Australian Government
Department of the Environment and Energy

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Office of Environment & Heritage

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# Recovery Plan for Marine Turtles in Australia

2017–2027

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The Department acknowledges the traditional owners of country throughout Australia and their continuing connection to land, sea and community. We pay our respects to them and their cultures and to their elders both past and present.

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## Introduction

Six of the world's seven species of marine turtles occur in Australian waters and are protected under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). These species are the EPBC Act listed threatened 'endangered' loggerhead *(Caretta caretta)*, olive ridley (*Lepidochelys olivacea*), and leatherback *(Dermochelys coriacea)* turtles, and 'vulnerable' green *(Chelonia mydas)*, flatback *(Natator depressus)* and hawksbill *(Eretmochelys imbricata)* turtles.

Marine turtles are found throughout Australia's marine environment and are most common across northern Australia. Australia has some of the largest marine turtle nesting rookeries in the Indo-Pacific region and is the only country where flatback turtles nest.

Anecdotal evidence from European explorers indicates that marine turtles were abundant in Australian waters in the early 1800s[44, 82]. From the mid-1800s turtles became subject to commercial harvest by European settlers for general consumption (meat and eggs), canned turtle soup, meat export, and for the tortoiseshell trade. Although commercial harvest ceased in the mid-1900s, it contributed to an observable decline in nesting numbers. Contemporary threats, including habitat degradation, fisheries bycatch, nest predation and marine debris, have also contributed to the decline in marine turtles in recent decades.

Coastal Aboriginal people across northern Australia and Torres Strait Islander communities have cultural, social and spiritual ties to marine turtles and manage land and sea country with marine turtle conservation and ongoing customary use as a high priority.

The first *Recovery Plan for Marine Turtles in Australia* was adopted in July 2003. The Australian Government reviewed the 2003 plan and recommended that it be remade. This new *Recovery Plan for Marine Turtles in Australia* (the plan) has been developed in conjunction with state and territory governments, Indigenous communities and other stakeholders.

## Recovery Objective

The long-term recovery objective for marine turtles is to minimise anthropogenic threats to allow for the conservation status of marine turtles to improve so that they can be removed from the EPBC Act threatened species list.

## Interim Recovery Objectives

Recognising that the long-term recovery objective is unlikely to be achieved during the ten year life of this plan, the following interim objectives and targets have been set for the life of this plan. The effectiveness of this plan will be measured, and progress towards long-term objectives assessed on the basis of how well the following targets for interim recovery objectives are met:

1. Current levels of legal and management protection for marine turtles are maintained or improved both domestically and throughout the migratory range of Australia's marine turtles.
2. The management of marine turtles is supported.
3. Anthropogenic threats are demonstrably minimised.
4. Trends at index beaches, and population demographics at important foraging grounds are described.

## Biology

The life history traits of marine turtles make them vulnerable to a wide range of anthropogenic threats. These traits include late maturation, high natural mortality of hatchlings and small juveniles, strong fidelity to breeding areas, migrating over long distances, and use of both terrestrial and marine environments to complete their lifecycle.

Marine turtles return to the region where they hatched to breed. This trait has resulted in discrete genetic stocks within each species. Each genetic stock represents a unique evolutionary history, which, if lost, cannot be replaced[63, 168]. As such, while the plan identifies the overarching priority actions for the protection of all species (Section 5.3), it also specifically identifies threats, actions and research requirements that are unique to each stock (Section 5.4). In doing so, the plan will also ensure the conservation of genetic diversity. Amongst the six species of marine turtle found in Australia, this plan considers 22 genetic stocks that nest or forage in Australian waters. The identified threats and subsequent management measures also encompass those turtles that forage in Australia and nest elsewhere (see maps in Section 3.2 and individual stock tables, Section 5.4).

## Threats

There are a range of anthropogenic threats that may inhibit the recovery of Australian marine turtles (see Section 4). The risk posed by these threats to the 22 marine turtle stocks varies depending on the habitats they occupy, timing of habitat occupancy, life cycle stage affected, abundance and trends in nesting and foraging numbers, and the management and mitigation currently in place. Threats were assessed through a risk assessment process (outlined in Section 4.4) and are as follows: climate change and variability; marine debris; chemical and terrestrial discharge; international take; terrestrial predation; fisheries bycatch; light pollution; habitat modification through infrastructure/coastal development and dredging and trawling; Indigenous take; vessel disturbance; noise interference; recreational activities; and disease and pathogens.

While the plan considers these threats in isolation, for most of the identified marine turtle stocks, it is the cumulative impacts of multiple threats that need to be addressed to secure their recovery.

## Actions

Actions were prioritised based on the number of stocks found to have a 'high' or 'very high' rating for the threat risk assessment. An action area has been developed for each threat found to pose a 'high' or 'very high' risk to at least one stock (Table 1). Table 1 identifies the priority action areas from highest to lowest for the recovery of marine turtle stocks. For threats where there was insufficient information available to assess the threat, research actions have been identified. The action areas have been devised to deliver tangible benefits to meet the Interim Recovery Objectives (Section 1.2). The plan also provides priority actions for each of the 22 marine turtle stocks (or in the case of leatherback turtles, those nesting in Australia) in the individual stock tables at Section 5.4.

Table 1. Summary of overarching action areas identified in the *Recovery Plan for Marine Turtles in Australia*

| ACTION |
| --- |
| **A. Assessing and addressing threats** |
| A1 Maintain and improve efficacy of legal and management protection |
| A2 Adaptively manage turtle stocks to reduce risk and build resilience to climate change and variability |
| A3 Reduce the impacts from marine debris |
| A4 Minimise chemical and terrestrial discharge |
| A5 Address international take within and outside Australia's jurisdiction |
| A6 Reduce impacts from terrestrial predation |
| A7 Reduce international and domestic fisheries bycatch |
| A8 Minimise light pollution |
| A9 Address the impacts of coastal development/infrastructure and dredging and trawling |
| A10 Maintain and improve sustainable Indigenous management of marine turtles |
| **B. Enabling and measuring recovery** |
| B1 Determine trends at index beaches |
| B2 Understand population demographics at key foraging grounds |
| B3 Address information gaps to better facilitate the recovery of marine turtle stocks |

Figure 1. Adult green turtle tracks, Raine Island, Queensland. Photo: © Copyright Geoff Richardson

# 1 Introduction

Six of the world's seven species of marine turtle occur in Australian waters and are listed as threatened, migratory and marine under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). These species are the EPBC Act listed threatened 'endangered' loggerhead *(Caretta caretta)*, olive ridley *(Lepidochelys olivacea)* and leatherback (*Dermochelys coriacea*) turtles; and 'vulnerable' green *(Chelonia mydas)*, flatback *(Natator depressus)* and hawksbill *(Eretmochelys imbricata)* turtles.

Within Australia, marine turtles are predominantly found in the waters of Queensland, Northern Territory and north Western Australia, although there are a few sightings of most species recorded around south-eastern Australia. Leatherback turtles are known to forage and migrate throughout Australia. There are only a few large nesting aggregations of the green, hawksbill and loggerhead turtles left in the world, and Australia has some of the largest aggregations in the Indo-Pacific region. Flatback turtles nest only in Australia and forage over the Australian continental shelf into continental waters off Papua New Guinea and Indonesia.

Marine turtles are reptiles that are highly migratory, utilising widely dispersed habitats throughout their life cycle. Marine turtles require both terrestrial and marine habitats to fulfil different life history stages. They also display late maturation as well as experience high juvenile mortality. All these traits mean that they are slow to recover from population declines and are vulnerable to a wide range of threats.

Historically, marine turtles were described as abundant in Australian waters in the early 1800s. From the mid-1800s European settlers commercially harvested green turtles for general consumption of meat and eggs, for turtle soup and meat export and hawksbill turtles for the tortoise shell trade[44, 82]. Although the commercial harvest ceased in the mid-1900s, it had led to an observable decline in nesting aggregations of these species[44, 82, 240].

More recently, marine turtles have been subject to increased pressures, including from terrestrial predation of nests, marine debris, expanding urbanisation and industrial development along coastal strips, fisheries bycatch, deteriorating water quality, and loss of nesting and foraging habitat.

Marine turtles are not just facing these pressures in Australian waters, but are exposed to them throughout their migratory range such that, for some species, it is the pressures outside Australia that are affecting their long-term viability.

The management of threats facing marine turtles and their habitats is undertaken by Commonwealth, state/territory and local government agencies, as well as through non-government organisations, industry partners and volunteers. Many Indigenous and local community groups are actively involved in the on-going protection and conservation of marine turtles. This is especially true in remote areas of northern Australia, where communities manage a range of threats to marine turtles and their habitats. Indigenous management of marine turtles has developed over many millennia in Australia and there is a strong desire among Indigenous communities for increased responsibility in managing marine resources[173] to ensure continued cultural connections and sustainable customary use into the future. Land and sea ranger programs conduct conservation, management and research activities for marine turtles in many areas across northern Australia.

# 1.1 Review of the *Recovery Plan for Marine Turtles in Australia – July 2003*

The EPBC Act provides for recovery plans to be made for the purposes of the protection, conservation and management of listed threatened species. Recovery plans identify the research and management actions necessary to stop the decline, and support the recovery of, listed threatened species so that their chances of long-term survival in nature are maximised.

The *Recovery Plan for Marine Turtles in Australia 2003* was made in July 2003. It identified a number of key impacts to marine turtles including fisheries bycatch, marine debris, Indigenous and international take, shark control activities, boat strike, aquaculture and defence activities. The 2003 plan had six specific objectives with 60 associated actions.

The 2003 plan was reviewed by the Department in 2013. The review found that the objectives of the 2003 plan were generally achieved in relation to fishery interactions, communication with stakeholders and international engagement. However, it noted that for all identified threats there were still opportunities to build on existing programs. Monitoring of key nesting and foraging sites had not been adequately achieved during the life of the plan. Similarly, whilst activities around reducing mortality, managing important turtle habitat and reducing the impacts of light had been initiated, the objectives around these threats had not been fully met. The review also noted that there were a number of emerging threats that had not been considered in the 2003 plan including climate change and increasing industrial noise (seismic and pile driving). Nor had the plan considered the cumulative impact of multiple threats. The review recommended that a new recovery plan be made to address residual and emerging threats to marine turtles in Australia.

# 1.2 Objectives, targets and performance indicators of the plan

## Long-term recovery objective

Minimise anthropogenic threats to allow for the conservation status of marine turtles to improve so that they can be removed from the EPBC Act threatened species list.

## Interim recovery objectives (2017–2027)

Recognising that the overarching objective is unlikely to be achieved during the life of the plan due to the long lifecycles and late maturation of marine turtles, interim recovery objectives and associated targets have been developed for this plan, and are listed below. The first objective provides the context for the legal protection that underpins this recovery plan. The second objective provides support for conservation initiatives that will facilitate achieving objective three – the reduction in recognised and emerging threats. Objective four requires the collection of data that will support understanding of whether threats are being reduced and recovery is underway.

## Targets for interim recovery objectives

**Interim Objective 1: Current levels of legal and management protection for marine turtle species are maintained or improved, both domestically and throughout the migratory range of Australia's marine turtles.**

Target 1.1: Domestic and international legislation and other agreements that support the recovery of Australian marine turtles are maintained, and, where possible, strengthened.

