Australian Government
Great Barrier Reef Marine Park Authority

Dugongs

Information valid as of June 2014

Summary

Diversity

Single species – dugong (*Dugong dugon*, last remaining species of the family Dugongidae; Order: Sirenia)

Susceptibility

Life-history traits that predispose dugongs to threats include being long-lived with low reproductive potential, delayed sexual maturity, high female investment in each offspring, migratory (they range across international boundaries into areas where they are highly targeted and less protected), and a reliance on inshore habitats which increases their exposure to human-related and land-based threats.

Major pressures

Impacts of greatest significance to dugongs south of Cooktown are habitat loss and degradation from cyclone activity and extreme weather, sediment, nutrient and pesticides from catchment run-off, clearing or modifying of coastal habitats, coastal reclamation, dredging and dumping and re-suspension of dredge material, disease, boat strike and vessel disturbance, death from incidental capture in nets (commercial net fishery and shark control program), and marine debris.

North of Cooktown, seagrass is exposed to fewer water quality-related impacts. There, impacts identified include habitat loss and degradation from cyclone activity and extreme weather, disease, incidental capture in nets (commercial net fishery), illegal fishing and poaching, and hunting for traditional use.

Cumulative pressures

Commonly, pressures experienced by dugongs in the Great Barrier Reef World Heritage Area (the World Heritage Area) can vary in severity, spatially and/or over time (perhaps seasonally or simply cumulatively as a function of time).

Pressures can be acute direct pressures such as mortality from boat strike, or chronic indirect pressures on seagrass meadows resulting from declining water quality. Boat strike is more likely to occur in areas adjacent to population centres and entrances to busy ports that may also be important foraging grounds for dugongs. These areas might also be exposed to declining water quality from catchment run-off and habitat degradation due to increased coastal and marine development. The combination of these pressures over time can cause impacts on dugong health, the availability or health of their food (primarily seagrasses) and eventually the status of the population.

Applied or assessed separately, these pressures may not seem significant, but research indicates the combined and cumulative impact of these major pressures present significant concerns for the conservation and management of dugongs in the World Heritage Area.

Management in the Great Barrier Reef

Legislative management tools for the conservation of dugongs that are in force in the World Heritage Area include:

- The *Environment Protection and Biodiversity Conservation Act 1999*
- *Great Barrier Reef Marine Park Act 1975* (including statutory plans of management such as those for Cairns, Hinchinbrook and Whitsundays) 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 is closed to extractive use), which along with the Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004 (Qld) provides complementary protection of coastal and some estuarine waters
- Dugong Protection Area Regulations under the *Fisheries Act 1994* (Qld), (with complementary provisions under Great Barrier Reef Marine Park

Dugong mother and calf

Act Species Conservation (dugong protection) Special Management Areas) and Fish Habitat Areas (under the *Fisheries Act 1994* (Qld)), provide protection for dugongs and their supporting habitats

- Trawling strip closures under Queensland Fisheries Regulations 2008 complement habitat protection provided by Marine Park zoning plans
- 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)
- *Coastal Protection and Management Act 1995* (Qld)
- The Queensland Coastal Plan guides coastal development
- *Sustainable Planning Act 2009* (Qld)
- Others (see management table, page 15).

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 dugongs 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 dugongs. 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]

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

- The Land and Sea Country Indigenous Partnerships Program — Traditional Use of Marine Resources Agreements. Traditional use of dugongs south of Cardwell has virtually halted as a voluntary conservation measure initiated by Traditional Owner groups
- Indigenous Land Use Agreements (that 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 dugongs in Queensland (and other protected marine species) and is provided with information from Queensland Fisheries' on 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
- Voluntary vessel transit lanes in important dugong habitat (for example Missionary Bay, Hinchinbrook channel)
- Public education of management actions through programs such as GBRMPA's Reef Guardians and listing of responsible reef practices for dugong 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.

Dugongs in the Great Barrier Reef Marine Park mostly inhabit shallow, turbid inshore waters

Great Barrier Reef Outlook Report 2014 **assessment:** Poor

Vulnerability assessment: high

- The dugong population in the Great Barrier Reef World Heritage Area (south of Cooktown) is

believed to be only a small fraction of pre-European levels.[9] This situation has occurred due to a variety of factors: commercial harvest of dugongs for oil and other by-products (1847–1969); incidental drowning in commercial set mesh nets and nets set for bather safety; declining water quality; habitat loss and degradation; Indigenous traditional use and illegal poaching.

- Dugongs are susceptible to a range of threats that impact on the recovery of their population in the World Heritage Area due to a combination of conservative life-history traits (they are long-lived, slow to mature, and have low reproductive potential) and their total reliance on ephemeral seagrass meadows that are susceptible to dieback when environmental conditions are unfavourable.
- Population modelling suggests even with the most optimistic combinations of life-history parameters (for example, low natural mortality and no human induced mortality), the dugong population is unable to increase by more than four to five per cent each year.[10] Dugong mortalities recorded by the Queensland Strandings and Mortality Program for 2011 were the highest since the program's annual reports began being published in 1998. The latest dugong survey results from 2011[11] for the urban coast of Queensland (south of Cooktown), also show a reduced presence of dugongs in central and southern parts of the Great Barrier Reef Marine Park in comparison to the previous survey in 2005. The conservation status for dugongs living in these areas is concerning considering their limited potential for population recovery.
- There are a range of threats that impact on dugongs at different spatial and temporal scales within their range along the east coast of Queensland. As a result, the east coast of Queensland has been artificially divided into a 'remote Great Barrier Reef dugong management unit' (Cooktown north) and an 'urban coast dugong management unit' (which extends from Cooktown to the southern extent of their distribution). The key threats in both these management units include:
- Incidental drowning in set mesh nets used by commercial fishers. There is also some remaining pressure from incidental capture in shark net apparatus used in the Queensland Shark Control Program
- Cumulative pressures to their primary food, seagrasses, from habitat loss and degradation as a result of extreme weather events (floods and cyclones); coastal development (ports/marinas and harbours infrastructure development, land reclamation); and reduced water quality due to catchment run-off and coastal development (ports/marinas and harbours, including operations and dredging)
- Increasing occurrence of boat strike and disturbance (most significantly in areas adjacent to high-traffic ports and/or major population centres)
- Ingestion of and entanglement in marine debris (entanglement in ghost nets adds another significant dimension to this pressure for animals inhabiting the remote north coast, Torres Strait and Papua New Guinea)
- Indigenous traditional harvest where management is yet to be well-established and/or there is illegal poaching/hunting.
- It is currently considered that the dugong population residing within the World Heritage Area may be stable, although confidence in this trend information is relatively low when large-scale movements of dugongs and sight ability bias (of observers) and availability bias (of dugong during transect passes) are difficult to account for when analysing aerial survey data. However, without continued application of well-developed (and adaptive) conservation management measures, the combined impact of human-related pressures that dugongs are exposed to may cause population decline, even when acting independently. There is even greater concern when the impacts combine to act cumulatively.
- Extreme weather events (including floods) create water quality conditions that are not conducive to seagrass productivity, while cyclonic conditions have been shown to physically remove seagrass meadows through benthic (seafloor) scouring. Recovery rates can be reduced when seed banks and organic benthic material necessary for plant propagation is also removed. Recent occurrences have resulted in unprecedented numbers of dugong carcasses being retrieved from along the developing coast in both 1992 and 2011[11,12] after extreme flooding and cyclones.
- The proposed expansion of several ports along the Queensland developing urban coast in locations such as Townsville and Gladstone will lead to an increased risk to dugongs and seagrass habitat from dredging and spoil disposal and re-suspension of sediments; land reclamation; port infrastructure development; boat strike from an increase in commercial and recreational vessel movements; disturbance from increased vessel activity and underwater noise; increased exposure to pollutants from shipping operations and accidents; and habitat degradation as a result of ship mooring requirements.
- Dugongs now face a variety of pressures that may reduce their resilience to current and future impacts of climate change and impede their capacity to

A herd of dugongs foraging in a shallow seagrass area near Clairview

adapt to the expected rate of change. These pressures include accelerated rates of climate change; depleted population; cumulative impacts of human-related threats; and a reduction of alternative habitats for foraging along the developing urban coast.

- Dugongs within the World Heritage Area are under threat from Indigenous traditional harvest when left unmanaged and through non-traditional or illegal poaching. Pressure is exerted on this same stock of animals when they venture into neighbouring jurisdictions in the Torres Strait and Papua New Guinea.

Details of how these major pressures are exerted upon dugongs within the World Heritage Area are discussed further within this vulnerability assessment.

Background

Brief description of dugongs

Dugongs (*Dugong dugon*) are marine mammals in the Order Sirenia; commonly called sea cows. There are only four living species of sea cow — three manatee species (Family Trichechidae) found in the Atlantic region and one dugong Family (Dugongidae) in Australian, south-east Asian and Indian Ocean tropical and subtropical waters.

The dugong's closest relative, the giant Stellar's sea cow (*Hydrodamalis gigas*), was hunted to extinction by sealers and fur traders in 1768. The order Sirenia is one of only three orders of mammals at significant risk of extinction at the ordinal level.[13]

Dugongs have a long rotund body and a tail fluke for propulsion. Dugongs grow to three metres long, can weigh up to 420 kilograms and live for 70 years or longer. In a study by Marsh,[10] the estimated age of the oldest female examined was 73 years. However, less than 1.5 per cent of females whose absolute age was estimated were older than 60 years.

The age of a dugong can be estimated by counting growth layers in its tusks. The tusks erupt after puberty in males and in a small proportion of older females. Their ears (which have no flaps or lobes) and eyes are set laterally on the head, allowing a field of view forward and to the sides. Dugongs do not see very well but are believed to have acute hearing within narrow sound thresholds. Cows and calves communicate by producing 'chirps' within the range of three to eight kilohertz. Pectoral fins are used for steering and support while feeding (dugongs do not have a dorsal fin). They have sensitive bristles covering their upper lip, which they use to find and then grasp seagrass.

