the southern GBR green turtle stock, though it also occurs for other species in the World Heritage Area.</p> <p>Movement and underwater noise from increased vessel traffic also disturbs marine turtles — this can alter</p>	<p>southern GBR stock rely on.</p> <p>Noise from vessel movements is in low frequency bands within the auditory range of marine turtles.^{27,28,111}</p> <p>Dredging activities are known to kill marine turtles, notably loggerhead turtles from the eastern Australian stock. Conservative mortality estimates from strandings data for loggerhead turtles within this stock are 1.7 turtles per year from dredging operations.</p> <p>Boat strike is likely to increase as ports are developed to handle increased vessel traffic.</p> <p>A serious oil spill event in the Great Barrier Reef could have potentially serious effects on marine turtle populations,</p>	<p>activities may provide a significant level of disturbance at local scales.</p> <p>Unmanaged recreational activities that seek to observe nesting marine turtles or that unintentionally disturb nesting marine turtles (walking dogs or beach-goers), could be significant for certain species if conducted at critical times (mostly those with high-density mainland nesting sites).</p>	<p>significant across the stock's range throughout the Torres Strait, Papua New Guinea and eastern Indonesia, though it also has significance at north-east Cape York Peninsula localities within the stock's foraging range. The practice generally targets large mature females.</p> <p>The harvest of flatback turtle eggs around Mackay may also have the potential to overharvest the resource at the local scale.</p>	<p>periodicity of marine turtles. There is also significant concern that rising air temperatures will increase incubation temperatures which will result in egg mortality and skewed sex ratios. This will impact on population dynamics.</p> <p>Sea level rise, increased intensity and frequency of storm activity, and rainfall variability have the potential to alter island and beach nesting habitat and the availability of forage resources for some species in some locations.</p> <p>Fine-scale predictions on how climate change will impact on marine turtles are extremely difficult to make due to the intrinsic complexity of linkages between climate change impacts, ecosystems, and marine turtle biology and ecology. Some of these impacts have the potential to cause positive or negative impacts on marine turtles. For</p>	<p>southern Great Barrier Reef stock of loggerhead and flatback turtles are under pressure from habitat loss and degradation due to urban encroachment.</p> <p>Foraging grounds of marine turtles are under pressure from land-based pollution, sedimentation and land reclamation.</p>	<p>debris that impact on marine turtle mortality.</p> <p>Toxic compounds that pollute catchments can be accumulated by animals, particularly those of higher trophic orders, such as marine turtles. Evidence shows that bioaccumulation of toxic compounds occurs in marine turtles that nest and forage in the World Heritage Area. The impact of these potentially damaging contaminants on marine turtle population dynamics remains to be determined. Studies on other marine animals, have demonstrated detrimental impacts to their health and reproductive success as a result of the bioaccumulation of toxins.</p> <p>In the Marine Park there is a link between water quality and the prevalence of the fibropapilloma virus, which is most prevalent in green turtles and with low incidence in the</p>

	Pressures									
	Commercial marine tourism	Defence activities	Commercial fishing	Recreational fishing	Ports and shipping	Recreation (not fishing)	Traditional use of marine resources	Climate change	Coastal development	Declining water quality due to land-based run-off
			<p>restricted to the Torres Strait and northern Australia. Ghost nets impact on stocks of hawksbill and green turtles that nest within the northern GBR and forage in northern Australia, (also flatback and olive ridley turtles that nest in Northern Australia, but forage within the Marine Park).</p> <p>The foraging habitat of some marine turtles is impacted by otter trawling. The risk posed by this activity is being reviewed as part of the Queensland Government trawl review process. A total of 67 per cent of the Marine Park is closed to otter trawling which limits the level of incidental capture and habitat degradation of benthic foraging habitat.</p>	<p>their behaviour and may increase energy expenditure and potentially, reproductive output. Should this be pervasive, the likely result is a reduction in reproductive output for affected marine turtle species at a stock level.</p>	<p>either directly through mortality related to intoxication, or indirectly through loss or degradation of habitat.</p> <p>Shipping-born pollution may expose marine turtles to higher levels of toxins which may result in early mortality and/or a higher prevalence of disease. This may also result from the re-suspension of sediment that contains toxins during port dredging operations which may be absorbed directly or through the food web.</p>			<p>example post-hatchlings may be positively or negatively affected by changes to ocean currents that are predicted to occur as the climate changes.</p> <p>The spatial and temporal variability, across which these aspects of climate change will act, provides further difficulty for predicting impacts on the six species of marine turtle recorded in the Marine Park.</p>		<p>Eastern Australian stock of loggerhead turtles.</p>