Target 1.2: Robust scientific information is available and used to support decision making.

**Interim Objective 2: The management of marine turtles is supported.**

Target 2.1: The sustainable management of marine turtles by Aboriginal and Torres Strait Islander communities and ranger groups to maintain long-term cultural, spiritual and economic associations with marine turtles is supported.

Target 2.2: The capacity of programs throughout northern Australia to conduct effective monitoring, management and research of marine turtles at nesting beaches and feeding grounds is maintained and increased.

**Interim Objective 3: Anthropogenic threats are demonstrably minimised.**

Target 3.1: Robust and adaptive management regimes that lead to a reduction in anthropogenic threats to marine turtles and their habitats are in place.

Target 3.2: Threat mitigation strategies are supported by high quality information.

**Interim Objective 4: Trends in nesting numbers at index beaches and population demographics at important foraging grounds are described.**

Target 4.1: Effective monitoring programs are implemented and maintained at index beaches and foraging areas for each of the six species.

Target 4.2: Measures of success identified for each stock are achieved within the life of the plan.

## Performance of the plan

The performance of this plan will be considered at the completion of the plan. The performance of the plan will be rated against how successful the plan has been in meeting targets (Table 2), and will give an indication of the degree of progress towards long-term recovery objectives. The progress of the plan will be considered at a five year (mid-term) review of the plan and at the completion of the plan.

Table 2. Performance measures for the *Recovery Plan for Marine Turtles in Australia*.

| Performance rating for the recovery plan | Targets | Progress towards long-term recovery objective |
|---|---|---|
| Successful | All targets met | Excellent |
| Moderately successful | Five of eight targets are met including 1.1, 2.1, 3.1, and 4.1 | Sound |
| Moderately unsuccessful | Four of eight targets are met including 1.1, 2.1 and 3.1 | Adequate |
| Unsuccessful | Fewer than four targets are met or 1.1 and 3.1 not met | Failure |

# 2 Legal Framework

## 2.1 International conventions and agreements

Marine turtles are considered to be in decline globally, despite successful conservation efforts in many countries that have improved the status of some populations. Australia is signatory to a range of international conventions and agreements that afford protection to marine turtles including the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS), the *Convention on Biological Diversity*, the *Convention Concerning the Protection of the World Cultural and Natural Heritage*, and the *Convention on the International Trade in Endangered Species of Wild Fauna and Flora* (CITES). Australia meets its international obligations to these conventions principally through the EPBC Act. The species in this plan are also listed in the *International Union for the Conservation of Nature* (IUCN) *Red List of Threatened Species*, which recognises them internationally as species of conservation concern. Table 3 provides the conservation status of each species under CITES, CMS and the IUCN Red List of Threatened Species.

Australia is signatory to a number of other international partnerships, agreements and initiatives. Collectively, these aim to protect marine turtles and their habitat from threats, increase and share knowledge of these animals and their threats, and inform policy and promote public awareness and co-operative management. Some examples of these partnerships, agreements and initiatives include: the *Indian Ocean and South East Asian Marine Turtle Memorandum of Understanding*, *Secretariat of the Pacific Regional Environment Programme,* the *Declaration on Strategic Action Programme for the Arafura and Timor Seas Ecosystems Action*, *Torres Strait Treaty*, and the *Agreement between the Government of Australia and the Government of the Republic of Indonesia relating to Cooperation in Fisheries*, signed 22 April 2992, [1993] ATS 18 (entered into force 29 May 1993).

In 2014, the CMS unanimously adopted the *Single Species Action Plan for the Loggerhead Turtle* (Caretta caretta) *in the South Pacific Ocean*. Although not legally binding, this agreement provides a framework for range states to implement management actions to address the decline of loggerhead turtles in the south Pacific.

Table 3. Global conservation status of marine turtles under international instruments

| Instrument | Species | | | | | |
|---|---|---|---|---|---|---|
| | **Green** | **Loggerhead** | **Flatback** | **Hawksbill** | **Olive ridley** | **Leatherback** |
| CITES Appendix# | Appendix I | Appendix I | Appendix I | Appendix I | Appendix I | Appendix I |
| CMS Appendix^ | Appendix I & II | Appendix I & II | Appendix II | Appendix I & II | Appendix I & II | Appendix I & II |
| IUCN Status§ | Endangered | Vulnerable | Data Deficient | Critically Endangered | Vulnerable | Vulnerable |

# CITES: Appendix I lists species that are threatened with/or in danger of extinction through trade.
^ CMS: Appendix I lists species that are threatened with/or in danger of extinction. Appendix II lists species that have an unfavourable conservation status.
§ The IUCN listing reflects the global status of the species, noting that some species are also listed on a regional management unit basis.

The Australian Government also actively engages in Regional Fishery Management Organisations with, amongst other objectives, the goal of minimising the impacts of international fisheries on non-target threatened and migratory species such as marine turtles.

The Australian Government engages on climate change issues through fora such as the *United Nations Framework Convention on Climate Change*.

## 2.2 National legislation and conservation status of marine turtle species

All six species of marine turtle found in Australian waters are listed as threatened, migratory and marine under the EPBC Act. Under Part 13 of the EPBC Act it is an offence to kill, injure, take, trade, keep or move listed species in a Commonwealth area, unless the person taking the action holds a permit under the EPBC Act or the activity is carried out in accordance with a state/territory or Commonwealth fishery plan of management accredited by the Commonwealth Minister responsible for the administration of the EPBC Act. In addition, it is an offence under Part 3 of the EPBC Act to take an action that will have a significant impact on listed species anywhere in Australia unless approved under Part 9. Actions likely to have a significant impact on a marine turtle species may be assessed by the Minister and where impacts are found to be acceptable may be approved subject to a range of conditions.

The *Great Barrier Reef Marine Park Act 1975* (GBRMP Act), which operates in conjunction with the EPBC Act, affords protection to marine turtles in the Great Barrier Reef Marine Park. There are other Commonwealth and state/territory marine parks and reserves in Australia that also afford protection for marine turtles.

Legal Framework

Marine turtles are also protected by state/territory legislation. Table 4 outlines relevant Acts by jurisdiction and provides the conservation status of the marine turtle species under each piece of legislation. Many of these Acts also require environmental assessment for actions likely to impact turtles.

The *Native Title Act 1993* identifies activities such as hunting and fishing as potential native title rights and interests. Section 211 of the *Native Title Act 1993* generally provides that a law which prohibits or restricts persons from carrying out a particular class of activity, other than in accordance with a licence or permit, does not prohibit or restrict native title holders from carrying out that activity for the purpose of personal, domestic or non-commercial communal needs and in exercise of native title rights and interests. This protects the pre-existing legal rights of native title holders.

Many Acts have specific clauses that identify the right and authority for Aboriginal and Torres Strait Islander people to hunt as part of cultural practice. These include:

- The GBRMP Act which permits the traditional use of marine resources by Traditional Owner groups in accordance with accredited traditional use of marine resource agreements.
- Turtle and dugong hunting in the Torres Strait Protected Zone are managed as traditional subsistence fisheries under the Commonwealth *Torres Strait Fisheries Act 1984*. The fisheries are limited to the Traditional Inhabitants of the Torres Strait, and animals may only be taken in the course of traditional fishing and used for traditional purposes.
- Section 61 of the Queensland *Aboriginal and Torres Strait Islander Communities (Justice, Land and Other Matters) Act 1984* allows a member of a community of Aboriginal and Torres Strait Islander people resident in a community government or Indigenous Regional Council Area to take marine products or fauna by traditional means for consumption by members of the community.
- The *Western Australian Wildlife Conservation Act 1950* provides an exemption otherwise applying to the taking of fauna for persons of Aboriginal descent to take fauna for food for their selves and their family, but not for sale.
- The Northern Territory *Territory Parks and Wildlife Conservation Act 1974* recognises the rights of Aboriginal peoples who have traditionally used an area of land or water to continue to use that area for traditional hunting, food gathering (other than for sale) and for ceremonial and religious purposes.
- State and territory animal cruelty legislation provides for humane treatment of marine turtles.

Table 4. Conservation status of marine turtles under Australian Commonwealth, state and territory legislation (February 2017)

| Legislation | Green | Loggerhead | Flatback | Hawksbill | Olive ridley | Leatherback |
|---|---|---|---|---|---|---|
| **Commonwealth** | | | | | | |
| *Environment Protection and Biodiversity Conservation Act 1999* | Vulnerable | Endangered | Vulnerable | Vulnerable | Endangered | Endangered |
| *Great Barrier Reef Marine Park Act 1975* | Protected | Protected | Protected | Protected | Protected | Protected |
| **Queensland** | | | | | | |
| *Nature Conservation Act 1992* | Vulnerable | Endangered | Vulnerable | Vulnerable | Endangered | Endangered |
| **Northern Territory** | | | | | | |
| *Territory Parks and Wildlife Conservation Act 2000* | Near threatened | Vulnerable | Data deficient | Vulnerable | Vulnerable | Critically endangered |
| **Western Australia** | | | | | | |
| *Wildlife Conservation Act 1950* | Vulnerable | Endangered | Vulnerable | Vulnerable | Endangered | Vulnerable |
| **South Australia** | | | | | | |
| *National Parks and Wildlife Act 1972* | Vulnerable | Endangered | Not listed | Not listed | Not listed | Vulnerable |
| **Tasmania** | | | | | | |
| *Threatened Species Protection Act 1995* | Vulnerable | Endangered | Not listed | Vulnerable | Not listed | Vulnerable |
| **Victoria** | | | | | | |
| *Flora and Fauna Guarantee Act 1988* | Not listed | Not listed | Not listed | Not listed | Not listed | Threatened |
| **New South Wales** | | | | | | |
| *Threatened Species Conservation Act 1995* | Vulnerable | Endangered | Not listed | Not listed | Not listed | Endangered |

# 3 Biology and Ecology

## 3.1 General biology and ecology of marine turtles

Marine turtles have a complex lifecycle that spans a large geographic range over multiple habitats (Figure 2) and many decades. They are highly migratory during some life phases, but during others show high site fidelity to small geographic areas. The following provides a generalised description of life history characteristics and requirements for marine turtles. For species-specific information please see individual stock tables at Section 5.4.

### Generalised life cycle

#### Adults

Although marine turtles spend the majority of their lives in the ocean, adult female marine turtles come ashore to lay eggs in the sand above the high tide. Females lay on average two to six clutches per season. The period between each successive clutch is known as the internesting period. During internesting turtles remain close to the nesting beach or rookery. Nesting leatherback turtles may not exhibit the same behaviours and have been observed nesting at locations up to 460 km apart within a season[108, 211]. The number of females nesting can fluctuate widely between years. In the case of green turtles this variation has been attributed to environmental conditions and food availability[143].