Dugongs generally surface to breathe after only a few minutes and can be difficult to detect as they surface very discreetly, often with only their nostrils breaking the surface of the water. Their paired nostrils on the top of the snout have valves to stop water entering when they dive.[10] Although dugongs have been recorded at depths of 70 metres up to 50 kilometres offshore,[14] recent research has determined that dugongs spend 72 per cent of their time in less than three metres of water, dive on average 12 times an hour and feed up to 16 hours per day.[15] This increased understanding of dive times and behaviours across habitat types has led to a review of past population estimates, which are now considered to be an underestimation.[16]

Where they are common, dugongs are often found in groups. The mean size of a group of dugongs (used to estimate population size) is generally between 1.3 and 1.6 animals.[14,16,17,18] From Smith's[19] documentation of traditional ecological knowledge of dugongs on eastern Cape York Peninsula, hunters at Lockhart River state that herds of dugongs comprise mostly females with their calves, young males and one or a few dominant males. Single animals are usually males that have been chased away from the group by a dominant male.[19]

Calves rely on the mother not only for sustenance but for protection, never straying far and often riding above her back. Dugongs have few natural predators but there is evidence that sharks, crocodiles and killer whales will feed on young dugongs.[20]

Reproduction and growth

The age at sexual maturity of male and female dugongs varies amongst individuals and possibly among and within populations.[20] In northern Australia, a female over 2.5 metres in length generally has borne a calf, whereas if she is less than two metres she almost certainly has not.[20] Females have their first calf when they are between six and 17 years old and then produce calves very variably; estimates range from between every three years to every seven years.[10,20] Traditional knowledge from Lockhart River suggests cows can calf annually as they are often seen with two calves.[19] Males less than 1.9 metres are almost certainly immature, whereas those larger than 2.5 metres are likely to be mature.[20] The variation in age at first breeding is considered to be dependent on the status of the food supply, with the age to maturity delayed in those years when quality seagrass forage is unavailable.[21]

Males follow a female when she is oestrous ('in heat') and compete for mating opportunities. Many males mate with a female, inflicting scars on her back and on each other. The female will bear one calf after a gestation period which lasts about 13 to 14 months.[10] Traditional, ecological knowledge of dugongs in the Buchaneer Archipelago area of northwest Western Australia indicates that pregnant females give birth in shallow water. Newborns are about 1.2 metres long and weigh about 30 kilograms.[10]

Dugongs are not in continuous breeding condition all year round and the timing of mating and birth in dugongs seems to vary with latitude — the breeding season being less pronounced in the tropics than at higher latitudes. This is supported by traditional knowledge from the Lockhart River area where it is believed that dugongs have a diffusely seasonal breeding season.[19] This seasonal variation in breeding is considered to be a function of seagrass productivity being more consistent year round in the tropics. In Queensland, a seasonal pattern of breeding activity occurs during the second half of the year, with a peak around the end of the summer months for populations at the southern end of their distribution.[22]

Diet and feeding behaviour

Dugongs feed on seagrasses and have distinct preferences for particular species, which seem to be based on nutritional quality.[23] They uproot the whole plant where accessible, but when this is not possible they feed only on the leaves.[24,25] Seagrass species of the genera *Halophila* and *Halodule* are preferred (most commonly *H. ovalis* and *H. uninervis*, respectively).[12,26] Dietary selectivity for these species is supported by traditional ecological knowledge from the Lockhart River area.[19] However, all seagrass species described for the World Heritage Area have been found in the stomach contents of dugongs.[27]

Sheppard and colleagues'[28] model of dugong resource selection suggests nitrogen is the primary limiting nutrient for dugong populations. Dugongs appear to optimise their diet by selectively grazing species that maximise digestible nutrients (most importantly, nitrogen and carbohydrates/starch).[23,28] Sheppard and colleagues[28] found diel (24 hour) cycles determined whether dugongs selected seagrasses on biomass (quantity) or nutrition (quality). This work found dugong habitat use was consistently centred over patches of seagrass with high nitrogen concentrations, except during the day at low tides when the animals had fewer habitat choices and space use was focused on areas with high seagrass biomass. Research has also found the dugong's preferred species *H. ovalis* and *H. uninervis* also generate more leaf biomass after grazing disturbance and seem to outcompete seagrass species less favourable to the dietary requirements of dugongs as a result of grazing.[29,30]

Marine algae are also eaten but this may occur only when seagrass is scarce[31,32] or incidentally. Examination of stomach and faecal samples from dugongs in more tropical areas of Australia shows these dugongs do not deliberately forage on macro-invertebrates.[33] However, Anderson[34] and Preen[12] have demonstrated that near the southern limits of their range in western and eastern Australia, dugongs deliberately forage for macro-invertebrates.

Calves start eating seagrass soon after birth and grow rapidly during the suckling period when they also receive milk from their mothers.[22] The suckling period extends for approximately 18 months.[10] The mammary glands are located beneath each pectoral flipper where there is a visible nipple.

Migratory behaviour and management implications

The results of numerous aerial surveys of dugongs have provided evidence of significant large-scale movements of dugongs in different parts of their Australian range including the east coast of Queensland.[35,36] Large-scale movements of dugongs have been confirmed by satellite tracking of individuals.[37,38] This information is consistent with research by McDonald[39] that provides genetic evidence that dugong populations along the Australian coast are not highly structured. Large-scale movements are considered to be a possible cause of the relatively large variance in the estimates of dugong abundance in the southern Great Barrier Reef in the mid-1990s.[40] Emigration following seagrass dieback may also be responsible for variation in abundance in the same southern region between 2005 and 2011 although there is currently no conclusive data to support this and in both instances variation is likely to have been the combined result of emigration, mortalities[11,40] and reduced reproduction[21] following seagrass diebacks. Seagrass meadows vary across bathymetric, nutritional and seasonal gradients and are subject to large-scale periodic diebacks (for example, Preen and Marsh[41]; Preen *et al.*[42]) and large-scale movements by dugongs are considered to be a response to such changes in the abundance of seagrass forage.[38,41]

Grech and Marsh[43] caution about using the results of aerial surveys as a reason for postponing management. They point out that even if the time-series of aerial surveys has not detected a decline in abundance, this does not prove that present levels of harvest are sustainable, especially if the rate of decline is low. Grech and Marsh[43] suggest the "improvement of performance in detecting declines in the dugong population depends on increasing survey extent and frequency, and developing different methods to detect decline. Such improvements would require a substantial increase in funding which is unlikely to be available. Thus, management intervention should not require the trigger of statistical evidence of reduction in abundance."

Marsh and colleagues[40] state that genetic analysis, satellite tracking and aerial survey data all indicate that effective dugong management requires initiatives to be co-ordinated across jurisdictions. They continue by saying that despite the lack of evidence for clear, genetically-appropriate boundaries for dugongs in Australian waters, the genetic and movement data both indicate that the appropriate ecological scale for management is some hundreds of kilometres of coastal waters. They suggest that it would be appropriate to differentiate dugong management in Queensland on the basis of the nature and scale of human impacts on dugongs and their habitat.[40] For this purpose, Marsh and colleagues[40] suggest separating dugong management of the developing coast between Cooktown and the Queensland–New South Wales border from management of remote areas off Cape York Peninsula, the Torres Strait and in the Gulf of Carpentaria.

Geographical distribution

The dugong has a large range that spans at least 37 countries and territories. is distributed through tropical and sub-tropical waters from east Africa to Vanuatu between about 26 to 27 degrees north and south of the equator.[44] The dugong's historic distribution is considered to be broadly coincidental with the tropical Indo-Pacific distribution of its food, the seed-producing seagrasses of the families Potamogetonaceae and Hydrocharitaceae.[44] It is generally believed that the dugong is represented by relict populations separated by

large areas where its abundance has been greatly reduced or it has already become locally extinct.[44] A recent synthesis for the International Union for Conservation of Nature (IUCN) Red List of Threatened Species suggests dugongs are declining or locally extinct in at least a third of its range; of unknown status in nearly half; and possibly stable in the remainder.[45]

In Australian waters, the dugong's range extends across the northern coast from Moreton Bay in southern Queensland to Shark Bay in Western Australia.[44] Genetic studies using mitochondrial DNA analysis show two separate female lineages, which are likely to have established in response to sea-level changes over geological time. One lineage is confined to the Queensland coast and part of the Northern Territory, while the other occurs across the entire Australian range.[39] Investigation of mitochondrial DNA genetic patterns in Australian dugongs suggest a male-biased gene flow which is consistent with common dispersal patterns in mammals where males are dispersive and females are more geographically restrictive.[39] The same study found healthy levels of genetic diversity amongst Australian dugongs and a demonstration of significant gene flow. This high level of gene flow makes the allocation of genetics-based management units difficult.[39]

Data gathered in the 1980s through to the early 2000s across the Great Barrier Reef coastal area have identified hotspots of high dugong abundance at relative densities greater than 0.5 dugongs per square kilometre (up to almost 10 dugongs per square kilometre).[46] This analysis has allowed areas of low, medium and high conservation value for dugongs to be mapped within the Marine Park[b].[46]

The relative density of dugongs is higher in the remote north where it ranged from 0.5 to 9.86 dugongs per square kilometre at various locations including Friendly Point, Port Stewart and embayments between Lookout Point and north to Bathurst Head (Princess Charlotte Bay).[46] These areas are considered to be of high conservation value for dugongs. Hinchinbrook Island, Cleveland Bay, Shoalwater Bay and Port Clinton on the urban coast of Queensland were also identified as being of high conservation value for dugongs, although the relative density of dugongs in these localities was lower than in the remote north, ranging from 0.5 to 1.92 dugongs per square kilometre.

Population status in the Great Barrier Reef Marine Park

Aerial surveys along much of the Queensland coast have been conducted since the mid-1980s as a part of an ongoing program to monitor the distribution and abundance of dugongs in Australian waters.[47,48,49] Aerial surveys of more than 120,000 square kilometres of coast since 2005 estimate the Australian population comprises approximately 68,700 individuals across their Australian range.[43] Analysis of the 20 year time series of aerial surveys suggests dugong populations are stable across most of the dugongs' range in Australia, though numbers have fluctuated in the Torres Strait, Hervey and Moreton Bays.[40,43] These fluctuations may be due to movements between survey regions and reduced reproduction in response to seagrass dieback[21,41,50] along with environmental and behavioural effects biasing survey counts.[18] This includes animals being unavailable or difficult to count as they dive on deeper water seagrass as a result of changes to seagrass habitat in intertidal or shallower sub-tidal meadows.[21]

Historical reports from the late 19th century of dugong herds that were much larger than those recorded in the 20th century suggest that dugong numbers had already experienced declines during the period between European settlement and the 1960s.[9] Anecdotal and scientific information indicate the dugong population of the urban (developing) coast of Queensland between latitudes 16.5 degrees south and 28 degrees south has undergone further substantial decline.[44] In a study by Marsh and colleagues,[9] information collected by the Queensland Shark Control Program was used to hindcast changes in dugong abundance along Queensland's urban (developing) coast between Cairns and the Gold Coast since the early 1960s. The extrapolated estimate of dugong abundance in 1962 was 72,000 dugongs — this was on the basis of the decline in catch per unit effort detected in the shark nets, indicating a rate of population decline of 8.7 per cent per year for 37 years. Based on aerial surveys conducted in the 1990s, the population of dugongs using this area was approximately 4220 individuals. This represents a population decline of 94 per cent from 1962 levels[c].[9]

In 2005, aerial surveys of the developing coast between Cooktown and the New South Wales–Queensland border were undertaken by two aircraft operating concurrently for the first time, using the aerial survey technique developed by Marsh and Sinclair.[17] Population sizes were estimated using aerial survey data corrected for perception and availability bias (refer to Marsh and Sinclair[17] and Pollock *et al*.[18]). The estimate of the dugong

[b] Within their study, Grech and Marsh[46] qualify their assumption that dugong density is a robust index of a region's conservation value for dugongs.