	Pressures									
	Commercial marine tourism	Defence activities	Commercial fishing	Recreational fishing	Ports and shipping	Recreation (not fishing)	Traditional use of marine resources	Climate change	Coastal development	Declining water quality due to land-based run-off
<p>Sensitivity to source of pressure (low, medium, high, very high)</p>	<p>Medium. Sensitivity medium if disturbances disrupt critical elements of the life cycle, particularly nesting. This can reduce the reproductive output of a nesting female with flow-on effects on population recruitment.</p>	<p>Low. Low for majority of defence activities; high for underwater demolitions. Long-term disturbance in areas commonly used by marine turtles may drive them into more marginal locations. On a Great Barrier Reef-wide scale, the sensitivity of marine turtles to defence activities is low.</p>	<p>Medium. Data indicates many of the marine turtles that interact with commercial fishing apparatus and nets set for bather protection are released alive. There are a low number of juvenile and adult turtles that drown as a result of entering crab pots or getting entangled in float lines. Very few marine turtles are now landed on otter trawlers as turtle exclusion devices have proven to be very effective at reducing mortalities. Net attendance rules for fishers using set mesh nets also reduces the mortality of turtles within the East Coast Inshore Fin Fish Fishery. However, given the level of exposure of marine turtles to commercial fishing across the fisheries and the difficulty in verifying marine</p>	<p>Medium. Sensitivity to this pressure is mostly from vessel traffic and boat strike and not directly from recreational fishing. However, there is concern for the impact that the use of poorly designed, lost or abandoned crab pots has on marine turtles along with lost or discarded fishing equipment that becomes debris that harms or kills marine turtles. Ongoing disturbance that alters behaviour or displaces marine turtles from optimal habitat may contribute to increases in energy expenditure and/or reduce nutritional intake. Therefore, it is</p>	<p>Medium. Ports and shipping activities near important foraging, inter-nesting or nesting grounds would place significant pressure on marine turtle populations in those areas. Indirectly, disturbance and loss and degradation of optimal habitats due to port developments are likely to contribute to long-term pressure on marine turtle species that forage, nest or migrate near facilities or dredging operations.</p>	<p>Low. This pressure is considered to be low across the six species that occur in the Marine Park. Recreational disturbances that disrupt marine turtle nesting can reduce the reproductive output of a nesting female. This has flow-on effects on population recruitment. In-water recreational activities that disturb marine turtles may drive them into less-optimal habitat with resultant negative impacts.</p>	<p>High — northern GBR green turtle stock at the stock level. Medium for hawksbill and medium to low for stocks of each of the other species that occur within the World Heritage Area. For green turtles, it is mostly adult females that are targeted. Population modelling has demonstrated that adult females are the most critical cohort to maintain population viability. This makes green turtles within the northern GBR stock highly sensitive to present traditional use practices. The present traditional use of green turtles of the southern GBR stock is</p>	<p>Very high. It is difficult to assess the sensitivity to climate change of the six species of marine turtle that occur in the Marine Park. This is due to the complexity and dynamic relationship between the known effects. Marine turtles have demonstrated through 150 million years of existence that they are able to cope with changes to the Earth's climate. However, marine turtles now face a variety of additional pressures that may increase their sensitivity to current and future climate change. These include accelerated rates of climate change; often declining or depleted populations; cumulative impacts of human-related threats; and restricted access to alternative habitats. The high degree of exposure of marine turtles to the range of pressures they experience reduces</p>	<p>High. The sensitivity of marine turtles to coastal and marine development pressures will vary between species. Marine turtles (particularly green, loggerhead, hawksbill and flatback turtles) have a high level of sensitivity to the cumulative impacts from increasing coastal development in the World Heritage Area. This sensitivity is species-specific and can apply at various stages or across all stages within their life cycles (apart from their pelagic post-hatchling phase).</p>	<p>High. Marine turtles have specific habitat requirements for foraging and nesting habitats. They also demonstrate a high degree of fidelity to nesting sites and foraging habitats. Marine turtles are sensitive to pressures that reduce the availability or productivity of these supporting habitats, especially in nearshore habitats where declines in water quality are more evident either as a result of extreme weather catchment run-off, catchment run-off containing pollution from land-use practices or poor water quality related to port dredging operations. Species potentially most sensitive to these impacts are green turtles which are highly reliant on seagrass meadows that are highly vulnerable to declining water quality parameters.</p>