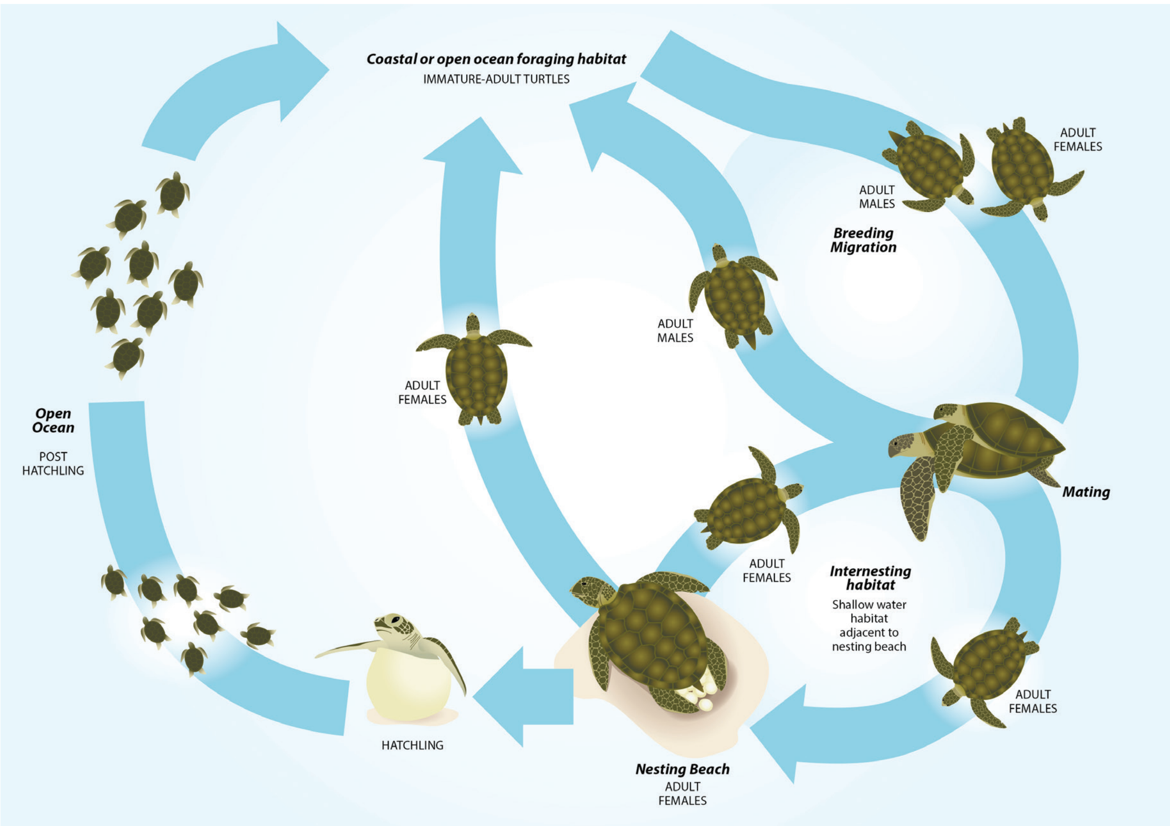


Figure 2. The generalised life cycle of marine turtles (adapted from Lanyon *et al*. (1989)[130]).

## Eggs

For successful incubation, marine turtle eggs must be buried in ventilated, high humidity, sandy sites that are not subjected to flooding or erosion, and have a temperature range that persists within 25-35$^{0}$C for the duration of incubation[1, 109]. Marine turtles have temperature dependent sex determination. This means that the temperature during incubation determines the sex of hatchlings, with higher temperatures producing predominantly females[166]. There are also upper and lower temperature thresholds for successful incubation. The time frame for incubation differs across species, but is typically about two months. Adult turtles provide no parental care of eggs or young.

## Hatchlings

Hatchlings emerge from the nest and orient towards the sea using the low elevation light horizon[258]. After entering the water, hatchlings use a combination of cues (wave direction, current, and magnetic fields) to orient themselves and travel into deeper offshore waters[150-152]. Crossing and swimming away from the beach is thought to imprint the hatchlings with the cues that allow individuals to return to their natal region for breeding as adults[153]. Hatchlings do not feed for the first few days of life relying on the remains of internalised yolk resources[257].

## Pelagic juvenile

The life stage after a hatchling leaves its natal beach and swims offshore, until it returns to coastal waters some years later as a small juvenile, is referred to as the post-hatchling or pelagic juvenile stage. In general, hatchlings disperse into oceanic currents and gyres where they will stay in these pelagic environments until large enough to settle in coastal feeding habitats[21, 27, 257]. There is limited information on the distribution and biology of pelagic juvenile turtles for most species, with the exception of south-west Pacific loggerhead turtles. Loggerhead turtle pelagic juveniles in the south-west Pacific migrate from eastern Australian rookeries to South America and back[21]. Migrations are most likely made in conjunction with the predominant surface currents where young turtles can use the natural floating debris and biota that congregate along the current fronts to provide protection and food[257]. There is high natural mortality during this pelagic life stage. One exception to oceanic migrations by post-hatchlings is found in the flatback turtle, whose hatchlings are thought to spend this life phase within the continental shelf waters of Australia[136].

While in pelagic habitats, all species are primarily carnivorous, feeding on a range of macro-zooplankton[133]. The feeding behaviour of pelagic turtles appears to be primarily opportunistic and a variety of anthropogenic debris has been found in the stomachs of loggerhead and green post-hatchling turtles[22]. The foraging ecology of post-hatchling flatback turtles is currently unknown. Limited observations suggest they also feed on small animals living in the water column[148].

## Juvenile, sub-adult and adult

After leaving the oceanic habitat, juvenile turtles (i.e. not sexually mature) generally ‘recruit’ or take up residency in continental shelf waters where they inhabit sub-tidal and intertidal coral and rocky reefs and seagrass meadows, as well as deeper soft-bottomed habitats. In general, they do not form social groups, but feed as individuals. They tend to live year round in coastal waters, often displaying small home ranges. The exception to this is the leatherback turtle that spends most of its life in the open ocean travelling vast distances whilst foraging[136]. Additionally, an unknown proportion of green and loggerhead turtles do not recruit to an inshore feeding ground and remain in the open ocean as an adults[92]. There is a knowledge gap in this regard for hawksbill, flatback and olive ridley turtles.

Within Australian waters, most juvenile and sub-adult turtles (turtles approaching sexual maturity) show strong fidelity to chosen feeding grounds and do not move large distances[207]. Turtles living in feeding grounds within Australia may migrate to breed outside of Australian waters, and similarly, turtles nesting in Australia may live in foraging areas outside of Australian jurisdiction. For example, flatback turtles use foraging areas off Papua New Guinea and Indonesia[209, 213] and hawksbill turtles live in the Great Barrier Reef and nest on islands in the south Pacific[13].

In general, marine turtle growth is slow and varies among species, habitats, sex and maturity. Marine turtles require 20-50 years to reach sexual maturity[7] and females will only reproduce when they are able to obtain and store sufficient fat to make the breeding migration and produce eggs. The time between female reproductive activity may vary from 1-8 years depending on species and food availability[167]. Adult turtles show strong fidelity to both feeding and breeding grounds, migrating long distances (can be up to thousands of kilometres) to return to the region where they hatched[136]. Fidelity to natal breeding grounds means that turtles that nest within a region are genetically more similar to one another than turtles that nest further away[169].

Effective management requires a complete understanding of life history demographics and habitat requirements for each species to determine most responsive life history stages for management[30, 43]. There are currently knowledge gaps around foraging for flatback, olive ridley and hawksbill turtles, and migratory corridors for all species.

## Generalised diet

After juvenile turtles take up residency in an inshore foraging habitat they tend to feed on plants or animals on the sea floor, resulting in a more species-specific diet. The typical diets of each marine turtle species residing in Australian coastal feeding grounds are outlined in Table 5. Exceptions to this generalised feeding behaviour also occur. For example, green turtles living in shallow habitat are thought to be primarily herbivorous, but some maintain a considerable carnivorous component to their diet[5, 26].



Table 5. Marine turtle dietary preferences by species (For more detail see Limpus (2009)[136] and Bjorndal (1997)[18])

| Species | Generalised diet |
|---|---|
| Green turtle | Primarily herbivorous, foraging on algae, seagrass and mangroves. In their pelagic juvenile stage, they feed on algae, pelagic crustaceans and molluscs[22] |
| Loggerhead turtle | Carnivorous, feeding predominantly on benthic invertebrates in habitats ranging from near shore to 55 m[136]. During their post-hatchling stage, they feed on algae, pelagic crustaceans and molluscs[22] |
| Flatback turtle | Primarily carnivorous, feeding on soft-bodied invertebrates. Juveniles eat gastropod molluscs, squid, siphonophores[262]. Limited data indicate that cuttlefish[37], hydroids, soft corals, crinoids, molluscs and jellyfish[262] are also eaten |
| Hawksbill turtle | Omnivorous, feeding on algae[12], sponges, soft corals and other soft-bodied invertebrates[249] |
| Olive Ridley turtle | Primarily carnivorous, feeding on soft-bodied invertebrates such as sea pens, soft corals, beche-der-mer (sea cucumbers) and jellyfish in depth between 15-200 m[136] |
| Leatherback turtle | Oceanic and therefore remain planktivorous throughout their life, feeding on jellyfish and large planktonic ascidians (e.g. sea squirts) in the water column[136] |

## 3.2 Australian stocks

Marine turtles return to the region where they hatched to breed. This trait has resulted in the evolution of discrete genetic stocks within each species that are defined by the presence of regional breeding aggregations. Each genetic stock represents a unique evolutionary history that if lost cannot be replaced[168]. This plan considers the management of turtle genetic stocks with the objective of protecting the biodiversity of each species.

Genetic stocks have been identified through genetic analyses[63]. Stocks are composed of multiple rookeries in a region and are delineated where there is little or no migration of individuals between nesting areas. Turtles from different stocks typically overlap at feeding grounds[169]. Figures 3-7 show the geographic distribution of nesting sites for each stock for five of the species of marine turtles nesting in Australia (green, loggerhead, olive ridley, hawksbill and flatback turtles). Figure 8 shows the known historical nesting locations and dispersal of leatherback turtles and Figures 9-15 describe the known geographic dispersal of the other five species. Dispersal information is based on tag recovery data, satellite tracking information and genetic analysis of mixed stocks foraging grounds.

### Green turtles

Green turtles nesting in Australia are distributed across nine genetically distinct stocks including newly identified Cobourg and the Cocos Keeling stocks[63]. The remaining stocks are found at the North West Shelf, Ashmore Reef, Scott Reef-Browse Island, Gulf of Carpentaria, northern Great Barrier Reef and Torres Strait, Coral Sea and southern Great Barrier Reef. In addition, there are green turtles that feed in Australia that are part of stocks that breed in other countries (e.g. Indonesia, Papua New Guinea and New Caledonia). Green turtles are predominantly found in Australian waters off the Northern Territory, Queensland, and Western Australian coastlines with more limited numbers in New South Wales, Victoria and South Australia.

### Loggerhead turtles

There are two genetically distinct stocks of loggerhead turtles nesting in Australia, one in Queensland (known as the south-west Pacific stock) and one in Western Australia. Loggerhead turtles forage in all coastal states and the Northern Territory, but are uncommon in South Australia, Victoria and Tasmania. As post-hatchlings they are known to travel as far as South America[21]. Loggerhead turtles foraging in New South Wales originate from the south-west Pacific stock[63].