[c] Although Marsh and colleagues highlight the qualitative value of such abundance hindcasting to illustrate the extent of the population decline of dugongs in the waters of Queensland's developing coastline, they assert that using the process to set quantitative targets for population recovery has less utility. This is because hindcast estimates of abundance are based on underlying assumptions which are yet to receive systematic testing and the environment may have also undergone significant degradation of carrying capacity since 1962.[9]

population in the central and southern Great Barrier Reef region (Daintree River to Baffle Creek) that was produced using the Pollock *et al*.[18] methodology was 2059 ± 413.[16]

In response to the extreme weather events of the 2010–11 summer, where widespread flooding from catchments adjacent to the Great Barrier Reef and tropical cyclones Tasha, Anthony and Yasi impacted major dugong habitats in coastal areas south of Cairns, an aerial survey was conducted in November 2011 to evaluate the response of the dugong population to these environmental disturbances.[11] These surveys revealed the estimated size of the dugong population in the central and southern Great Barrier Reef region was the lowest since surveys began in 1986, with only an estimated 608 ± 213 animals using the Pollock *et al*.[18] methodology.

The dugong population in the central and southern Great Barrier Reef has reduced by approximately 70 per cent between 2005 and 2011 (refer Table 1). Movement between southern and northern Great Barrier Reef regions over this time may explain some of the variation in dugong population estimates. Some will have perished due to the loss of seagrass as represented by the elevated numbers of dugongs in the strandings data of 2011 and 2012[51] and there is likely to have been reduced reproduction in response to seagrass dieback.

Table 1. Standardised estimates of the dugong population by region using the Pollock *et al*. (2006) methodology (from Marsh *et al*., 2007; Marsh and Lawler, 2006; Sobtzick *et al*., 2012)

Region	Year	Population estimate	Year	Population estimate
Torres Strait	2001	13465 ± 2152	2006	14767 ± 2292
Northern Great Barrier Reef	2000	9730 ± 1485	2006	8812 ± 1769
Central and southern Great Barrier Reef	2005	2059 ± 413	2011	608 ± 213
Hervey Bay	2005	2077 ± 543	2011	2029 ± 576
Moreton Bay	2005	421 ± 60	2011	700 ± 156

In 2006 the same aerial survey technique[17] and statistical method[18] were used to estimate the population of dugongs of the northern Great Barrier Reef between Cooktown and Cape York to be 8812 ± 176.[52] In 2001 the same techniques and methods estimated a population of 9730 ± 1485.[52] Analysis of variance between surveys showed no significant difference of population estimates which is consistent with analysis of previous survey data for the same region using the Marsh and Sinclair methods to estimate population.[52] Aerial surveys of the northern Great Barrier Reef dugong population since 1985 have not been able to demonstrate a significant decline in dugong numbers although the likelihood of localised depletions requires further investigation.[36]

Taylor and colleagues[53] have demonstrated the limited ability of surveys to detect declines in marine mammal stocks, even when the decline is steep. The power of aerial surveys to detect low rates of population declines is most limited.[52] Although the precision of dugong population estimates in the northern Great Barrier Reef and Torres Strait is considered quite high for marine mammal surveys[52,53], Grech and Marsh[43] caution about using the results of aerial surveys as a reason for postponing management and point out that even if the time-series of aerial surveys has not detected a decline in abundance, this does not prove that dugong populations of the Torres Strait and northern Great Barrier Reef are not in decline for if they are, the decline occurring is almost certainly low and thus difficult to detect.[52]

Ecosystem role/function

Dugongs are herbivorous mammals that consume large quantities of seagrass to fulfil their substantial energy requirements. Research has shown that in areas where grazing is the only major source of natural disturbance, dugongs (and green turtles) are likely to play a significant role in influencing multi-species tropical seagrass communities by altering their biomass, net above-ground biomass productivity and the species composition of seagrass meadows.[26,29] In a subsequent study, dugongs and green turtles were found to influence the nutritional value of seagrass species.[30] Following on from the earlier work, Aragones[30] found seagrass habitats have the potential to be degraded in terms of both species composition and nutritional value should the abundance of dugongs (and green turtles) be substantially reduced.

Dugongs often occur in small herds.

Ecosystem goods and services

Ecosystem goods and services category	Services provided by the species, taxa or habitat
Provisioning services (e.g. food, fibre, genetic resources, bio-chemicals, fresh water)	Dugongs provide a provisioning service for Australian Indigenous people where they provide sustenance, particularly for isolated communities where store-bought food is often very expensive. Quantitative information on traditional use of dugongs is lacking.
Cultural services (e.g. spiritual values, knowledge system, education and inspiration, recreation and aesthetic values, sense of place)	Dugongs are of enormous cultural, spiritual and economic (subsistence) importance to Aboriginal and Torres Strait Islander peoples. Through a long association with dugongs, Indigenous people have developed a detailed body of traditional ecological knowledge that includes information on the natural history and ecology of these animals. Dugongs have spiritual significance for many Indigenous peoples, which is reflected in the stories and accounts of the past in many coastal Indigenous communities. Their spiritual significance fulfils roles in traditional lore regarding their management and use. Furthermore, use of animals such as dugong and other traditional foods reinforces a living culture and demonstrates continuity with tradition and traditional estates as required for the recognition of native title under the *Native Title Act 1993*. In ceremonies, dugongs play different roles for many coastal Indigenous people. In some areas the dugong forms part of creation stories and can be found in all aspects of spirituality, art and life. The activity of pursuing the dugong itself can have great significance and be an expression of continuance of a long cultural tradition. The importance of the hunting and butchering of the dugong is also expressed through the social sharing of the animal as food according to traditional kinship protocols. The hunt may also form an important part of a young male's progression from boyhood to manhood when given the opportunity for his first hunt. Aesthetic and intrinsic conservation values provide a strong social and economic impetus for the conservation of dugongs. For many people, dugongs are iconic and can represent symbols of inspiration or have spiritual value.
Supporting services (e.g. primary production, provision of habitat, nutrient cycling, soil formation and retention, production of atmospheric oxygen, water cycling)	Dugongs cycle nutrients within the ecosystems in which they forage. While foraging, dugongs bioturbate the benthos allowing the substrate to become oxygenated and introducing nitrogen-rich detritus to the root zone, increasing seagrass nitrogen fixation and biomass productivity.[30]
Regulating services (e.g. invasion resistance, herbivory, seed dispersal, climate regulation, pest regulation, disease regulation, natural hazard protection, erosion regulation, water purification)	Through the foraging process, dugongs (and green turtles) have been found to influence the structure and dynamics of multi-species tropical seagrass communities by altering their biomass, net above-ground biomass productivity and the species composition of seagrass meadows. In a subsequent study, dugongs and green turtles were found to influence the nutritional value of seagrass species.[30] Seagrass habitats have the potential to be degraded in terms of both composition and nutritional value should the abundance of dugongs (and green turtles) be substantially reduced.[30]

Pressures influencing dugongs in the Great Barrier Reef Marine Park

Pressures

Dugongs 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 the population (such as the acute pressure from flood and cyclone-related loss of seagrass forage) or be exerted over the long term (chronic pressure from reduced water quality, boat strike and traditional harvest), where different impacts may act cumulatively to affect their survival. These acute and chronic cumulative pressures can influence the status and trend of the population through immediate ill health and mortality or can work to reduce the reproductive potential of dugongs over generations. Animals in poor condition are likely to be immuno-compromised and more susceptible to disease and pre-existing injuries. They may also have a reduced ability to escape predators, avoid boat strike and are likely to succumb to exhaustion more rapidly if captured incidentally in set mesh nets.

A dugong feeding on a shallow seagrass meadow.

The ecology and life-history traits of dugongs are complex and their management is challenged by knowledge gaps, making the task of managing the threats they face difficult. Despite these knowledge gaps, there is considerable information available and management decisions must take into account reasonable predictions of likely effects of human activities on dugongs and their habitat. While information gaps must be addressed for management to be effective in the long term, the precautionary principle should be applied at the same time to ensure reasonable actions are considered and implemented to avoid or minimise potentially serious or irreversible effects. Regular evaluation of the impacts of human activities on dugongs and monitoring the status of the population via aerial surveying and other population monitoring methods are essential to continue to inform large-scale ecosystem planning and management practices. This approach also allows for the evaluation and modification of management measures through use of key performance indicators.

There are a suite of impacts that threaten dugongs in the World Heritage Area. These are listed below in approximate order of importance.

Impacts of greatest significance to dugongs south of Cooktown:

- habitat loss and degradation from cyclone activity and extreme weather, sediment, nutrient and pesticides from catchment run-off
- clearing or modifying of coastal habitats
- coastal reclamation
- dredging and dumping and resuspension of dredge material; disease
- boat strike and vessel disturbance
- death from incidental capture in nets (commercial net fishery and shark control program), and marine debris.

Impacts of greatest significance to dugongs north of Cooktown:

- habitat loss and degradation from cyclone activity and extreme weather
- disease
- incidental capture in nets (commercial net fishery)
- illegal fishing and poaching, and hunting for traditional use.

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[54], this vulnerability assessment aims to provide an integrated assessment of social, ecological, economic and governance information on the conservation and management of dugongs 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 dugongs 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 dugongs to reach a final assessment of the overall residual vulnerability of dugongs to that particular pressure. This allows for suggested actions to be developed to minimise the impact of the pressures which dugongs are most vulnerable to.

A summary of the assessment of the impacts of pressures is contained in the table below, however for the detailed assessment and explanatory notes refer to Appendix 1.