	Pressures									
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			turtle interaction data, the level of sensitivity to this pressure is considered to be medium.	likely to reduce their reproductive output. Furthermore, if marine turtles come to tolerate increased disturbance from vessel traffic, they may be of greater risk to boat strike. This is most likely to occur in areas adjacent to growing coastal populations.			not considered to make that population highly sensitive to this pressure.	their resilience to climate change pressures.		
Adaptive capacity – natural (poor, moderate, good)	Moderate. There is little information on whether marine turtles become habituated to tourism-related disturbance. Nesting females will move to other nesting beaches if disturbed, so there is some natural flexibility to deal with disturbances at nesting beaches. Tolerance of disturbance once committed to laying eggs	Moderate. Marine turtles exhibit high site fidelity and may not have good natural adaptive capacity to relocate to new foraging grounds if known habitat becomes unavailable through disturbance.	Moderate. A high degree of site fidelity to foraging and nesting areas may mean that marine turtles do not have good adaptive capacity to avoid commercial fishing activities if they occur in the same areas.	Moderate. A high degree of site fidelity to foraging and nesting areas may mean that marine turtles do not have good adaptive capacity to avoid recreational fishing activities if they occur in the same areas.	Moderate. A high degree of site fidelity to foraging and nesting areas may mean that marine turtles do not have good adaptive capacity to avoid impacts from ports and shipping if they occur in the same areas.	Moderate. There is little information on whether marine turtles become habituated to disturbance. Nesting females will move to other beaches if disturbed, so there is some natural adaptive capacity to deal with disturbance at nesting beaches. Impacts arise when alternative sites are not optimal to nesting	Moderate. A high degree of site fidelity to foraging and nesting areas predisposes green turtles (and hawksbill turtle eggs) to Indigenous harvest. Breeding cycles of marine turtles and their timing are well known by saltwater peoples, allowing hunters to target green	Poor. Some species of marine turtle may have greater adaptive capacity to certain climate change pressures than others. Hamann and colleagues ³³ suggest turtles are likely to have two adaptive responses to cope with increased temperatures and inundation of nesting sites. In the first instance, there is likely to be a shift in the start, end and peak of the nesting season to coincide with cooler	Moderate. This needs to be assessed with regard to cumulative pressures from climate change and catchment run-off that degrade or reduce the availability of alternative suitable nesting habitat, or the productivity of foraging grounds.	Moderate. This needs to be assessed in light of cumulative pressures from climate change, coastal and marine development and catchment run-off that may degrade or reduce the availability of alternative suitable nesting habitat, or the productivity of foraging grounds.