### Hawksbill turtles

This plan describes three hawksbill turtle stocks, one in the northern Great Barrier Reef and Torres Strait (known as the north Queensland stock) and one in Arnhem Land (the north-east Arnhem Land stock), which is differentiated by temporal variation in breeding[63]. A third is found on the north-west shelf of Western Australia (the Western Australia stock)[229]. Nesting hawksbill turtles from the northern Great Barrier Reef migrate to the Northern Territory, the southern coast of West Papua (formerly Irian Jaya) and Papua New Guinea. Hawksbill turtles that forage on the Great Barrier Reef migrate to neighbouring countries including Papua New Guinea, Vanuatu, and the Solomon Islands. It is not known from which stock hawksbill turtles foraging in New South Wales originate. The genetic relatedness of hawksbill turtles nesting in the Kimberley to hawksbill turtles nesting elsewhere in Western Australia is currently unknown.

## Flatback turtles

There are five stocks of flatback turtles currently described around Australia[63, 187], however genetic studies being undertaken (as a collaboration between the Department of Parks and Wildlife and CSIRO) on flatback turtles nesting on islands off the Kimberley coast indicate that they may comprise an additional genetic stock (FitzSimmons, pers. comm. 2017). The five described stocks are known as the: eastern Queensland, Arafura Sea, Cape Domett, south-west Kimberley and Pilbara stocks. Additional genetic analysis is being undertaken to provide better resolution of geographic boundaries for flatback turtles in Western Australia. Flatback turtles forage across the Australian continental shelf and into the continental waters off Indonesia and Papua New Guinea.

## Olive ridley turtles

There are two olive ridley turtle stocks in Australia, one that nests in the Northern Territory (Northern Territory stock) and one that nests on western Cape York near Weipa (north-western Cape York stock)[63]. Low density nesting has also been described on the Kimberley coast, but genetic relatedness is unknown. There is limited tag recovery data for olive ridley turtles, but satellite tracking data indicates that they appear to remain on the Australian continental shelf into waters off Indonesia[232, 247].

## Leatherback turtles

There are potentially three leatherback turtle genetic stocks in the Indo-Pacific[63]. Genetic linkages are yet to be determined between areas where leatherback turtles are known to nest/occur, and those found in Australian waters[14]. As there is no genetic basis on which to separate leatherback turtles into stocks in Australia[63], for the purposes of this plan, leatherback turtles are classified on whether they nest in Australia or in neighbouring countries. Small numbers of leatherback turtles nest on the Cobourg Peninsula and there have been unconfirmed accounts of leatherback turtles nesting in Western Australia. Although historically there was sparse nesting in south east Queensland, there have been no records of nesting along the Queensland coast since 1996[136].

Leatherback turtles are more commonly found foraging in Australian waters along the east coast and in Bass Strait. The southern waters of Australia are one of five identified foraging sites (where area restricted behaviour occurs) for Leatherback turtles[8]. These turtles are likely from the western Pacific genetic stock that nests in north west Papua, northern Papua New Guinea, the Solomon Islands and Vanuatu[14]. Aerial surveys have also recorded leatherback turtles foraging in Northern Territory waters[75]. Leatherback turtles foraging off Western Australia may come from nesting areas in the Andaman Sea and there has been one tag recovery of a turtle that nested in Java[136].

## International stocks foraging in Australian waters

For all six species it is known that some turtles nesting outside Australia migrate to forage in Australian waters. These turtles are considered in the table 'All species – International stocks foraging in Australian waters' at Section 5.4.

## Green Turtle Stocks Nesting in Australia

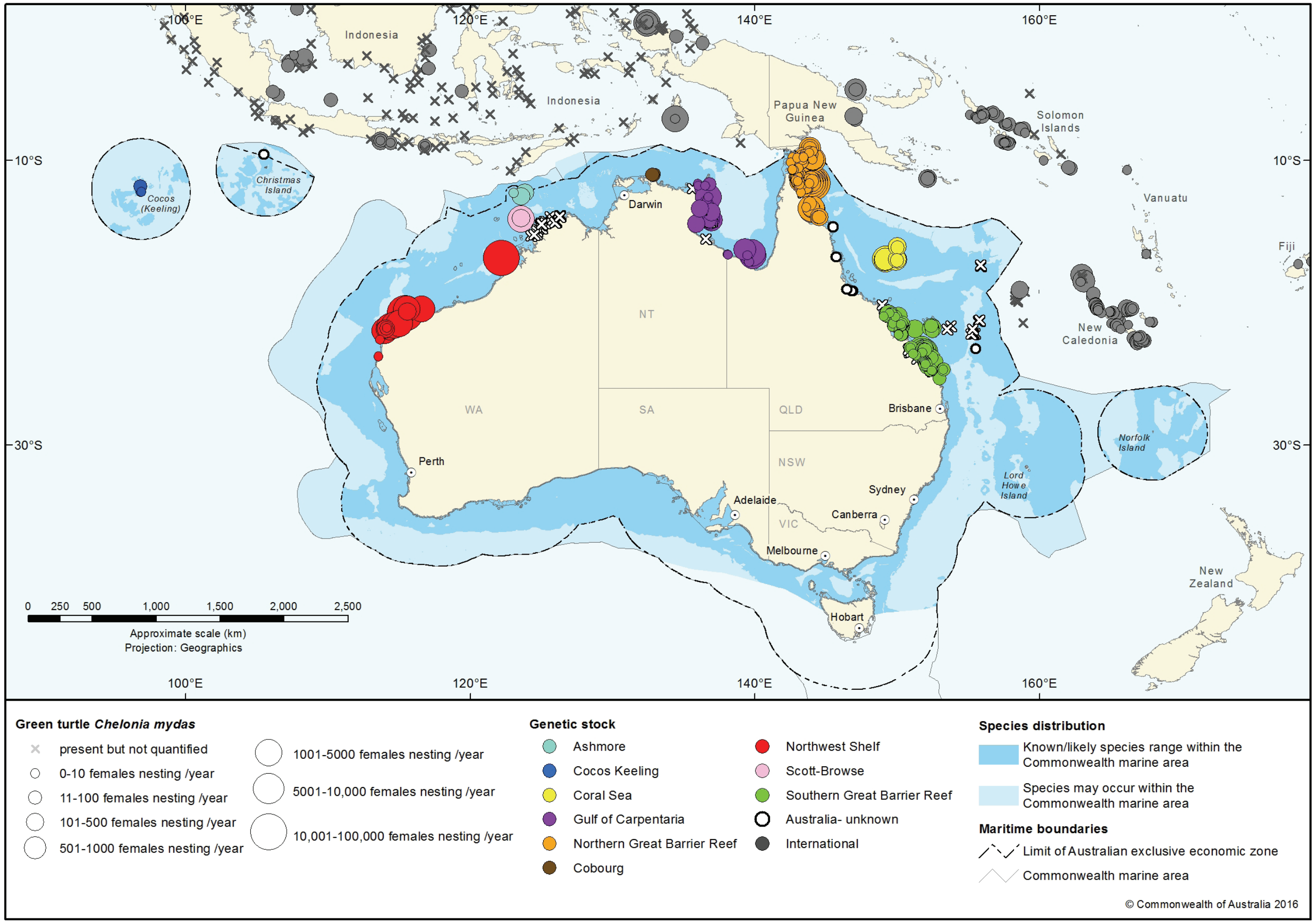


Figure 3. Green turtle (*Chelonia mydas*) nesting sites in Australia and surrounding regions.

Source: Queensland Department of Environment and Heritage Protection marine turtle tagging database, Chatto and Baker (2008)[36], FitzSimmons and Limpus (2014)[63], Waayers (2014)[231].

## Loggerhead Turtle Stocks Nesting in Australia

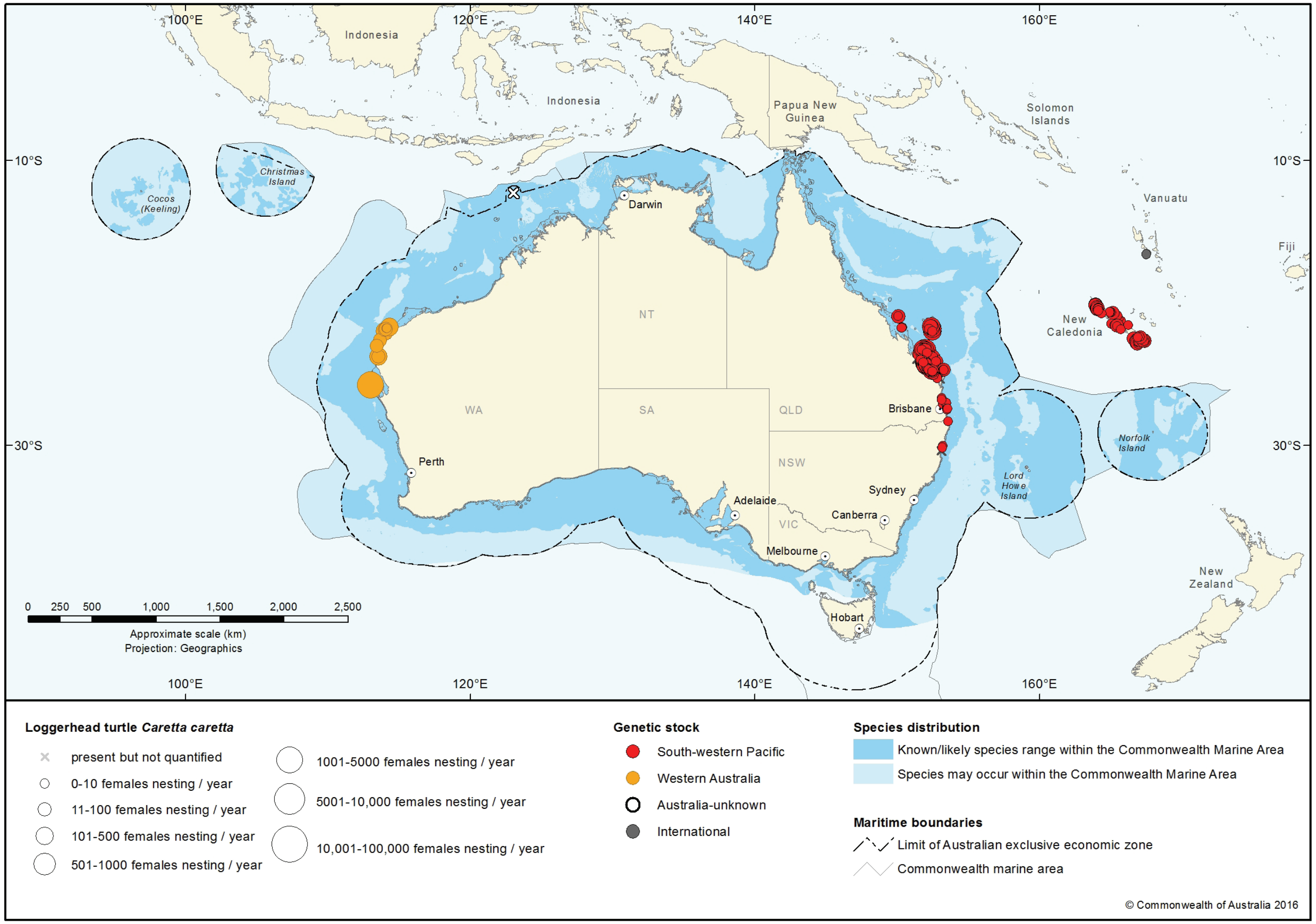


Figure 4. Loggerhead turtle (*Caretta caretta*) nesting sites in Australia and surrounding regions.