Vulnerability assessment matrix summary for dugongs 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	Low	Poor	Good	Low	Poor (to moderate)
	Defence activities	Yes, locally	Low	Low	Poor	Good	Low	Good
	Commercial fishing	Yes, Reef-wide, but predominantly inshore within the East Coast Inshore Fin Fish Fishery (ECIFFF)	High (ECIFFF)	High (ECIFFF)	Poor	Moderate	High (inshore)	Moderate
			Low (for other commercial fisheries that may impact dugongs)	Low (for other commercial fisheries that may impact dugongs)			Low (for other commercial fisheries that may impact dugongs)	
	Recreational fishing	Yes, predominantly south of Cooktown	Medium	Medium	Poor	Moderate	Medium	Poor (to moderate)
	Ports and shipping	Yes, locally (with potential for regional significance)	High (within port limits)	High (within port limits)	Poor	Moderate (within port limits)	High (within port limits)	Good (effects of pollutants on seagrass)
			Low (outside port limits)	Low (outside port limits)		Good (outside port limits)	Low (outside port limits)	Poor (cumulative effects on seagrass and dugongs)
	Recreation (not fishing)	Yes, regionally (boat strike, disturbance)	Low	Low	Poor	Moderate	Low	Poor (to moderate)
	Traditional use of marine resources	Yes, locally (with population-level significance)	High (remote coast north of Cooktown and the area around Cairns)	High	Poor	Moderate	High (mostly within the remote coast management unit north of Cooktown and the area around Cairns)	Moderate
			Medium (developing urban coast south of Cooktown but excluding the area around Cairns)				Medium (developing urban coast south of Cooktown but excluding the area around Cairns)	
	Climate change	Yes	High	High	Poor	Poor	High	Moderate
	Coastal development	Yes, predominantly south of Port Douglas	Medium	Medium	Poor	Moderate	Medium	Poor
	Declining water quality due to catchment run-off	Yes, predominantly south of Cooktown	High	High	Poor	Moderate	High	Poor

Key concerns

The effective conservation of dugongs 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 (particularly seagrass meadows). The following impacts are of key concern:

- Seagrasses are highly dependent on the availability of light for growth and health. Run-off and other factors that increase turbidity and reduce light availability will negatively impact important dugong forage.[55]
- The increased run-off of sediments and nutrients from terrestrial ecosystems and landscapes, which are likely to occur as a result of global climate change, will cause loss of seagrass.[55] Toxic elements and contaminants can indirectly impact on dugongs through their effects on seagrass on which they forage. Use of herbicides in terrestrial agriculture has resulted in their transfer to nearshore sediments in seagrass habitat important to dugongs.[56,57] Diuron has been recorded in seagrasses important to dugongs, and experiments have demonstrated that diuron suppresses photosynthesis in seagrasses[d].[58]
- Direct removal of seagrasses has occurred during reclamation for port infrastructure, channel dredging and coastal developments. When seagrass is removed it cannot be replaced or offset.
- Indirect impacts from reduced water quality result from a range of non-point source pollutants including poor broadscale agricultural practices; coastal development and urban pollution sources; pollution from shipping activities and incidents; port and harbour operations and development and dredging operations to support these requirements (which can also cause unfavourable changes to hydrodynamics). In addition, habitat degradation is expected to occur if ships anchor offshore while waiting for port access.
- Port developments and marina infrastructure are closely managed, and generally the area of seagrass lost is small.[59] However, it is the cumulative impact of many small loses of seagrasses that impacts the resilience of this habitat. Dredging can expose acid-sulphate soils and other toxic compounds[60] and, when disposed of within marine environments, spoil is exposed to resuspension during high wind and/or tide conditions. This can lead to increased turbidity levels that can reduce the light available to seagrasses for growth and can smother or bury seagrass meadows.[59,61,62] These impacts can be exacerbated during extreme weather events. When combined with reduced water quality from other sources, this is likely to reduce the resilience of seagrasses.
- Acute impacts on foraging resources from habitat loss and degradation as a result of climate change and extreme weather events (flood and cyclone-related seagrass loss) and the impacts on habitat from otter trawling.
- Indigenous traditional use in parts of Australia (most prominently in the Torres Strait and eastern Cape York Peninsula) and across to Papua New Guinea.
- Boat strikes — these occur in higher numbers in areas adjacent to high-traffic ports or population centres. Most boat strikes are reported from the Moreton Bay Marine Park adjacent to Brisbane.[63] (Although the numbers of dugong incidents have not changed, there has been a noticeable increase in 2011 and 2012 in the number of dead marine turtles in Gladstone Harbour as a result of boat strike and propeller cuts. This correlates with increased vessel traffic in the harbour as port infrastructure development has come on line[64]).
- Disturbance from increased boating activity around such high-use areas is also of increasing concern. Hodgson and Marsh[65] found boat traffic in Moreton Bay may reduce dugongs' feeding time budget throughout the diel cycle by 0.8 to six per cent. They concluded that this would be unlikely to have a substantive effect on the nutirtional intake of dugong populations at their Moreton Bay study site. However, they emphasise the need to monitor vessel and noise disturbance dynamics on dugongs where high vessel traffic occurs in small and/or isolated dugong habitats or in conservation areas designed to protect dugongs.[65] They also highlight the fact that as dugongs do not appear to swim away from passing vessels, this demonstrates the high risk of boat strike to dugongs, especially high speed vessels.[65]
- This illustrates the need to implement mechanisms such as 'go-slow' and vessel transit lanes to reduce vessel speed in areas with seagrass habitat critical to dugongs.[65,66] Groom and colleagues[67] recommended such measures in areas in Moreton Bay where vessels at high speed were causing mortalities when they travelled through seagrass meadows commonly used by dugongs. However, for these mechanisms to work there needs to be an enforcement presence, otherwise they become ineffective despite people's best intentions.[68]
- Management measures need consideration in particular areas after extreme weather events. In these circumstances, dugongs can be displaced from favoured seagrass meadows (critical habitat) as a result of extreme weather impacts, and seek food resources in alternative areas that they are unfamiliar with. Often, they are also in reduced physical condition that may limit their ability to respond to high-speed vessel traffic.
- Incidental capture in set mesh nets used by commercial fishers and shark nets used in bather protection programs under the Queensland Shark Control Program. This pressure has been substantially reduced with most of the shark nets within the World Heritage Area being replaced with baited hooks, though mortality still occurs in the remaining nets.[63] One dugong died in Queensland Shark Control Program nets in 2009 and 2010.[63]

[d] Refer also to the Vulnerability Assessment for the Great Barrier Reef seagrass.

- Commercial netting is now banned from approximately 64 per cent of the high density dugong habitat, 44 per cent of the medium density habitat and 31 per cent of the low density habitat. However, Grech and colleagues[69] estimated the actual area where netting is conducted is now much less than these figures: four per cent of high density dugong habitat; nine per cent of medium density dugong habitat; and seven per cent of low density dugong habitat.

  They also identified three areas where additional spatial closures would significantly reduce the remaining risk of netting to dugongs: Lookout Point in the Starke River region; Bathurst Head in Princess Charlotte Bay; and Friendly Point, between Port Stewart and Lockhart River.[69]

  The Bathurst Head area is partly covered by a portion of the Princess Charlotte Bay Special Management Area (within the Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004 and the Great Barrier Reef Marine Park Zoning Plan 2003) where commercial netting is limited to a small number of commercial fishers that require the written permission of the Authority to use or enter the special management area for netting (other than bait netting).
- Ingestion of and entanglement in marine debris (including discarded fishing gear), float lines and ropes. (In northern Australia, entanglement in ghost nets adds another dimension to this pressure).
- Mortality due to disease and ill health.
- Necropsies conducted on deceased dugongs reported to the Queensland Parks and Wildlife Service indicate that disease is the cause of death for between 20 and 25 per cent of the 298 animals for which the cause of death has been determined between 1996 and 2010[63]
- Exposure to pollution and contaminants.
- The nearshore and estuarine environments inhabited by dugongs expose them to terrestrial and port-based sources of pollution from run-off, wind transportation, waste disposal and leaks/leaching and spills during maritime operations and ship's maintenance. For example, although bioaccumulation of metals and organochlorine compounds (other than dioxins) are not considered to represent a significant risk to Great Barrier Reef dugong populations, dugong carcasses stranded in more urban localities tend to show higher concentrations of metals and some organochlorine compounds in tissues than found in carcasses from areas with less human impact.[70]
- When considering recent work on the diving behaviour of dugongs and the inherent difficulties in accurately estimating population size, estimates of the number of dugongs within the World Heritage Area to date are very likely to be somewhat conservative.[52] Taylor and colleagues[53] have demonstrated that a time series of aerial surveys have been shown to have limited capacity to detect declines in marine mammal stocks, even when the decline is precipitous. Aerial surveys are likely to have a limited capacity to detect population trends in timeframes relevant to management, and accurate population estimates are confounded by dugong movements within and between survey areas.
- Although biologists and anthropologists have recorded the numbers of dugongs hunted at various times and locations (summarised in Saalfield and Marsh 2004[71] and Marsh et al. 2002[44]), there is limited reliable information available to quantify the current level of dugong harvest from Indigenous peoples across northern Australia. Given the life-history of dugongs, researchers have estimated that even if a dugong population were to experience no mortality other than which occurs naturally (that is, without consideration of human-related mortality), they are only able to maintain population growth of five per cent per annum at best.[72]

  Based on this information, Marsh and colleagues[72] and Heinsohn and colleagues[73] suggested that when unmanaged, the harvest of dugongs in the Torres Strait has previously been unsustainable.[e] There is some concern that this may also apply to eastern Cape York Peninsula in areas where either traditional owners lack management processes or compliance with management processes in place are limited. However, overharvesting is difficult to prove empirically with the available data and because of other confounding influences on the population, especially the tendency for dugongs to undertake large-scale movements for reasons that are not entirely understood.[74]

  On analysis of the 20-year time series of aerial surveys of the northern Great Barrier Reef coast, Grech and Marsh[43] have not detected a significant decline in dugong numbers, despite concern about the sustainability of the Indigenous harvest in this region.[73] However, Marsh and colleagues qualify this by saying that as aerial surveys have limited power to detect low rates of population decline, the possibility that the dugong populations of Torres Strait and the northern Great Barrier Reef are slowly declining cannot be ruled out and do not provide conclusive evidence that present levels of harvest are sustainable.[52,75] Grech and Marsh[43] suggest that the "improvement of performance in detecting declines in the dugong population depends on increasing survey extent and frequency, and developing different methods to detect decline. Such improvements would require a substantial increase in funding which is unlikely to be available. Thus, management intervention should not require the trigger of statistical evidence of reduction in abundance."

[e] Since the time of these publications there have been significant advances made with improving the sustainable harvest of dugongs in the Torres Strait through community-based management plans with the support of a major ranger program operated by the Torres Strait Regional Authority.