	Pressures									
	Commercial marine tourism	Defence activities	Commercial fishing	Recreational fishing	Ports and shipping	Recreation (not fishing)	Traditional use of marine resources	Climate change	Coastal development	Declining water quality due to land-based run-off
	<p>may be more likely. Research into the impacts from this source of disturbance has shown resultant reductions in clutch size. Either way, long-term impacts on populations would be significant if unmanaged, especially disturbance during nesting that could force nesting females to relocate to sub-optimal nesting locations.</p> <p>Evidence of basking behaviour ceasing after the introduction of tourism to Heron Island suggests marine turtles do not adapt to tourism associated disturbance.</p>					requirements.	turtles when migrating.	<p>temperatures, and in the second, a shift in the main nesting beaches used.</p> <p>Human-related pressures may degrade or reduce the availability of alternative suitable nesting/internesting habitat, or the productivity of foraging grounds.</p> <p>The mobility and foraging ecology of marine turtles may enable them to select alternative suitable habitat localities to forage if necessary and available. The actual adaptive capacity of marine turtles to these pressures is poorly understood. It is not known what the thresholds of pressure may be if marine turtles were forced to transition to alternative nesting or foraging localities if previous localities were lost or degraded or were not productive enough to support provisioning.</p>		

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<p>Adaptive capacity – management (poor, moderate, good)</p>	<p>Good. Current management arrangements and education strategies have been shown to provide a level of effectiveness for reducing visitor disturbance impacts.⁴¹ For example, strict control of visitors at Mon Repos (outside of the World Heritage Area) reduces the impact on nesting turtles and improves public awareness of the needs that turtles have during nesting, incubation and hatchling emergence.⁴¹ Marine turtle and dugong tourism is managed under a national code of practice. GBRMPA works closely with industry to promote best practice tourism with regards to threatened species,</p>	<p>Good. Defence activities are well managed and limited in extent, duration and geographic distribution.¹ Strategies to minimise the impact of underwater demolitions and explosions on marine turtles need to be considered by the Department of Defence and responsible agencies.</p>	<p>Moderate. The Great Barrier Reef Marine Park Zoning Plan 2003 is providing protection of habitat used by marine turtles in the Great Barrier Reef. Under both state and Commonwealth Great Barrier Reef zoning plans, inshore zonings of Marine National Park and Conservation Park provide some restriction to the extent of habitat available to inshore netters and crabbers. The Queensland Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004 provides complementary protection of some estuarine waters. The capacity to adapt the state and Commonwealth Great Barrier Reef zoning plans to meet changing spatial management requirements is</p>	<p>Moderate. The Great Barrier Reef Marine Park Zoning Plan 2003 is providing protection of habitat that is used by marine turtles in the Great Barrier Reef. Thirty-three per cent of the Marine Park is closed to extractive uses. Inshore zonings of Marine National Park and Conservation Park in combination with provisions under the Queensland Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004 provide some restriction to the extent of habitat available to crabbers and fishers. Strategies to reduce the occurrence of boat strike on marine turtles need to be</p>	<p>Moderate. GBRMPA has strategies and statutory tools to assess and mitigate the risks posed by ports and port expansions and lower the risk of vessel-related oil spills and pollution incidents. However, the risks can only be lowered and not eliminated. Processes that reduce impacts on habitat and mortality and injury of marine turtles, such as those from port development and dredging activities, continue to be improved to eliminate, reduce or offset the impact. The Australian and Queensland governments' Strategic Assessment of the Great Barrier Reef World Heritage Area processes have terms of reference to take</p>	<p>Moderate. Management arrangements (such as management plans for protected area estate, plans of management under the Great Barrier Reef Marine Park Zoning Plan 2003) and the state and Commonwealth legislative frameworks currently in place provide a level of effectiveness for reducing visitor disturbance impacts. These can be adapted to suit changing management needs through processes of review. Strategies to reduce the occurrence of boat strike on marine turtles need to be further co-developed between the responsible agencies.</p>	<p>Moderate. The Land and Sea Country Indigenous Partnerships Program is funded at \$10 million over five years. This is in part to aid the development of Traditional Use of Marine Resources Agreements throughout the Great Barrier Reef Marine Park. An agreement may, for example, put in place management arrangements to ensure any traditional take of marine turtles does not exceed sustainable limits. It also establishes a partnership between the Traditional Owners, GBRMPA and the Queensland Government to collaborate on monitoring of</p>	<p>Poor. Options for local or regional scale management of climate impacts on marine turtles remain very limited, mostly because impacts are directly linked to large-scale global climate phenomena rather than more local threatening processes. Current information on climate change impacts on marine turtles are being implemented into management actions within the World Heritage Area. However, long-term studies that take account of temporal and spatial variability and identify the relationships between climate change impacts and marine turtle populations at the species-specific level are required to inform management. The current framework for managing climate change impacts within GBRMPA has been developed to implement new</p>	<p>Moderate. The <i>Great Barrier Reef Marine Park Act 1975</i> provides limited scope to manage activities outside the Marine Park. To achieve good water quality and coastal ecosystem outcomes for the Great Barrier Reef, GBRMPA facilitates the development of partnerships with industry, the community, local and state government and other Australian Government agencies to influence the management and planning of catchment and coastal pressures. This develops and maintains a culture of mutual obligation. This is undertaken by fostering partnerships through the <i>Reef Water Quality Protection Plan 2013</i> and the Reef Rescue Program.</p>	<p>Moderate. The <i>Great Barrier Reef Marine Park Act 1975</i> provides limited scope to manage activities outside the Marine Park. To achieve good water quality and coastal ecosystem outcomes for the Great Barrier Reef, GBRMPA facilitates the development of partnerships with industry, the community, local and state government and other Australian Government agencies to influence the management and planning of catchment and coastal pressures. This develops and maintains a culture of mutual obligation. This is undertaken by fostering partnerships through the <i>Reef Water Quality Protection Plan 2013</i> and the Reef Rescue Program.</p>