Source: Queensland Department of Environment and Heritage Protection marine turtle tagging database, FitzSimmons and Limpus (2014)[63], Whiting and Guinea (2005)[242].

## Hawksbill Turtle Stocks Nesting in Australia

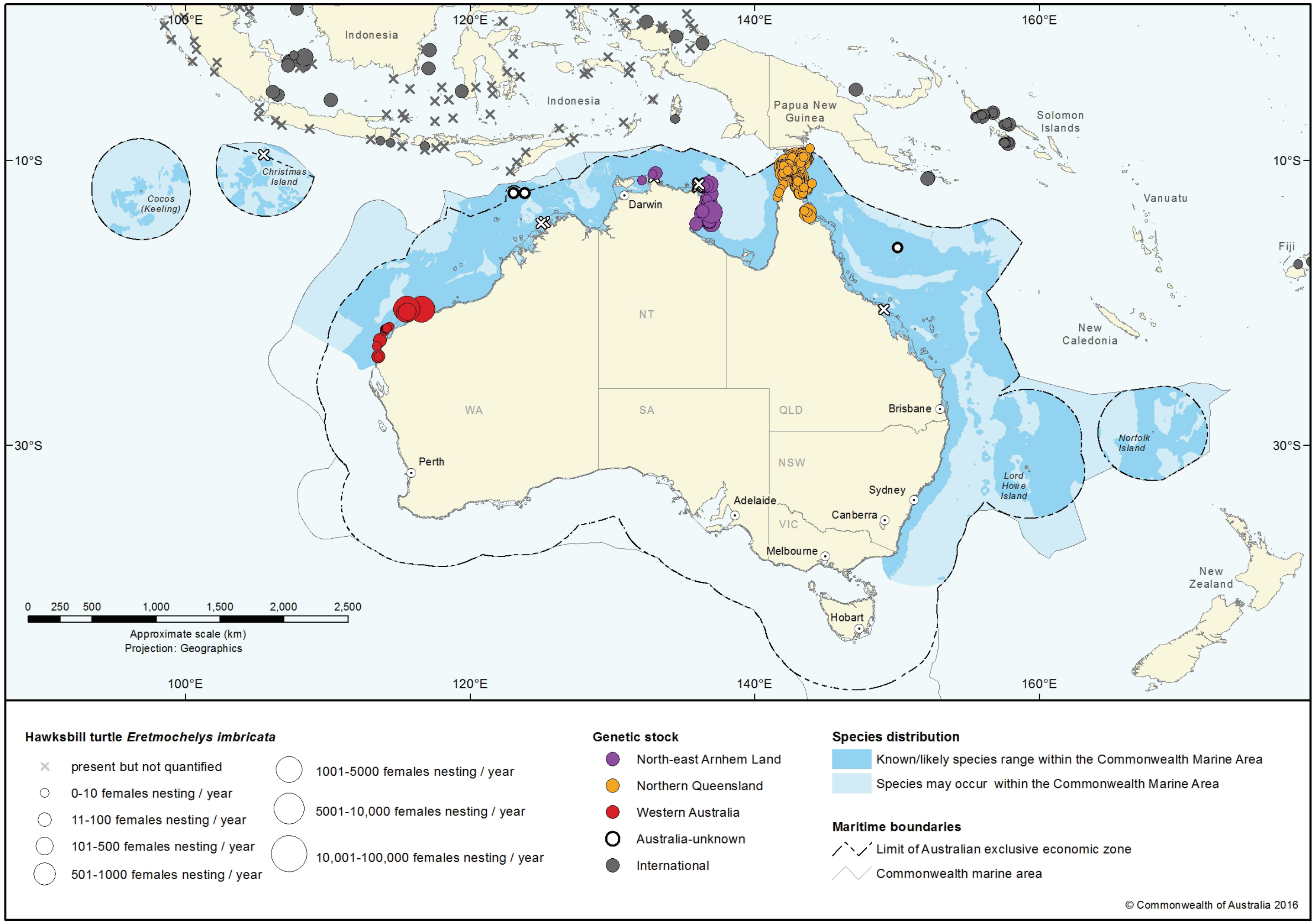


Figure 5. Hawksbill turtle (*Eretmochelys imbricata*) nesting sites in Australia and surrounding regions.

Source: Queensland Department of Environment and Heritage Protection marine turtle tagging database, Chatto and Baker (2008)[36], FitzSimmons and Limpus (2014)[63], Guinea (2013)[79], K. Pendoley (unpublished data 2016), Vargas *et al.* (2016)[229], Waayers (2014)[231], Western Australian Department of Parks and Wildlife – unpublished data (2016).

## Flatback Turtle Stocks Nesting in Australia

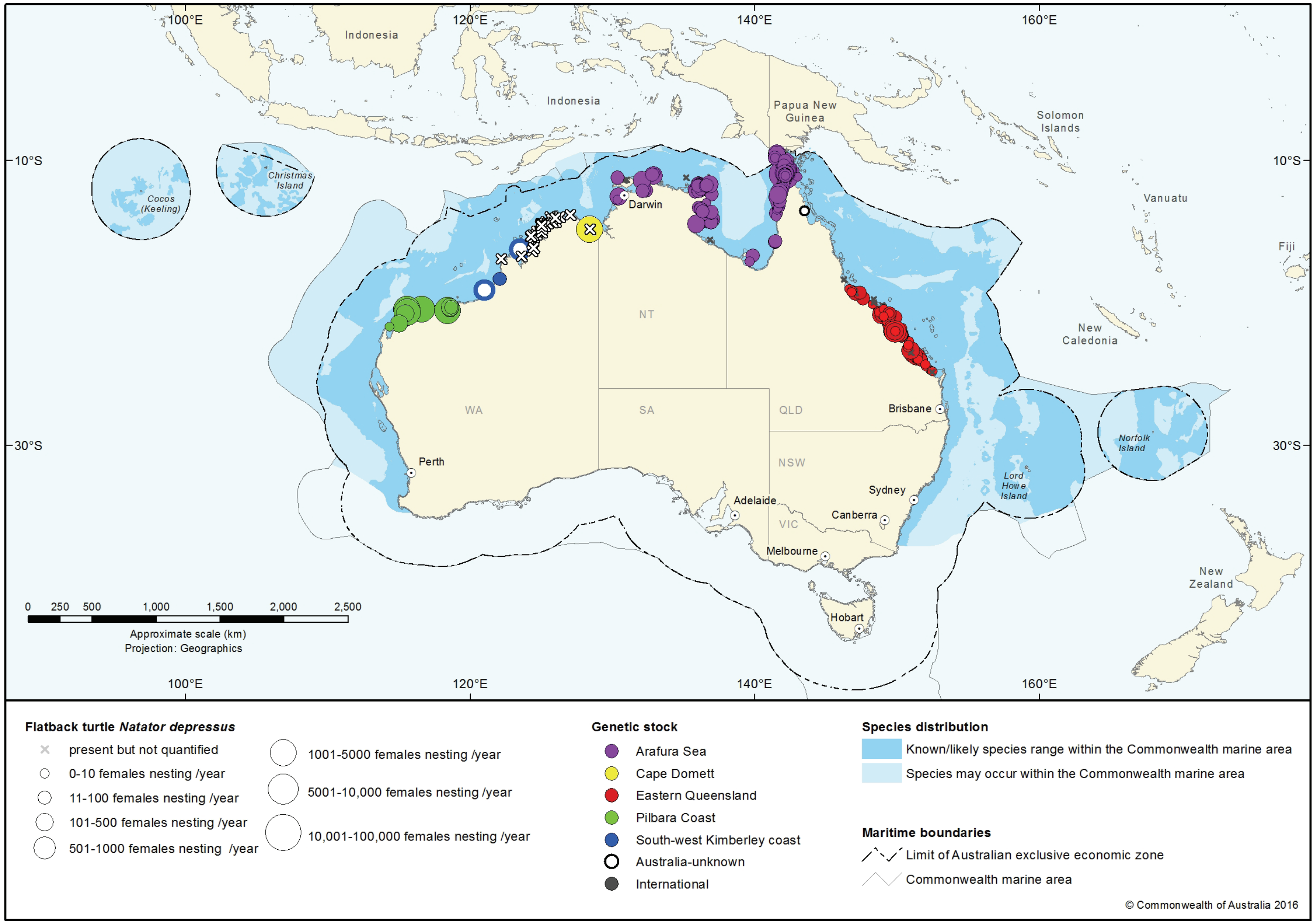


Figure 6. Flatback turtle (*Natator depressus*) nesting sites in Australia and surrounding regions.

Source: Queensland Department of Environment and Heritage Protection marine turtle tagging database, Chatto and Baker (2008)[36], FitzSimmons and Limpus (2014)[63], Waayers (2014)[231], Western Australian Department of Parks and Wildlife – unpublished data (2016), Whiting *et al.* (2008)[238].