- El Niño Southern Oscillation events are expected to continue as a source of high inter-annual climate variability in northeast Australia under predicted climate change scenarios.[76] Climate variability that produces increased rainfall will have direct and indirect impacts that will alter the short and long-term viability of seagrass meadows that dugongs rely on.
- The extreme weather of 2010–2011 in Queensland (widespread flooding and Tropical Cyclone Yasi) exposed dugongs to significant additional pressure, particularly on animals within the urban (developing) coast management unit south of Cooktown where most impacts were experienced. These events, along with the previous two years of higher than average rainfall along Queensland's eastern seaboard, have caused the significant decline of seagrasses that dugongs forage upon (L. McKenzie, pers. comm. 2011). It may take a number of years for these seagrasses to recover and is dependent on a number of factors including a return to a more normal rainfall pattern (L. McKenzie, pers. comm. 2011).
- The Queensland Government's Marine Wildlife Strandings and Mortality Database reports indicate the number of dugong mortalities in 2011 were the highest ever recorded — more than twice that of the previous highest annual record since the program began in 1996. The total number of dugongs recorded was 190 animals, with four released alive. Due to the dieback of seagrass forage from above average rainfall of the past few years, it is likely that animals have been moving around looking for suitable forage. The additional significant impacts of 2010–2011 are likely to have contributed to animals exhibiting particularly poor body condition where some are likely to be immuno-compromised and more susceptible to disease and pre-existing injuries. This may also mean they have reduced ability to escape predators, avoid boat strike and are likely to succumb to exhaustion more rapidly. It is likely that the reproductive potential of this population will be reduced for many years.
- The 20-year time series of aerial surveys has allowed researchers to produce a spatially explicit model for the distribution and relative abundance of dugongs on the Great Barrier Reef coast. This model has been used to inform marine protected area planning, ecological risk assessments and evaluation of local-scale impacts.[43] This time series of distribution and relative abundance information has also allowed researchers to estimate sustainable levels of human-related mortality[16] using the Potential Biological Removal technique developed by Wade.[77]
- Marsh and Lawler[16] suggest if the ecological objective is to facilitate the recovery of the dugong population along the urban developing coast, management should aim to ensure the total human-induced mortality of dugongs is fewer than 10 per annum. However, they state that ideally the aim should be zero as this would account for uncertainty in life history data (such as age at first reproduction, mean calving intervals, variation in dugong population estimates, or determination of stock structure). In light of the record level of dugong mortalities in the central and southern parts of the Great Barrier Reef Marine Park during 2011, a defensible position can be made for a nil human-induced mortality target within those regions into the medium-term future.

  Using the same method and rationale, Marsh and colleagues[52] estimate that 56 dugongs per annum would be a wise management target for the northern Great Barrier Reef population of dugongs given their significance to world heritage listing and the management objective of population recovery for dugongs in the World Heritage Area. This may need to be reviewed once the results of the next aerial survey of the northern Great Barrier Reef become available in early 2014.
- Given the range of pressures faced by dugongs in the World Heritage Area there is a need to continue to enhance the long-term monitoring program to improve the ability to detect changes/trends in the population based on the species' biology and behaviour. Seagrass surveys are required over a broader spatial and temporal scale. Seagrass and water quality monitoring should also be adaptive to meet the changing information needs of species-specific and ecosystem-based management and may need to take better account of subtidal and deepwater seagrass meadows identified as being important habitat to dugongs.

Management of dugongs 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	• The Great Barrier Reef inscribed as a World Heritage Area in October, 1981 • 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 • Presence of dugongs was an explicit reason for the area's world heritage listing.	• 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	• The three main objectives of the Convention on Biological Diversity are:
	  • 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.
		• 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 — Convention on Biological Diversity Secretariat

International Union for the Conservation of Nature — Red List of Threatened Species (v. 2010.2)	• Establishes the conservation status of species based on the assessment of their global population and trends • Species listed as 'vulnerable'.	• 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)
Convention on International Trade of Endangered Species of Wildlife Fauna and Flora (CITES)	• Dugongs are listed within Appendix I of CITES.	• GBRMPA forms part of the Council of Parties that contributes to the review and assessment of management provisions established for signatory nations under the conventions • Species listed on Appendix I of CITES are threatened with	United Nations Environment Programme — CITES Secretariat

Legislation or policy	Object as it applies to the species	Tools for conservation	Who administers it
		extinction and the convention prohibits international trade in specimens of these species except when the purpose of the import is not commercial (for example, scientific research).	
Convention on Migratory Species	• Provides a basis for forming international agreement on the protection, conservation and management of migratory species • Dugongs are listed as marine migratory species under Appendix II of the convention.	• The parties to the convention agree to: a) promote, cooperate 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 on Migratory Species are considered as matters of national environmental significance under the *Environment Protection and Biodiversity Conservation Act 1999* and are protected under the Act.	United Nations Environment Programme — Convention on Migratory Species Secretariat
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and Environment Protection and Biodiversity Conservation Regulations 2000	• 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 dugongs except for traditional use (as defined to the *Native Title Act 1993*) • Legislative role includes the listing and regulation of threatened and protected species and communities, the preparation of recovery plans for threatened and protected species, the identification of key threatening processes and, where appropriate, the development of threat abatement plans • See comments above regarding species listed as 'migratory' on appendices of the Convention on Migratory Species.	• Species listed as a protected migratory and marine species under sections 209 and 248 of the EPBC Act, respectively • Listed threatened and migratory species and ecological communities are recognised as matters of national environmental significance. Consequently, any action that is likely to have a significant impact on listed threatened species and ecological communities under the EPBC Act are subject to referral and assessment under the Act • An action affecting dugongs 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 necessary research and management actions required to address these threats: • Threat abatement plan for the impacts of marine debris on vertebrate marine life — 2009 • Assessment and export	Commonwealth Department of the Environment

Legislation or policy	Object as it applies to the species	Tools for conservation	Who administers it
		approval processes for all fisheries with an export component (or wildlife trade operation) that must consider interactions with threatened species • Penalties for non-compliance • Processes of review.	
Great Barrier Reef Marine Park Act 1975 and Great Barrier Reef Marine Park Regulations 1983	• Provides for biodiversity conservation through zoning, issuing of permits and implementation of plans of management that collectively enable management of human activities in the Great Barrier Reef Marine Park • Table 29 in Regulation 29 of the Regulations provides a list of protected species including dugongs • The Regulations establish provisions for the Cairns, Whitsundays and Hinchinbrook plans of management.	• Plans of management regulate activities within the Marine Park with regard to dugongs and other protected species • Activities within the Marine Park are managed spatially via zoning provisions within the Act • Under the Regulations, GBRMPA 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.	Great Barrier Reef Marine Park Authority (GBRMPA)

Great Barrier Reef Marine Park plans of management
(subordinate to the Great Barrier Reef Marine Park Regulations 1983)
	• A multiple-use marine protected area management tool that protects biodiversity by regulating activities within high-use regions of the Marine Park
	• Regulations for dugong conservation are found in:
	  • Cairns 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
		• Plans of management outline the values, issues and strategies for the conservation of dugongs. Prohibits taking of dugongs (as defined under the Great Barrier Reef Marine Park Zoning Plan 2003)
		• Provisions for enforcement have penalties for non-compliance
		• Plans of management are reviewed on a regular basis in line with changes to management requirements, legislation and national guidelines
		• Penalties for non-compliance
		• Processes of review.
			GBRMPA

Strategic assessment of the Great Barrier Reef World Heritage Area and adjacent coastal zone	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 Two complimentary strategic assessments – a marine component undertaken by the GBRMPA and a coastal zone component undertaken by the Queensland Government	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'smanagement 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	Australian and Queensland governments

Legislation or policy	Object as it applies to the species	Tools for conservation	Who administers it
Reef 2050 – Long-term Sustainability Plan	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	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	Australian and Queensland governments
Great Barrier Reef Marine Park Zoning Plan 2003	• A multiple-use marine protected area management tool that protects biodiversity by the regulation of 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	• Spatial management of activities within the Great Barrier Reef is based on protection of habitat type representative areas • Thirty-four 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 dugongs and their habitats under special circumstances • Species Conservation (dugong protection) Special Management Areas (spatial restrictions on commercial set mesh netting) provide protection for dugongs (e.g. Hinchinbrook Island Area and Bowling Green Bay Area) • Penalties for non-compliance • Processes of review.	GBRMPA
Fisheries Act 1994 (Qld) and Fisheries Regulation 2008	• 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 • Dugong Protection Area provisions introduced in mid-1997. Dugong Protection Areas provide spatial restrictions on commercial set mesh netting over areas of high conservation value to dugongs.	• Depending on the type of Dugong Protection Area, netting is either prohibited or restricted in the 16 nominated areas in Queensland • Dugongs listed as species of conservation interest • Net attendance rules in set mesh net fisheries (must be in attendance at all times) • Rules (N_1, N_2, N_4, N_{11}, S Regulations) for net operation and apparatus parameters designed to limit interactions with species of conservation interest, including dugongs • Species of conservation interest logbook reporting requirements • Penalties for non-compliance • Review of the Act in 2011.	Queensland Government
Fisheries (East Coast Trawl) Management Plan 1999 (Qld)	• East Coast Trawl Management Plan provides for the management of fishery • Accredited Wildlife Trade Operation (WTO) under the	• Management plan regulates for the mandatory use of bycatch reduction devices such as turtle exclusion devices, equipment used, the amount of effort in the	Queensland Government

Legislation or policy	Object as it applies to the species	Tools for conservation	Who administers it
	Environment Protection and Biodiversity Conservation Act 1999 managed by Fisheries Queensland.	industry through licensing and entitlements/quotas, and spatial management provisions • Commonwealth Regulation requires 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 dugongs. This data is gathered through logbooks • *Looking after protected species in Queensland — a comprehensive guide for commercial fishers* published to assist fishers in interactions with dugongs and other protected species.	
East Coast Inshore Fin Fish Fishery management arrangements	• Regulations are established under the *Fisheries Act 1994* (Qld) and Fisheries Regulation 2008 • Accredited Wildlife Trade Operation (WTO) under the *Environment Protection and Biodiversity Conservation Act 1999* managed by Fisheries Queensland.	• Published *Guidelines for commercial operators in the East Coast Inshore Fin Fish Fishery* to provide commercial fishers with a summary of management arrangements • Commonwealth Regulation requires 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 dugongs. This data is gathered through logbooks and verified through an observer program • *Looking after protected species in Queensland — a comprehensive guide for commercial fishers* published to assist fishers in interactions with dugongs and other protected species • Review of the fishery under the *Environment Protection and Biodiversity Conservation Act 1999*. Review completed February 2012. New Wildlife Trade Operation with conditions issued; valid to 2015.	Queensland Government
Queensland Shark Control Program	• Community education and protection policy under *Fisheries Act 1994* (Qld) • The Queensland Shark Control Program deploys up to 191 drumlines (Cairns, Townsville, Mackay, Capricorn Coast, Gladstone district) and five nets within the Great Barrier Reef World Heritage Area.	• Nets designed to capture sharks greater than two metres in length. Nets are 186 metres long. Most nets have a depth of 6 metres and a mesh size of 500 millimetres • Five remaining shark nets in the Great Barrier Reef Marine Park — five off Mackay beaches • Drumline arrays consist of up to six or more shark hooks with	Queensland Government