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	<p>including marine turtles.</p> <p>Strategies to reduce the occurrence of boat strike on marine turtles need to be further co-developed between the responsible agencies and operators.</p> <p>Management of marine turtle tourism can review best practice guidelines to reflect such developments.</p>		<p>generally limited to the use of Special Management Areas that can restrict commercial fishing activities in sensitive or critical habitats under exceptional circumstances and after extensive consultative processes.</p> <p>For commercial fishing impacts that fall outside of GBRMPA's jurisdiction — such as those from trawling, inshore set mesh nets or oceanic long-lining — processes such as collaborative risk assessments, consultations and general advocacy on issues of concern remain as avenues for adaptive management.</p> <p>Strategies to reduce the occurrence of boat strike on marine turtles need to be further co-developed between the responsible agencies and operators.</p>	<p>further co-developed between the responsible agencies and operators.</p>	<p>account of regional and cumulative impacts from activities such as ports and shipping.</p> <p>Strategies to reduce the occurrence of boat strike on marine turtles need to be further co-developed between the responsible agencies and operators.</p>		<p>the habitats and ecosystems, and human activities in their sea country.</p> <p>There is also considerable compliance effort placed on illegal poaching of marine turtle resources by non-Traditional Owner hunters. Inherent difficulties in enforcing compliance associated with remote locations are steadily being addressed through programs aimed at enabling Traditional Owners to gather evidence of alleged offences.</p>	<p>information as it becomes available.</p>	<p>development in Queensland.</p>	

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	Commercial marine tourism	Defence activities	Commercial fishing	Recreational fishing	Ports and shipping	Recreation (not fishing)	Traditional use of marine resources	Climate change	Coastal development	Declining water quality due to land-based run-off
Residual vulnerability (low, medium, high)	Low	Low	Medium	Medium	Medium	Medium	Medium (for northern GBR green turtle stock and the harvest of hawksbill turtle eggs)	High	Medium	Medium
Level of confidence in supporting evidence (poor, moderate, good)	Moderate. Limpus 2007 ⁴² , 2008 ¹⁴ , 2008 ⁴¹ , 2008 ¹⁶ , 2008 ¹⁷ , 2009 ¹⁵ , 2009 ¹⁷	Good. O'Neill 2009 ¹¹²	Good. Limpus 2007 ⁴² , 2008 ¹⁴ , 2008 ⁴¹ , 2008 ¹⁶ , 2009 ¹⁵ , 2009 ¹⁷ Greenland & Limpus 2003 ¹¹⁰	Moderate. Limpus 2007 ⁴² , 2008 ¹⁴ , 2008 ⁴¹ , 2008 ¹⁶ , 2009 ¹⁵ , 2009 ¹⁷	Moderate.	Poor — behavioural ecology — little is known on what level of disturbance causes a decline in the reproductive outputs of marine turtles. Moderate – Marine Wildlife Strandings and Mortality Database shows an increase in boat strike along the Great Barrier Reef coast. Part of this can be attributed to recreational boating.	Good. Limpus 2007 ⁴² , 2008 ¹⁴ , 2008 ⁴¹ , 2008 ¹⁶ , 2009 ¹⁵ , 2009 ¹⁷	Poor. Limpus <i>et al.</i> 2003 ¹³ Lough 2007 ¹⁰⁸ Hamann <i>et al.</i> 2007 ³³ Smithers <i>et al.</i> 2007 ¹¹³ Turner & Batianoff 2007 ¹¹⁴ Fuentes <i>et al.</i> 2011 ¹⁰⁷	Poor. Limpus 2007 ⁴² , 2008 ¹⁴ , 2008 ⁴¹ , 2008 ¹⁶ , 2009 ¹⁵ , 2009 ¹⁷	Poor. Hutchings <i>et al.</i> 2005 ¹¹⁵