## Olive Ridley Turtle Stocks Nesting in Australia

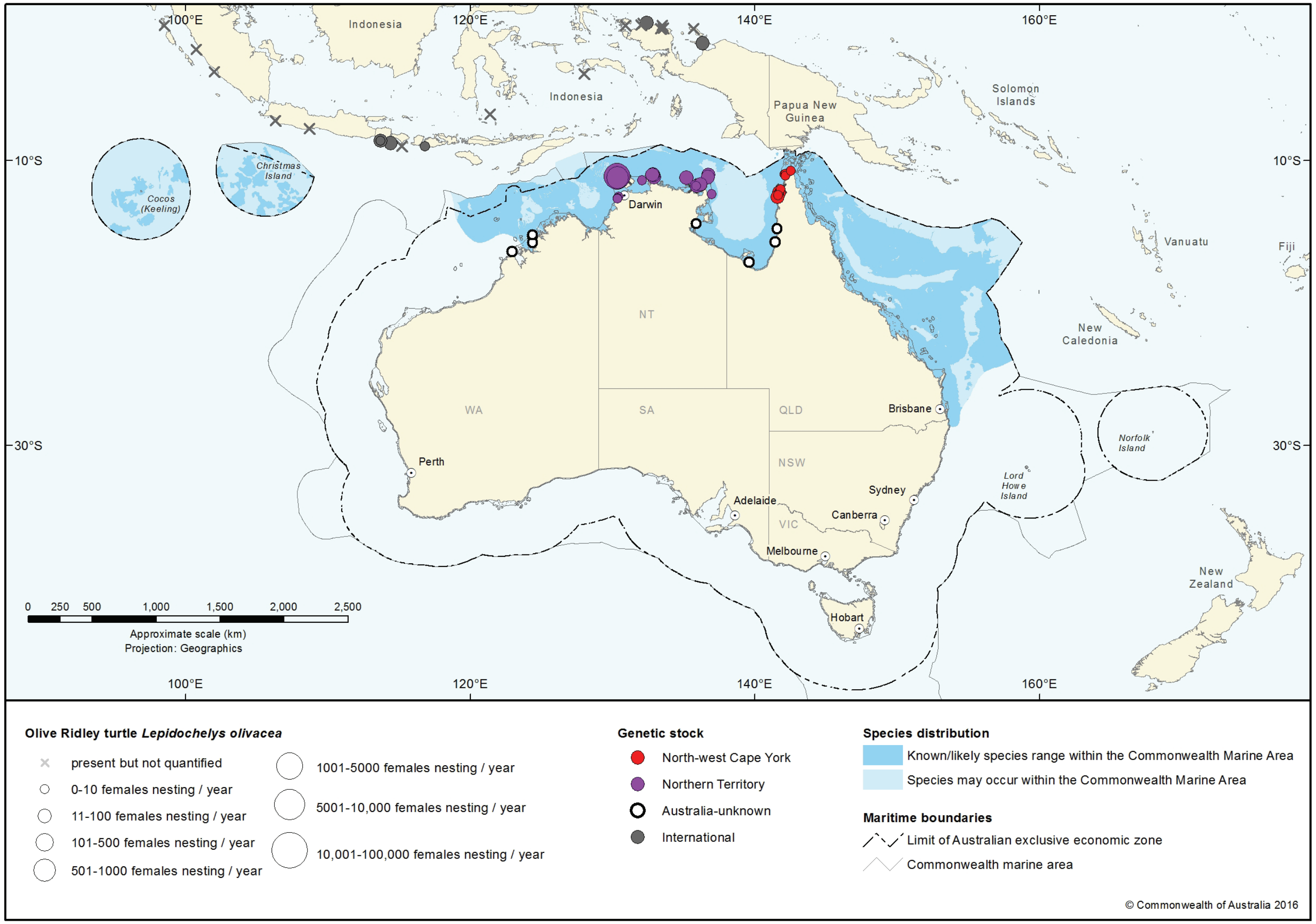


Figure 7. Olive ridley turtle (*Lepidochelys olivacea*) nesting sites in Australia and surrounding regions.

Source: Queensland Department of Environment and Heritage Protection marine turtle tagging database, Chatto and Baker (2008)[36], FitzSimmons and Limpus (2014)[63], Prince *et al.* (2010)[190], Western Australian Department of Parks and Wildlife – unpublished data (2016).

## Leatherback Turtle Nesting and Foraging

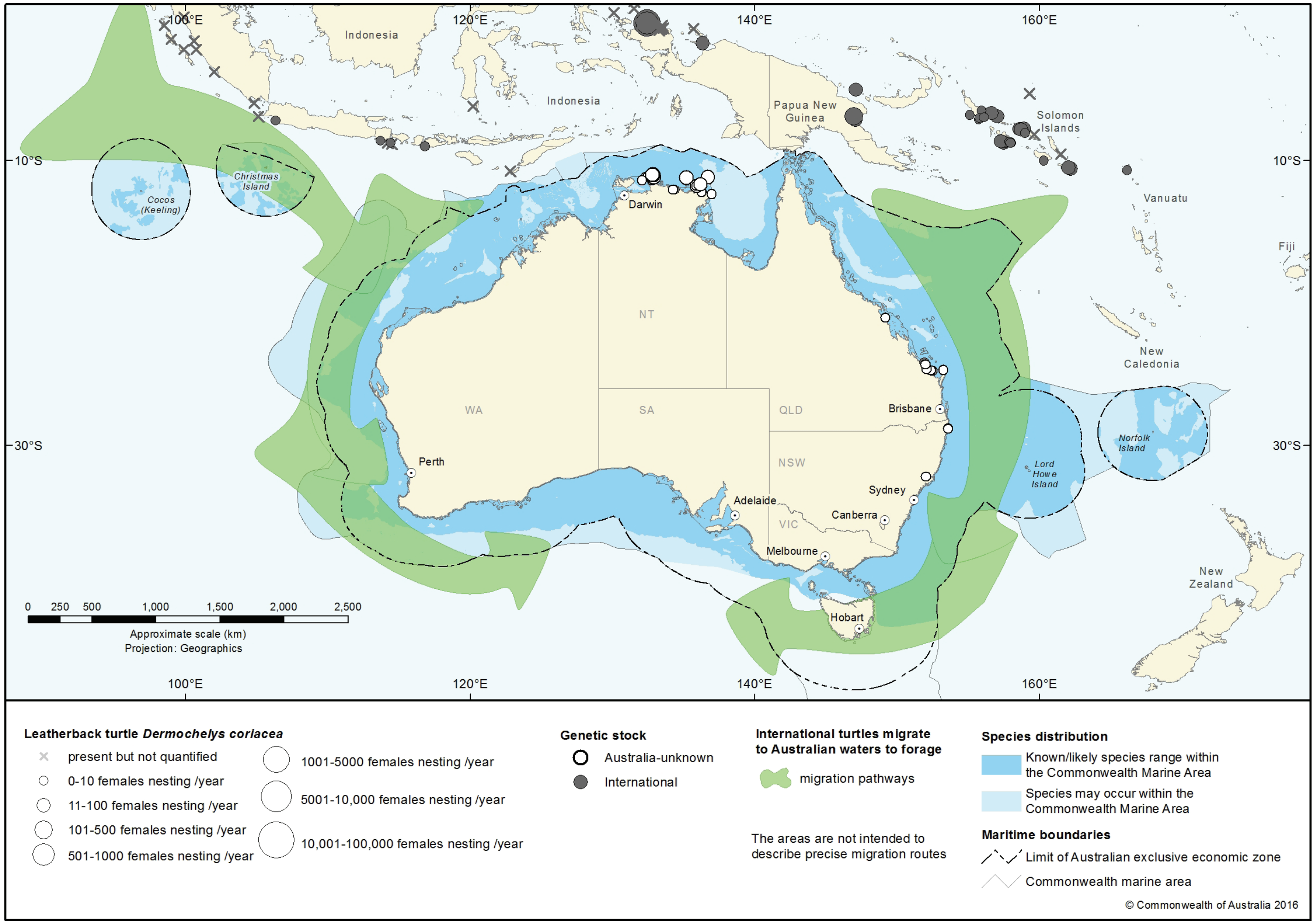


Figure 8. Leatherback turtle (*Dermochelys coriacea*) nesting sites in Australia and surrounding regions, noting nesting has not been observed in Queensland since 1996[136]. Indicative dispersal for leatherback turtles nesting in the Indo-Pacific is based on tag recovery data and satellite telemetry. Green arrows represent turtles nesting outside Australia and foraging within Australian waters.

Source: Queensland Department of Environment and Heritage Protection marine turtle tagging database, Benson *et al.* (2011)[14], Chatto and Baker (2008)[36], FitzSimmons and Limpus(2014)[63], Namboothri *et al.* (2012)[174].

# Northern Great Barrier Reef and North West Shelf Green Turtle Stock Dispersal

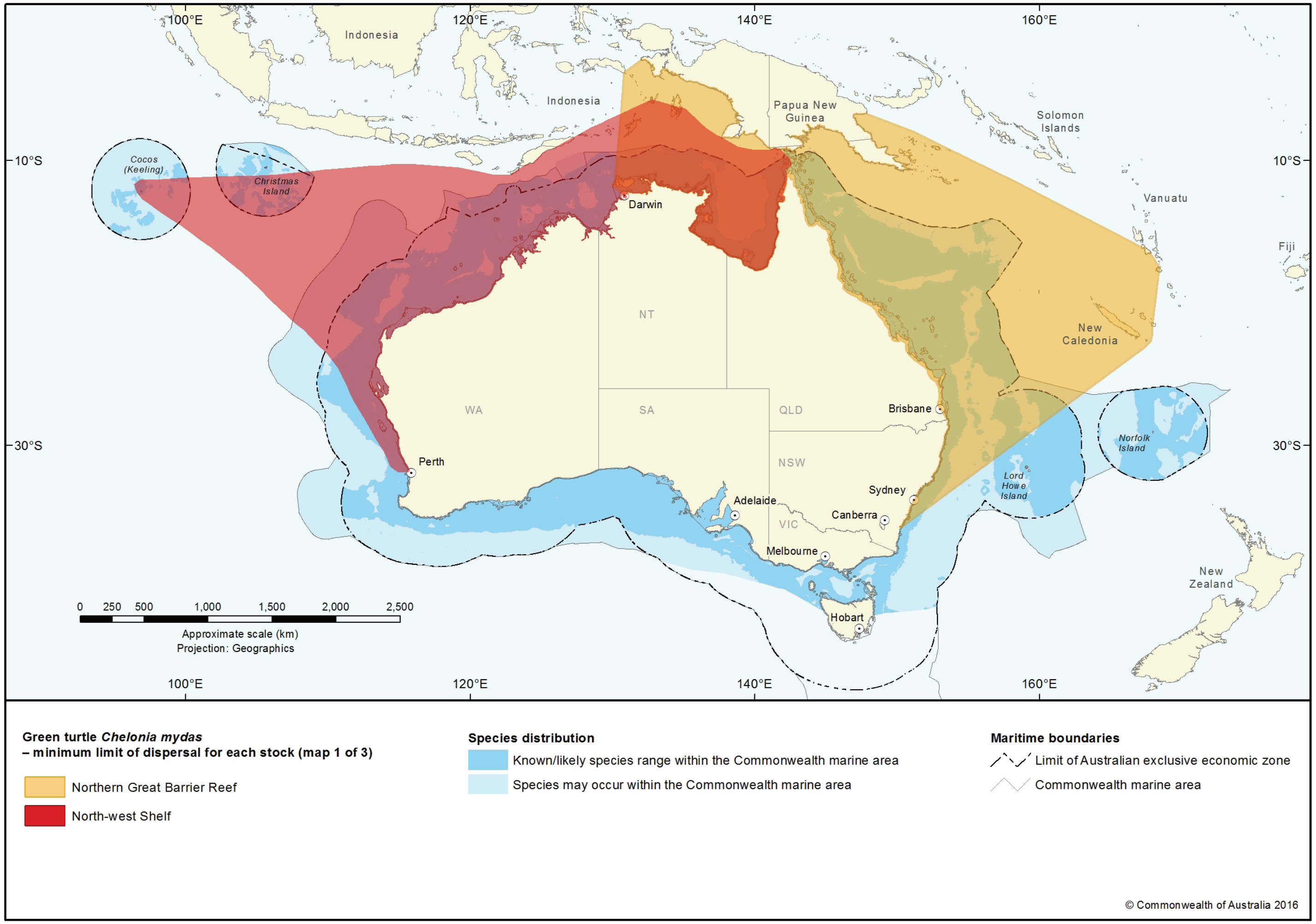


Figure 9. Indicative dispersal for northern Great Barrier Reef and North West Shelf green turtle (*Chelonia mydas*) stocks based on tag recovery, satellite telemetry and genetic mixed stock analysis.