Legislation or policy	Object as it applies to the species	Tools for conservation	Who administers it
		fresh bait suspended individually from large plastic floats. (Roughly one net equals six drumlines) • Equipment checked every second day, weather permitting • Other measures employed to reduce interactions with threatened species • Processes of review.	
Nature Conservation Act 1992 (Qld) and Nature Conservation (Wildlife) Regulation 2006; and Nature Conservation (Wildlife Management) Regulation 2006	• 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 dugongs. Under this legislation it is illegal to harm, interfere with or disturb dugongs except for traditional use • Provides legislative requirement for the development of conservation plans.	• Dugongs listed as vulnerable • Section 332 of the Wildlife Management Regulation prohibits tampering with a protected animal's place of breeding being used to incubate or rear the animal's offspring • Penalties for non-compliance • Processes of review.	Queensland Government

Marine Parks Act 2004 (Qld) and Marine Parks Regulation 2006	• The object of this Act is to provide for the conservation of the marine environment by:
	  • 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.
		• 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)	• A multiple-use marine protected area management tool that protects biodiversity by the regulation of 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.	• 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
Great Barrier Reef Biodiversity Conservation Strategy 2013	• Identifies dugongs as a species that is at risk in the Marine Park • Grades the level of risk that	• The Biodiversity Conservation Strategy outlines a framework for action with three strategic objectives aimed at building or	GBRMPA

Legislation or policy	Object as it applies to the species	Tools for conservation	Who administers it
	dugongs are exposed to via a vulnerability assessment process.	maintaining ecosystem resilience and protecting biodiversity: 1. Engaging communities and fostering 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.	
Reef Rescue Land and Sea Country Indigenous Partnerships Program	• Expand the Traditional Use of Marine Resources Agreement program across the Reef catchment • Strengthen communication between local communities, managers and Reef stakeholders and build better understanding of Traditional Owner issues about the management of the Great Barrier Reef Marine Park.	• Expansion of the Traditional Use of Marine Resources Agreement program, which complements dugong and green turtle management along with 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.	GBRMPA (funded by Commonwealth Government's Reef Rescue program)
Great Barrier Reef Climate Change Adaptation Strategy and Action Plan 2012–2017	• Establishes a strategic approach to the development of resilience within Great Barrier Reef ecosystems as a means to enable those systems to adapt to climate change impacts.	• Resilience analysis identifies the means to reduce human impacts and disturbances, and conserve the Great Barrier Reef's biodiversity and ecological processes.	GBRMPA
Reef Water Quality Protection Plan 2013	• 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 Great Barrier Reef lagoon.	• Improve water quality that flows into the Reef by targeting priority outcomes, integrating industry and community initiatives and incorporating new policy and regulatory frameworks.	Joint Australian and Queensland Government initiative
Marine Wildlife Stranding Program	• Collects and reports on stranding and mortality information of threatened marine wildlife species within Queensland.	• Provides critical information to aid and inform research and management initiatives • Processes of review.	Queensland Government (jointly funded by GBRMPA through the Field Management

Legislation or policy	Object as it applies to the species	Tools for conservation	Who administers it
			Program)
Back on Track Biodiversity Action Plans	• The Back on Track Species Prioritisation Framework identifies priority species for conservation management, regional threats, and suggested recovery actions • Dugongs are identified as a critical priority for conservation management in all areas in which they are found within the Marine Park.	• Identifies regionally-appropriate management actions to mitigate the risks to these species • Processes of review.	Queensland Government (with natural resource management groups and other stakeholders for implementing identified management actions)
Great Barrier Reef Protection Amendment Act 2009 (Qld)	• A framework for reducing the levels of dangerous pesticides and fertilisers found in Great Barrier Reef waters by 50 per cent in four years.	• Mix of strict controls on farm chemicals and Regulations to improve farming practices.	Queensland Government
Coastal Protection and Management Act 1995 (Qld) and Coastal Protection and Management Regulation 2003	• 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.	• Queensland Coastal Plan provides guidelines for effective protection and management of the coastal zone	Queensland Government

Sustainable Planning Act 2009 (Qld) and Sustainable Planning Regulation 2009	• 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 the development of regional plans.
		• Coastal development generally requires impact assessment and a development approval under the *Sustainable Planning Act 2009*.
		• 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:
		  • 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.
			Queensland Government

Queensland Coastal Plan (prepared under the *Coastal Protection and Management Act 1995*)	• 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).	• Coastal activities that are not defined as development under the *Sustainable Planning Act 2009* are considered under the State policy for Coastal Management (currently under review following the change in government) • The suspended State Planning	Queensland Government

Legislation or policy	Object as it applies to the species	Tools for conservation	Who administers it
		Policy 3/11 provided policy direction and assessment criteria to direct land-use planning and development assessment decision making under the *Sustainable Planning Act 2009*. The Coastal Protection State Planning Regulatory Provision now offers much less specific guidance.	
Queensland Wetlands Program	Long-term conservation and management of wetlands WetlandInfo – a synthesis of information on wetlands and their management	Process for setting desired outcomes and management goals for classified wetlands Rehabilitation guidelines	Queensland Government
Environmental Protection (Water) Policy 2009 (Qld)	A statutory policy established under the *Environmental Protection Act 2009* (Qld) Achieving water quality fit for purpose which includes protection of aquatic ecosystems	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	Queensland Government
State Planning Policy 4/10 for Healthy Waters	Made under the *Sustainable Planning Act 2009* 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	Mangroves and saltmarshes can be identified as areas of high ecological value and hence water objectives are set to achieve their ecosystem protection Establishes standards and best practice	Queensland Government
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 *Sustainable Planning Act 2009* 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 *Sustainable Planning Act 2009*: • 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
Strategic assessment of the Great Barrier Reef World Heritage Area and adjacent	Assessment under the EPBC Act that provides the opportunity to achieve both conservation and planning outcomes at a much	The two strategic assessments contain recommendations and inform separate Program Reports for the Great Barrier	Australian and Queensland governments

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coastal zone	larger scale than can be reached through project-by-project assessments Two complimentary strategic assessments – a marine component undertaken by the GBRMPA and a coastal zone component undertaken by the Queensland Government	Reef Region. The Program Reports are a detailed description of the GBRMPA's and Queensland Government'smanagement 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	
Reef 2050 – Long-term Sustainability Plan	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	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	Australian and Queensland governments
Reef Water Quality Protection Plan 2013 (Reef Plan)	Collaborative program of coordinated projects and partnerships designed to improve the quality of water entering the Great Barrier Reef though improved land management in reef catchments The development of Reef Plan was guided by the new Scientific Consensus Statement which shows that poor water quality is continuing to have a detrimental effect on reef health	Focus is on reducing the load of diffuse agricultural sources of pollutants which account for more than 80 per cent of the load of nutrient and sediment delivered to Great Barrier Reef waters. The Plan aims to achieve this through: • Improved land management practices that deliver water quality targets • Integrating government policies and programs that support Reef Plan goals and targets • Education and capacity building • Research • Monitoring, evaluation and reporting of Reef Plan to measure efficiency and effectiveness	Australian and Queensland governments
Water Quality Guidelines[78,79]	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 *Environmental Protection (Water) Policy 2009*	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	Community driven through Natural Resource Management bodies Townsville City Council Voluntary practice uptake for improvements

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		water • ways to monitor and assess the effectiveness of the protection	
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 • identify opportunities for improving NRM arrangements	
Regional Natural Resource Management plans	There are 54 natural resource management regions across Australia based on catchments or bioregions Each region is supported by a non-government natural resource management body supported by Commonwealth and State governments 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	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	Regional Natural Resource Management bodies
Government policies, guidelines, codes of practice and programs.	• Sea Guardians program to educate and build stewardship capacity with regards to marine pollution and fishing best practice • GBRMPA dredging and spoil disposal policy • Tourism Operators Handbook outlines a range of responsible reef practices — a tool developed to show tourism industry staff how to minimise the impacts of their operations on species and habitats • Code of practice for the sustainable management of dugong and marine turtle tourism in Australia (Commonwealth Environment Department) • Looking after protected species in Queensland — a comprehensive guide for commercial fishers (Queensland Government) • Best environmental practices on the correct disposal of waste.	• Industry and public education tools designed 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 developments.	GBRMPA Where identified, Queensland Government and Commonwealth Environment Department

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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 catchment run-off**
Exposed to source of pressure **(yes/no)**	Yes, locally (with regional significance)	Yes, locally	Yes, Reef-wide but predominantly inshore	Yes, predominantly south of Cooktown*	Yes, locally (with potential for regional significance)*	Yes, regionally*	Yes, locally (with population-level significance)	Yes	Yes, predominantly south of Port Douglas*	Yes, predominantly south of Cooktown*
Degree of exposure to source of pressure **(low, medium, high, very high)**	Low. Dugongs predominantly inhabit shallow turbid inshore waters and their behaviour is not conducive to tourism targeted at viewing animals. There are limited tourism operations targeted at dugong-watching in the World Heritage Area. If high tourism vessel traffic were to occur over areas of high conservation value to dugongs, this would likely lead to an increase in boat strike and may extract an energy cost	Low. Dugongs are not thought to be significantly impacted by defence activities in the Great Barrier Reef. Defence operations work to avoid key locations and manage their activities so as to limit interactions with protected species, including dugongs. However, the Shoalwater Bay underwater demolitions locality (Triangular Island) is in the vicinity of	High (inshore within the East Coast Inshore Fin Fish Fishery) Low (for other commercial fisheries that may interact with dugongs or impact their habitat). Previous commercial harvest of dugongs between the 1880s and 1969 is thought to have seriously depleted the Great Barrier Reef dugong stock. There is remaining mortality through set mesh nets used in the East Coast Inshore Fin Fish Fishery and the Queensland Shark Control Program (although not a commercial fishery, it is a contracted operation). However, available data indicates that	Medium. There is mortality and injury to dugongs being recorded from: • ingestion of and entanglement in discarded fishing gear • increased boating traffic along the Great Barrier Reef coast causing a greater occurrence of boat strikes on dugongs. Marine Wildlife Strandings and Mortality Database shows an increase in boat strike on dugongs in areas adjacent to population centres along the Great Barrier Reef	High (within port limits) Low (outside port limits). Dugongs are most exposed to port and shipping activities at the local level. Demand for increased or expanded port facilities along Queensland's coast will result in degradation and partial loss of habitat that dugongs rely on within port limits, especially seagrass meadows (refer to the Vulnerability Assessment for the Great Barrier Reef seagrass). Noise from vessel movements mostly fall in low frequency bands	Low. Recreational in-water or boating activities that purposefully seek to interact with dugongs could provide disturbance at local scales if at significant levels. Although this is not likely to be the case, when assessed cumulatively with other vessel-traffic impacts, the combined pressure could be discernible at a local scale. However, the degree of exposure that dugongs experience from recreational activities in the Marine Park (based on consideration of the areas of high	High — (remote northern coast and Cairns area). Medium — (developing urban coast south of Cooktown, but excluding the area around Cairns). Marsh and colleagues[72] and Heinsohn and colleagues[73] suggest that unregulated harvest of dugongs in the Torres Strait is unsustainable and there are concerns to a lesser extent this may also be the case for eastern Cape York Peninsula. However, overharvesting is difficult to prove empirically with the data available and with so many other confounding influences on the population, especially the	High. Climate driven processes are having an impact on the habitats on which dugongs rely for food. These impacts can affect dugong survivability, their biology and ecology. Extreme weather likely to be associated with climate change will expose dugongs to greater threat. Increased storms, floods and more intense cyclones will impact on seagrass meadows. Cyclones can cause injury and strand dugongs.[83] The extreme weather events of 2010–2011 that occurred in Queensland (widespread flooding and Tropical Cyclone Yasi) may be climate change-related. These events applied	Medium. Projected increases in the human population and the associated increase in coastal developments impact on the dugong population in the World Heritage Area. The exposure of dugongs to coastal and marine development pressures vary between the remote northern coast management unit and the southern developing urban coast south of Cooktown. The developing urban coast dugong management unit is under	High. Discharge and run-off into the Great Barrier Reef lagoon affects water quality that influences the health of the Reef ecosystem. This has many direct and indirect impacts on dugongs, seagrass habitats and ecosystem processes they rely upon.[56,57,58] Infectious disease such as *Toxoplasma gondii* has been found in dugongs necropsied in south-east Queensland.[84] *T. gondii* is hosted by the domestic cat and infects marine animals when cat faeces are washed into the marine environment.[85] Marine debris has been identified as