The pressures addressed in this vulnerability assessment were identified in the *Great Barrier Reef Outlook Report 2014*.¹

Coastal habitats (rivers, estuaries, seagrasses, mangroves and wetlands) are under increasing pressure from human activities. More than 85 per cent of Queensland's population live on the coastal fringe. Predicted strong population growth means the intensity of activity and development in coastal zones is likely to persist.¹¹⁶

The purpose of the vulnerability assessment is to provide a mechanism to highlight key concerns and make assessments of the vulnerabilities that species, groups of species or habitats (or elements of biodiversity) have to known sources of pressure within the Great Barrier Reef World Heritage Area using a standardised and transparent process.

This was undertaken using a standard approach to assess the exposure and sensitivity and adaptive capacity to these pressures (Figure 1) based on the best available information on that particular element of biodiversity.

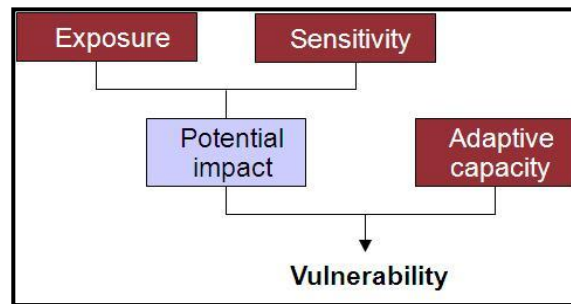


Figure 1. The key components of vulnerability assessments (adapted from Wachenfeld *et al.*, 2007)

To achieve this objective it has been necessary to apply a linear relationship to comparisons that are sometimes non-linear by nature. For example, when applying the potential impact matrix⁹ to create a combined score for exposure and sensitivity, if an element of biodiversity has a very high level of exposure to a pressure but low sensitivity to it, it is scored as having a medium–high potential impact score. This medium–high score may be the same as determined for another assessment where there may be a low level of exposure but a very high level of sensitivity. This implies a linear relationship for the sensitivity a species or habitat has to a given level of exposure, which may not necessarily be the case. However, it does provide managers with the required level of resolution on these relationships for the purpose of the vulnerability assessments that inform the *Great Barrier Reef Biodiversity Conservation Strategy 2013*.

The natural capacity of marine turtles to adapt to pressures in the World Heritage Area, and the capacity of management to intervene (which in turn may assist marine turtles to adapt to these pressures), are considered as two dynamics that affect their residual vulnerability to any of the identified pressures. These two dynamics are then combined to produce an overall rating for adaptive capacity and then applied to the potential impact rating to provide a score for the residual vulnerability that marine turtles may be expected to experience due to the given pressure.

An explanation of the procedure by which the vulnerability assessment process (represented in Figure 1) has been applied, and qualifying statements for the assessment of exposure, sensitivity and adaptive capacity (natural and management) scores are provided within the vulnerability assessments page of the Great Barrier Reef Marine Park Authority website.

⁹ The potential impact matrix is described within the vulnerability assessments page of the Great Barrier Reef Marine Park Authority website.

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