Source: Queensland Department of Environment and Heritage Protection marine turtle tagging database, Dethmers *et al.* (2010)[50], Jensen (2010)[116], Pendoley (2005)[181], Waayers *et al.* (2015)[232], Jensen *et al.* (2016)[117]. International stocks are also known to forage in Australian waters[136].

## Ashmore Reef, Coral Sea and Gulf of Carpentaria Green Turtle Stock Dispersal

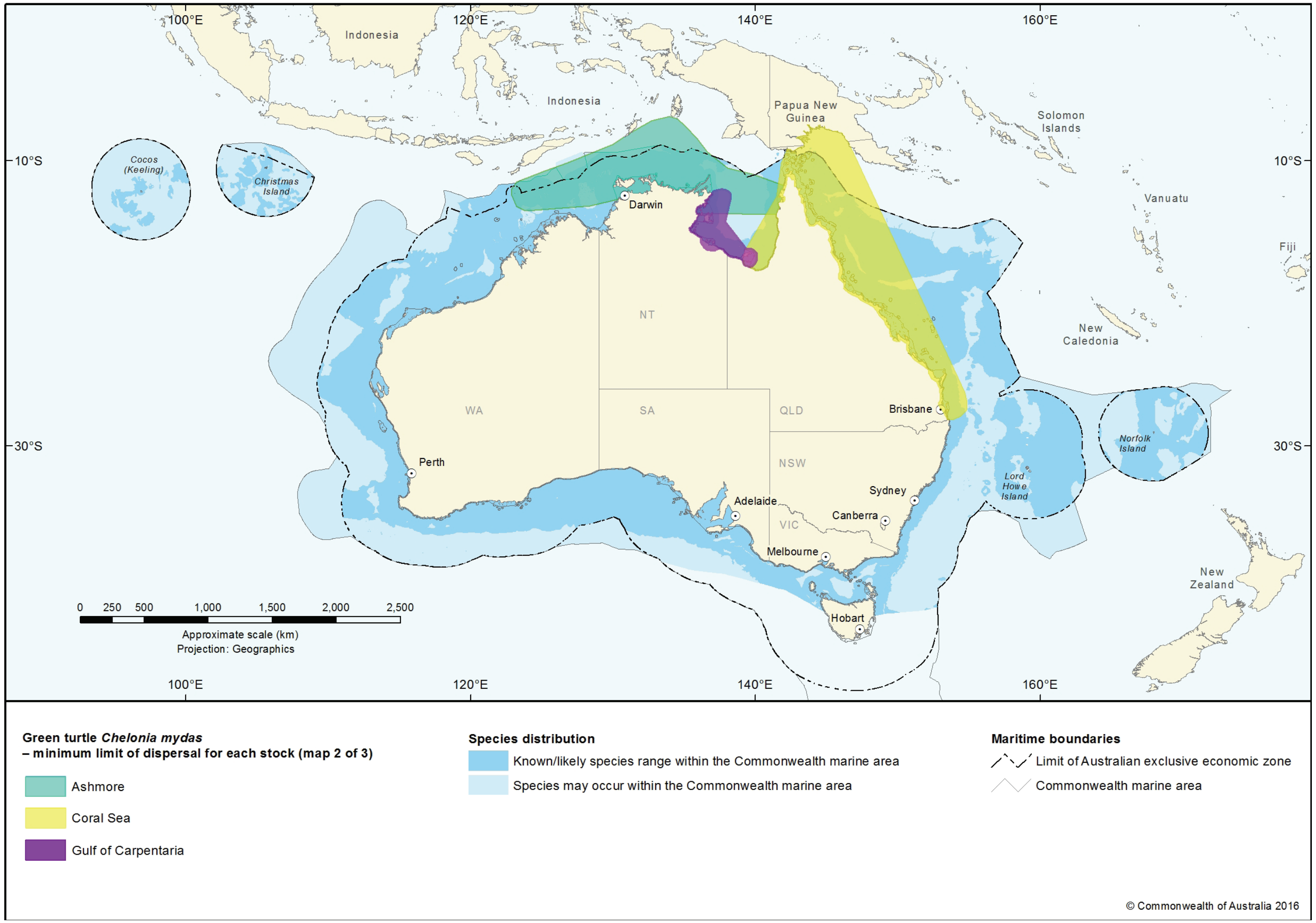


Figure 10. Indicative dispersal for Coral Sea, Gulf of Carpentaria and Ashmore Reef green turtle (*Chelonia mydas*) stocks based on tag recovery, satellite telemetry and genetic mixed stock analysis.

Source: Queensland Department of Environment and Heritage Protection marine turtle tagging database, Dethmers *et al.* (2010)[50], Jensen (2010)[116], Kennett *et al.* (2008)[126], Limpus *et al.* (2009)[137], Spring and Pike (1998)[210]. International stocks are also known to forage in Australian waters[136].

## Cocos Keeling, Cobourg, Scott-Browse and southern Great Barrier Reef Green Turtle Stock Dispersal

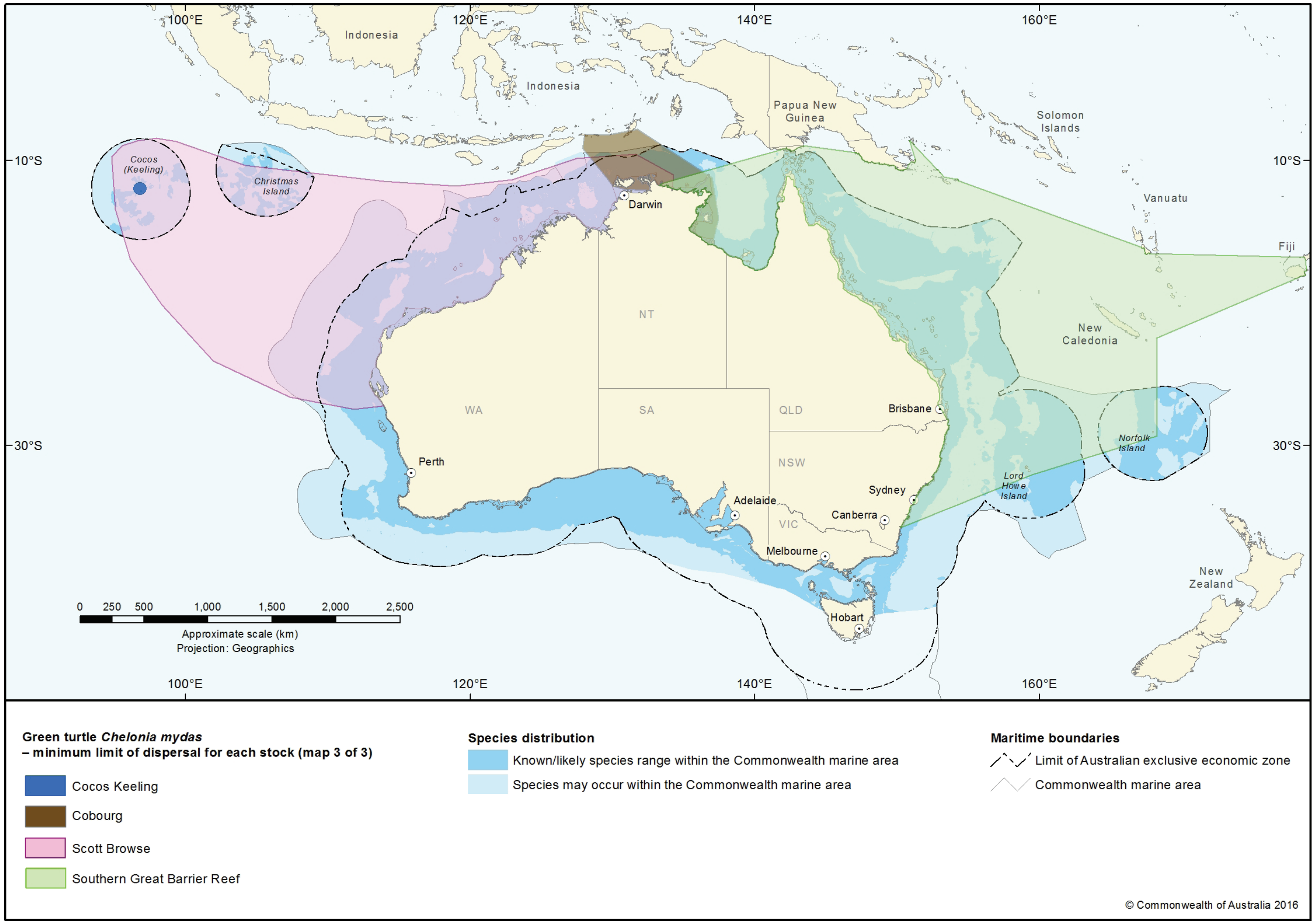


Figure 11. Indicative dispersal for southern Great Barrier Reef, Scott-Browse, Cocos Keeling and Cobourg green turtle (*Chelonia mydas*) stocks based on tag recovery, satellite telemetry and genetic mixed stock analysis.

Source: Queensland Department of Environment and Heritage Protection marine turtle tagging database, Dethmers *et al.* (2010)[50], Guinea (2011)[78], Jensen (2010)[116], Northern Territory Department of Land Resource Management and S. Whiting (unpublished data), Pendoley (2005)[181], Whiting *et al.* (2014)[249], Jensen *et al.* (2016)[117]. International stocks are also known to forage in Australian waters[136].