	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 catchment run-off**
	with elevated vessel-related disturbance and displacement of animals which could be significant if unmanaged.	dugong transit corridors used during meso-scale migrations between embayments and is not far from subtidal seagrass beds that dugongs are known to use.	the number of animals drowned in Queensland commercial fisheries in 2009–2010 was low (five interactions, three dead, two released alive).[80] The foraging habitat of dugongs can be impacted by otter trawling. The risk posed by this activity is being reviewed as part of the Queensland Government's trawl review process. Sixty-seven per cent of the Marine Park is closed to otter trawling which limits the level of habitat degradation of subtidal seagrass meadows. In the very north of the Great Barrier Reef Marine Park there have been mortalities in ghost nets, but this is predominantly restricted to the Torres Strait and northern Australia. North-east Cape York Peninsula is a region of high conservation significance to	coast. Increases in boating for recreational fishing on the Great Barrier Reef and registration data indicate these vessels are becoming larger and more powerful. It is likely that dugongs will become more exposed to vessel strikes due to this pressure. Movement and underwater noise from increased vessel traffic is also considered likely to disturb and displace dugongs, in that they alter their behaviour and may increase energy expenditure. Should this be pervasive, the likely consequence is a reduction in reproductive output for affected dugongs.	that may be slightly below the sensitive auditory range of dugongs.[81,82] As ports are developed, with a commensurate increase in vessel traffic, boat strike is likely to increase. The increase in ports and shipping is also likely to increase the threat of a serious oil spill in the Great Barrier Reef that could have potentially serious effects on dugong populations, either directly through mortality related to toxin ingestion, or indirectly through habitat loss or degradation. Shipping-borne pollution may expose dugongs to higher levels of toxins which may result in early mortality and/or a higher prevalence of disease.	conservation value to dugongs) is not considered to be high, but can contribute to vessel-related impacts on dugongs.	tendency for dugongs to undertake large-scale movements for reasons that are not entirely understood.[74]	significant additional pressure on dugongs and along with the previous two years of higher than average rainfall on Queensland's eastern seaboard, have caused the significant decline of seagrasses that dugongs forage upon (L. McKenzie, pers. comm. 2011). This decline in seagrass distribution and abundance may take a number of years to regenerate and is dependent on a number of factors including the continuation of a more normal rainfall dynamic (L. McKenzie, pers. comm. 2011). Fine-scale predictions on how climate change will impact on dugongs are extremely difficult to make due to the intrinsic complexity of linkages between climate change impacts, ecosystems, and dugong biology and ecology. The spatial and temporal variability, across which these aspects of climate	pressure from habitat loss and degradation due to urban encroachment and port infrastructure developments. Seagrass habitats, upon which dugongs rely, are under pressure from land-based pollution, sedimentation and land reclamation.	a hazard for dugongs. Although most debris on offshore islands in the southern Great Barrier Reef is found to come from ocean sources, the northern Great Barrier Reef receives a northward flow of litter from land-based sources that congregates towards Cape York Peninsula and appears to remain contained within the Reef's lagoon.[86] Increased catchment run-off may contribute to more marine debris being delivered to the Reef lagoon. Toxic compounds that pollute catchments can be accumulated within seagrass and benthic sediment and be consumed by dugongs. Evidence shows bioaccumulation of toxic compounds occurs in dugongs in the World Heritage Area.[70,87]

	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 catchment run-off**
			dugongs where there have been reports of ghost nets. Many of the nets removed from the environment are considered to come from foreign fishing vessels.					change will act, provides further difficulty for predicting impacts on dugongs in the Marine Park.		Studies on other marine mammals have demonstrated detrimental impacts to their health and reproductive success as a result of the bioaccumulation of toxins.[88,89]
Sensitivity to source of pressure **(low, medium, high, very high)**	Low. Sensitivity low due to limited tourism targeted at dugong watching in the World Heritage Area. Tourism-related disturbances that disrupt feeding or extract an energy requirement may reduce the reproductive output of dugongs. Dugongs do not appear to swim away from passing boats which demonstrates the high risk of boat strike to dugongs, especially high	Low. Low for majority of defence activities; high for underwater demolitions. Overall assessment of sensitivity to defence activities is low.	High (inshore within the East Coast Inshore Fin Fish Fishery). Low (for other commercial fisheries that may interact with dugongs or impact their habitat). Available reports and anecdotal information indicate that a high proportion of dugongs that become entangled in set mesh nets almost always drown. Data indicates the level of dugong interaction with commercial fishing apparatus and nets set for bather protection is not high. Net attendance rules for fishers using set mesh nets may also decrease the	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 of lost or discarded fishing equipment which becomes debris and may injure or kill dugongs. Ongoing disturbance that alters behaviour or displaces dugongs from optimal habitat may contribute to increases in energy expenditure	High (within port limits). Low (outside port limits). Loss and degradation of critical habitat and disturbance/ displacement of dugongs due to port developments and increased vessel activity are likely to contribute to long-term pressure on dugongs in the World Heritage Area at the community level. Dugongs are expected to be highly sensitive to seagrass habitats impacted within port limits where seagrass is removed or their habitat is	Low. It is considered that there is limited recreational activity targeted at dugong watching in the World Heritage Area. However, sensitivity to this pressure is mostly from vessel traffic and boat strike. Recreational disturbances that disrupt feeding or extract an energy requirement may reduce the reproductive output of dugongs with potential for population level impacts if the pressure was to be pervasive. Recreational in-water or boating activities that	High. When dugongs are found by Traditional Owners who intend to harvest them, they are invariably caught and die. However, due to the level of exposure to hunting pressure south of Cooktown, dugong sensitivity to traditional use is medium. Researchers have estimated that even if a dugong population were to experience no mortality other than that which occurs naturally (that is, no human-related mortality), due to conservative life-history traits they are only able to maintain population growth of five per cent per annum at	High. It is difficult to assess the sensitivity to climate change of dugongs in the Marine Park. This is due to the complex and dynamic relationship between the known effects. Dugongs now face a variety of additional pressures that may increase their sensitivity to current and future impacts of climate change. These include accelerated rates of climate change; depleted populations (with the potential to decline); cumulative impacts of human-related threats; and restricted access to alternative habitats. The high degree of exposure of dugongs to the range of pressures	Medium. Dugongs have a high level of sensitivity to the cumulative impacts from increasing coastal development affecting seagrass habitats in the World Heritage Area.	High. Dugongs have specific habitat requirements for foraging and are sensitive to pressures that reduce the availability or productivity of these supporting habitats, especially in the nearshore habitats where declines in water quality are more evident.

	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 catchment run-off**
	speed boats.[65] Boat strike risk from tourism operators is not considered high from dugong-targeted tourism operators as they are well informed and operate within an established code of practice.		mortality of dugongs within the East Coast Inshore Fin Fish Fishery, and there is record of a mother and calf being released alive after entanglement in a set mesh net.[63] Seagrass habitat affected by otter trawling may also apply an indirect pressure that acts cumulatively with others to negatively impact on the availability of seagrass forage. The direct impact on dugongs is difficult to quantify. For example, meadows may play roles as food refugia when preferential ones are lost, degraded or depleted. The dugong population on Queensland's east coast has been significantly reduced due to the historic use of set mesh nets. This is because when dugongs come into contact with nets, unless they are immediately	and/or reduce nutritional intake and may therefore reduce their reproductive output.	degraded, limiting seagrass regeneration and growth. Due to the ecology of seagrass, it is necessary to emphasise that when seagrass meadows are removed they cannot be translocated, nor can another area be generated or rehabilitated.	disturb dugongs may drive them into less-optimal habitat with resultant negative impacts. This response has not been comprehensively studied, though research in Moreton Bay has shown dugongs are not readily disturbed by boating activity — a response which is considered to expose them to higher boat strike risk.[65]	best.[72] This means they are highly sensitive to traditional over-harvest, especially when considered in combination with other human-related impacts. However, Grech and Marsh[43] have concluded that aerial surveys of the remote Great Barrier Reef coast have not detected a significant decline in dugong numbers,[40] despite concern about the sustainability of the Indigenous harvest in this region.[73]	they experience reduces their resilience to climate change pressures.		

	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 catchment run-off**
			released they almost always drown. Therefore the level of sensitivity to this pressure is considered to be high.							
Adaptive capacity — natural **(poor, moderate, good)**	Poor. There is little information on whether dugongs become habituated to human tourism-related disturbance or are displaced by it.	Poor. Long-term disturbance in areas commonly used by dugongs may force them into more marginal locations.	Poor. Dugongs appear to undertake large-scale and meso-scale migrations primarily in response to the abundance of suitable seagrass forage. Although a 20 year time series of aerial surveys has provided spatial analysis of habitat of high conservation value and these areas are mostly well protected,[69] dugongs are not able to avoid set mesh nets when undertaking migrations or feeding in areas that are not protected. Otter trawling practices can degrade seagrass habitat. Dugongs have been shown to succumb to high levels of mortality when seagrass	Poor. Dugongs do not appear to swim away from passing vessels, which demonstrates the high risk of boat strike to dugongs (and a poor natural adaptive capacity to this impact), especially high speed vessels.[65] This is most likely to occur in areas adjacent to growing coastal populations. They also have no adaptive ability to detect threats from marine debris, partly expected to be a function of their poor eyesight.	Poor. Ports and shipping activities and infrastructure developments can degrade or remove seagrass habitat. Dugongs have been shown to succumb to high levels of mortality when seagrass meadows are lost or degraded.[42]	Poor. Dugongs do not appear to swim away from passing vessels which demonstrates the high risk of boat strike to dugongs (and a poor natural adaptive capacity to this impact), especially high speed vessels.[65] This is most likely to occur in areas adjacent to growing coastal populations.	Poor. The distribution and large-scale and meso-scale migrations of dugongs are largely determined by the distribution and abundance of seagrasses of high nutritional value to dugongs. Dugongs do not have the ability to avoid detection by hunters or move to alternative locations where they are not pursued if there is no forage available at the alternative location. Due to poor eyesight and the often high turbidity of their habitat, they are also susceptible to capture in mesh nets set illegally by some members in Indigenous communities (large-gauge set mesh nets that	Poor. Climate change is considered to be impacting seagrass meadows within the World Heritage Area.[89] Dugongs have been shown to succumb to high levels of mortality when seagrass meadows are lost or degraded.[42] Some impacts have the potential to cause positive or negative impacts on dugongs. For example, it is suggested that with increasing sea surface temperatures, seagrass distribution may shift south[89] and dugongs will follow.[90] However, when assessing the current seagrass resources in New South Wales, it is considered difficult to predict whether a large dugong population could	Poor. Dugongs' natural adaptive capacity to coastal development impacts need to be assessed in combination with cumulative pressures from climate change and catchment run-off that degrades or reduces the availability of suitable seagrass forage. Refer to the assessment column for dugong vulnerability to climate change and the vulnerability assessment for the Great Barrier Reef seagrass.	Poor. The natural adaptive capacity of dugongs to catchment run-off impacts need to be assessed in combination with cumulative pressures from climate change and coastal and marine development that degrade or reduce the availability of suitable seagrass forage. Refer to the assessment column for dugong vulnerability to climate change and the vulnerability assessment for the Great Barrier Reef seagrass.

	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 catchment run-off**
			meadows are lost or degraded.[42]				target large animals are not used in traditional harvest practices supported by Traditional Owner elders).	expand into those regions.[91] The actual adaptive capacity of dugongs to these pressures is poorly understood. The mobility of dugongs may enable them to select alternative suitable habitat localities to forage when necessary and if available. However, the way in which dugongs use seagrass resources is very individualistic and reflect different animals having differing knowledge of the distribution of alternative food sources.[38]		
Adaptive capacity – management **(poor, moderate, good)**	Good. Dugong and marine turtle tourism is managed under a national code of practice. GBRMPA works closely with industry to promote best practice tourism for interactions with threatened species, including	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 dugongs have been	Moderate. The Great Barrier Reef Marine Park Zoning Plan 2003 protects habitat used by dugongs in the Great Barrier Reef Marine Park. Under Queensland and Commonwealth Great Barrier Reef zoning plans, inshore areas of the Marine National Park and Conservation Park zones provide some restriction to	Moderate. The Great Barrier Reef Marine Park Zoning Plan 2003 protects habitat used by dugongs in the Great Barrier Reef Marine Park. Thirty-three per cent of the Marine Park is closed to extractive uses. Inshore areas of Marine National Park and Conservation	Moderate (within port limits) Good (outside port limits). 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, these risks can only be	Moderate. Management arrangements (such as vessel 'go slow' areas within management plans, plans of management under the Great Barrier Reef Marine Park Zoning Plan 2003) and the Queensland and Commonwealth legislative frameworks currently in place provide a	Moderate. The Caring for our Country Reef Rescue Indigenous Land and Sea Country 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	Poor. Options for local or regional scale management of climate impacts on dugongs 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 dugongs is being used in management	Moderate. The *Great Barrier Reef Marine Park Act 1975* provides limited scope to manage activities outside the Marine Park. To achieve coastal ecosystem outcomes for the Great Barrier Reef, GBRMPA facilitates the development of partnerships with industry, the community, local	Moderate. The *Great Barrier Reef Marine Park Act 1975* 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

	Pressures									
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	dugongs.	developed by Department of Defence in collaboration with relevant management agencies.	the extent of habitat available to inshore netters. 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 generally limited to the use of special management areas that can restrict commercial fishing activities in sensitive or critical habitats under exceptional circumstances and following extensive consultative processes. For commercial fishing impacts that fall outside of GBRMPA's jurisdiction, such as impacts from trawling and inshore set mesh nets, processes such as	Park zones, 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 fishers. Strategies to reduce boat strikes on dugongs need to be further co-developed between the responsible agencies and operators.	lowered and not eliminated. Processes that reduce impacts on dugong habitat, such as those from port construction 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 has terms of reference that take account of regional and cumulative impacts from such activities as ports and shipping. Strategies to reduce boat strikes on dugongs need to be further co-developed between the responsible agencies and operators.	framework for reducing impacts on dugongs. These can be adapted to suit changing management needs through processes of review. Strategies to reduce boat strikes on dugongs need to be further co-developed between the responsible agencies and operators.	may, for example, put in place management arrangements to ensure any traditional take of dugongs does not exceed sustainable limits. It also establishes a partnership between Traditional Owners, GBRMPA and the Queensland Government to collaborate on monitoring of the habitats and ecosystems, and human activities in their sea country. Traditional use of dugongs from Cardwell to the New South Wales border has virtually been halted as a voluntary conservation measure by Traditional Owner groups. There is also considerable compliance effort placed on illegal poaching of dugong resources by non-Traditional Owner hunters. Inherent difficulties in enforcing compliance associated with	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, dugong populations and their habitats are required to inform management. The current framework for managing climate change impacts within GBRMPA has been developed to incorporate and implement new information as it becomes available.	and state government and other Australian Government agencies to influence the management and planning of coastal pressures. The objective is to produce a culture of mutual obligation. One way this is undertaken is by providing input into the Queensland Coastal Plan policies and statutory regional plans which plan for coastal development in Queensland.	government and other Australian Government agencies to influence the management and planning of catchment and coastal pressures. This produces a culture of mutual obligation. This is undertaken by fostering partnerships through the Reef Water Quality Protection Plan 2013 and the Reef 2050 Program.

	Pressures									
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			collaborative risk assessments, consultations and general advocacy on issues of concern remain as avenues for adaptive management. Strategies to reduce the occurrence of boat strike on dugongs need to be further co-developed between the responsible agencies and operators.				remote locations are steadily being addressed through programs aimed at enabling Traditional Owners to gather evidence of alleged offences.			
Residual vulnerability **(low, medium, high)**	Low	Low	High (inshore) Low (for other commercial fisheries)	Medium	High (within port limits) Low (outside port limits)	Low	High (remote coast management unit north of Cooktown, but also areas surrounding Cairns) Medium (developing urban coast south of Cooktown but excluding area around Cairns)	High	Medium	High
Level of confidence in supporting evidence **(poor, moderate, good)**	Poor: Behavioural ecology — little is known on what level of disturbance causes a decline in the	Good. O'Neill 2009[92] Defence Standing Orders for Shoalwater Bay Training Area;	Moderate. Marine Wildlife Strandings and Mortality Database DEEDI 2010[80] Department of Primary Industries and Fisheries	Poor: Behavioural ecology — little is known on what level of disturbance causes a decline in the	Good: Effects of pollutants on seagrass Haynes *et al*. 2007[94] Erftemeijer *et al*. 2006[62]	Poor: Behavioural ecology — little is known on what level of disturbance causes a decline in the	Moderate. Although quantitative information is limited, hunting has been voluntary halted by most Traditional Owner	Moderate. Lough 2007[76] Lawler *et al*. 2007[90] Waycott *et al*. 2007[89] Preen *et al*.1995[42] Sobtzick *et al*. 2012[11]	Poor. Haynes et al. 2007[94] Hutchings *et al.* 2005[95] Marsh *et al*. 2012[20]	Poor. Haynes et al. 2007[94] Hutchings *et al.* 2005[95] Haynes 2001[87] Preen *et al*.1995[42]

	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 catchment run-off**
	reproductive outputs of dugongs. Moderate: Boating-related impacts Marine Wildlife Strandings and Mortality Database. Hodgson and Marsh 2007[65] Preen 2001[66] Groom 2003[68] Groom *et al*. 2004[67] Marsh *et al*. 2012[20]	Defence Maritime Activities Environmental Management Plan.	2006[93] Marsh *et al*. 2012[20]	reproductive outputs of dugongs. Moderate: Boating-related impacts Marine Wildlife Strandings and Mortality Database Hodgson and Marsh 2007[65] Preen 2001[66] Groom 2003[68] Groom *et al*. 2004[67] Marsh *et al*. 2012[20]	Hutchings *et al*. 2005[95] Haynes 2001[87] Long *et al*. 1996[61] Poor: Cumulative effects on seagrass and dugongs from all ports and shipping-related impacts. This includes vessel-related impacts. Marine Wildlife Strandings and Mortality Database Hodgson and Marsh 2007[65] Preen 2001[66] Groom 2003[68] Groom *et al*. 2004[67] Marsh *et al*. 2012[20]	reproductive outputs of dugongs. Moderate: Boating-related impacts Marine Wildlife Strandings and Mortality Database Hodgson and Marsh 2007[65] Preen 2001[66] Groom 2003[68] Groom *et al*. 2004[67] Marsh *et al*. 2012[20]	groups from Cardwell south and formalised through agreements and memorandums of understanding. In the remote Great Barrier Reef coast north of Cooktown, aside from strong cultural imperatives, there is a greater provisioning requirement to source dugong resources. Harvest pressure is also known to be higher. Smith and Marsh 1990[96] Smith 1987[19] Marsh *et al*. 2012[20]	Marsh *et al*. 2012[20]		Marsh *et al*. 2012[20]

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.[97]

The purpose of the vulnerability assessment s 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.

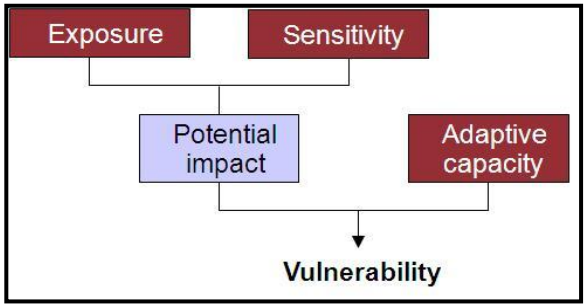

Figure 1. The key components of vulnerability assessments (Adapted from Wachenfeld *et al*., 2007)

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 matrix[f] 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 dugongs to adapt to pressures in the World Heritage Area, and the capacity of management to intervene (which in turn may assist dugongs 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 dugongs 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 GBRMPA website.

[f] The potential impact matrix is described within the vulnerability assessments page of the GBRMPA website.

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