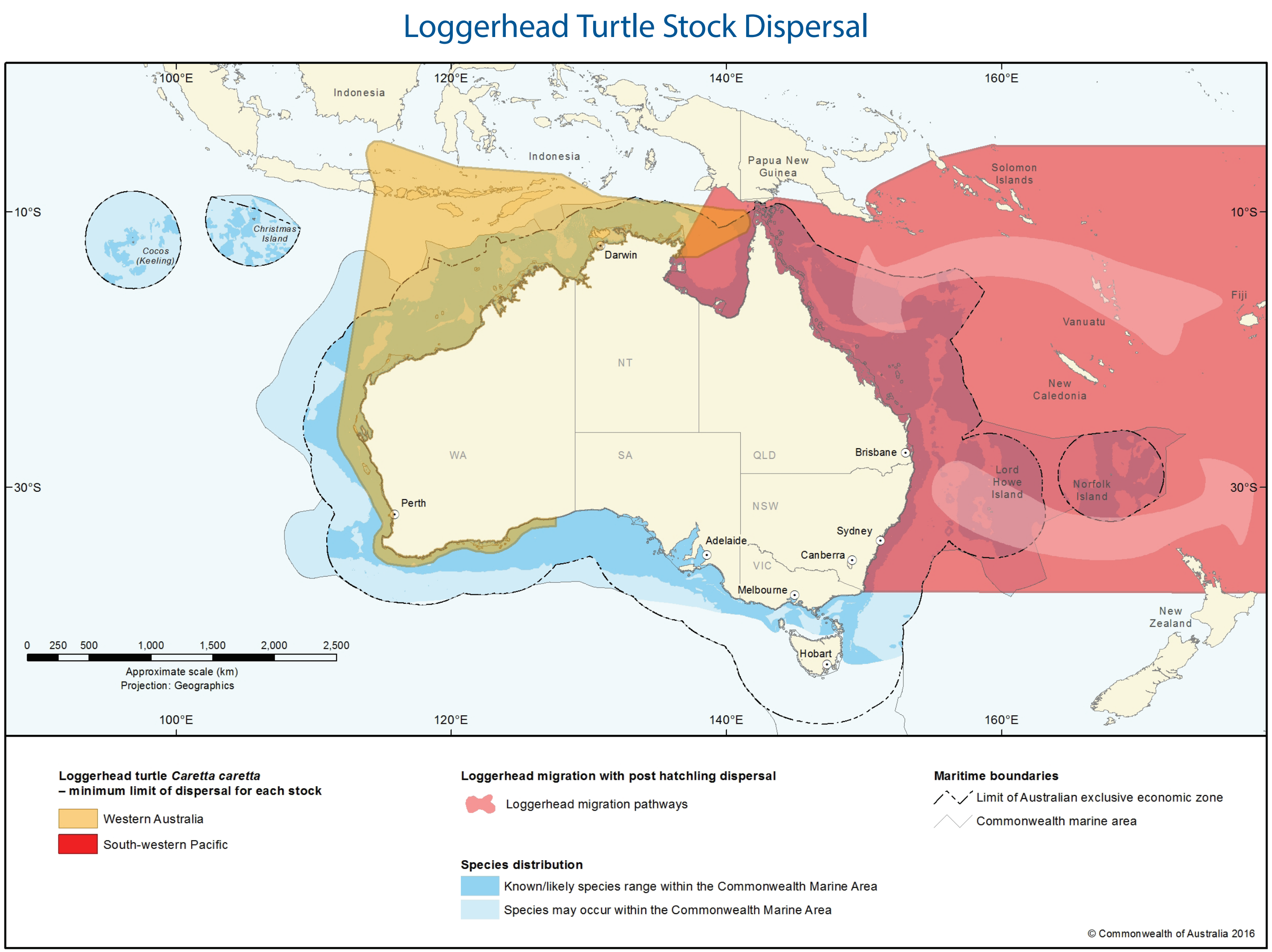


Figure 12. Indicative dispersal for the south-west Pacific and Western Australia loggerhead turtle (*Caretta caretta*) stocks based on tag recovery.

Source: Queensland Department of Environment and Heritage Protection marine turtle tagging database, Boyle *et al.* (2009)[21], Waayers *et al.* (2015)[232].

## Hawksbill Turtle Stock Dispersal

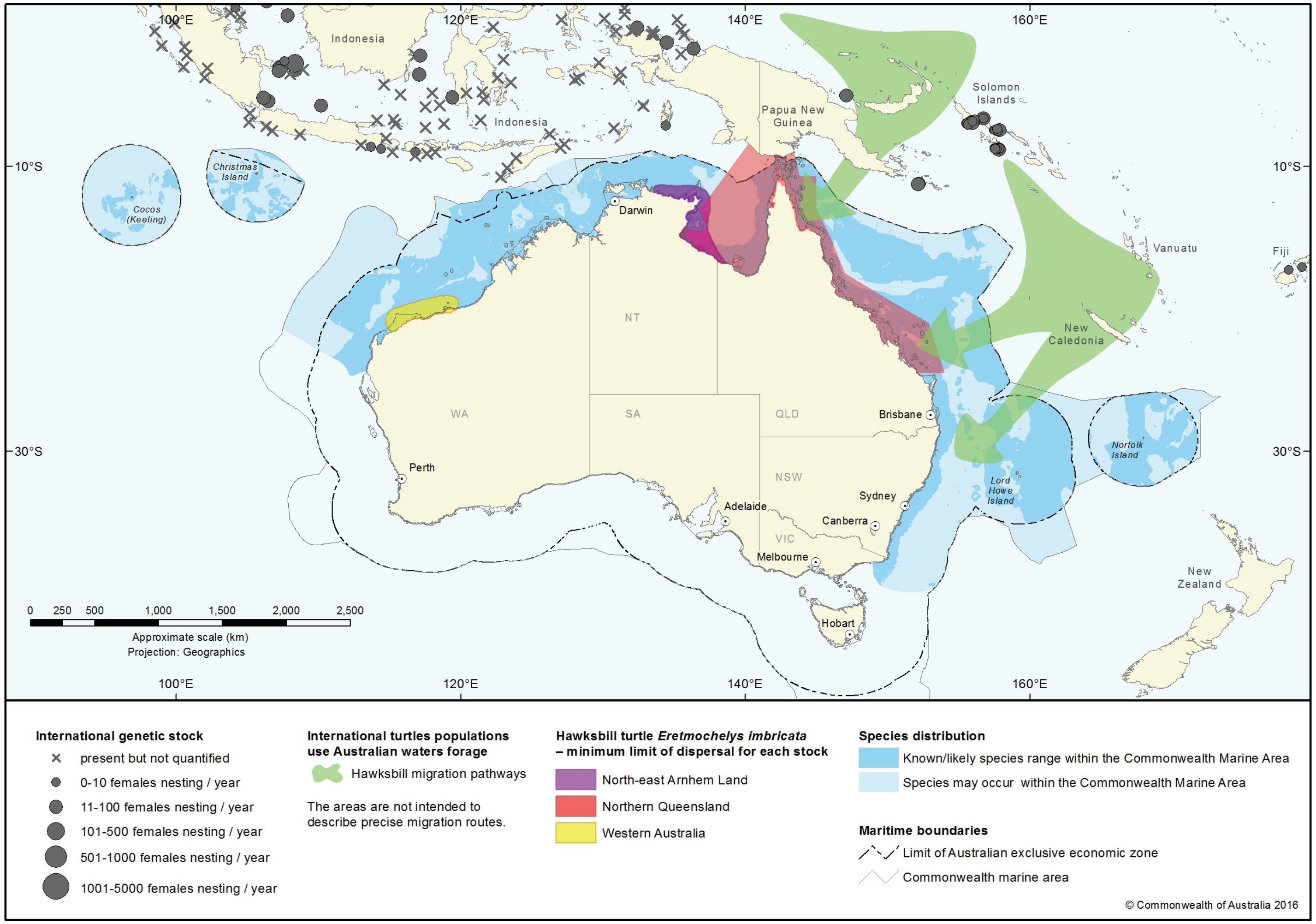


Figure 13. Indicative dispersal for the north-east Arnhem Land and north Queensland hawksbill turtle (*Eretmochelys imbricata*) stocks based on tag recovery and satellite telemetry. Green arrows represent turtles nesting outside Australia and foraging within Australian waters.

Source: Queensland Department of Environment and Heritage Protection marine turtle tagging database, Bell *et al.* (2012)[13], Dobbs *et al.* (1999)[54], Hoenner *et al.* (2015)[106], Pendoley (2005)[181], Whiting *et al.* (2006)[245].

## Flatback Turtle Stock Dispersal

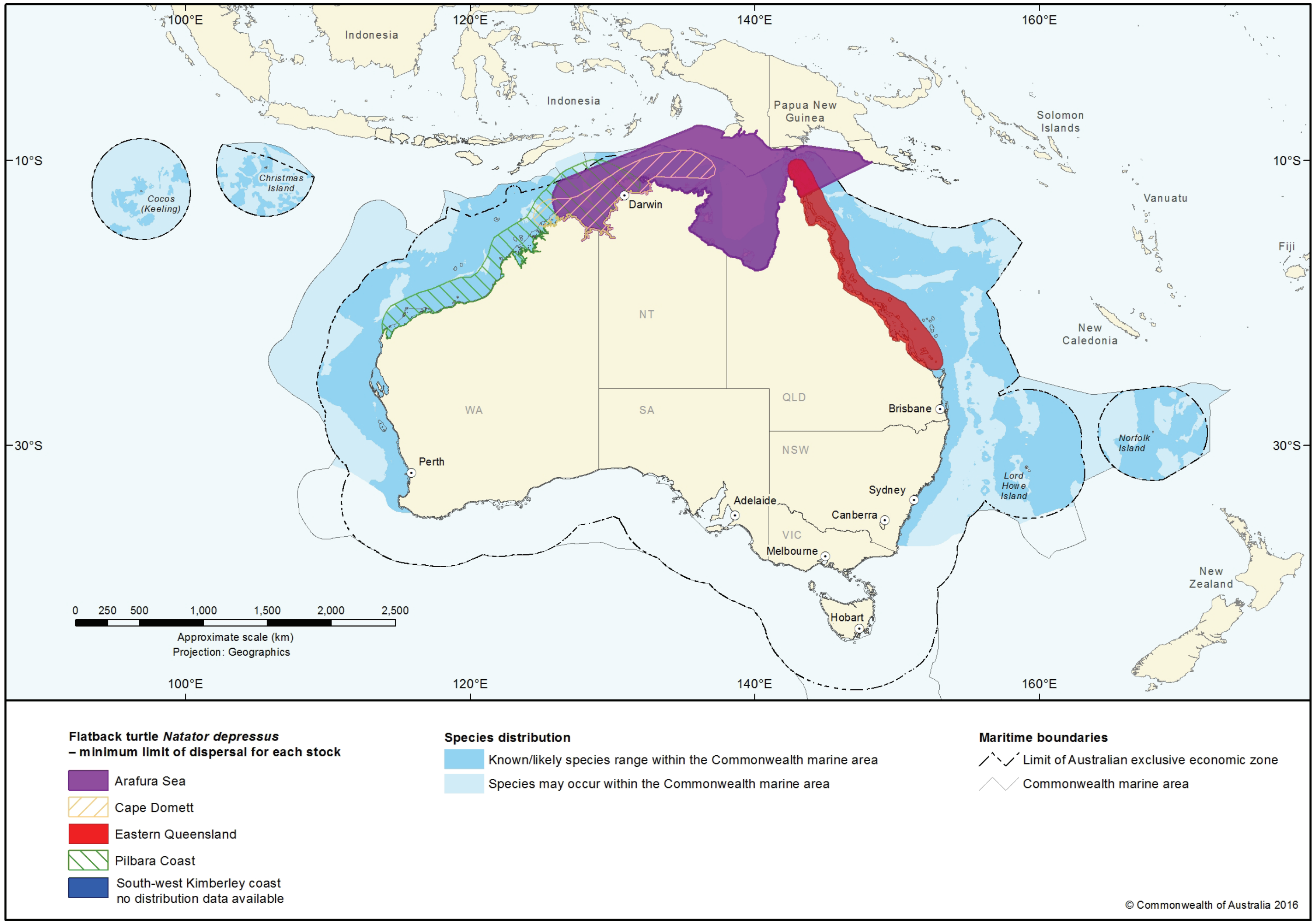


Figure 14. Indicative dispersal for the Arafura Sea, Cape Domett, eastern Queensland and Pilbara flatback turtle (*Natator depressus*) stocks based on tag recovery and satellite telemetry.

Source: Queensland Department of Environment and Heritage Protection marine turtle tagging database, Hamann *et al* (2015)[86], Pendoley (2005), Smith *et al.* (2014)[208], A.U. Whiting (unpublished data 2016), Waayers *et al.* (2015)[232], Whittock *et al.* (2016)[253].

## Olive Ridley Turtle Stock Dispersal

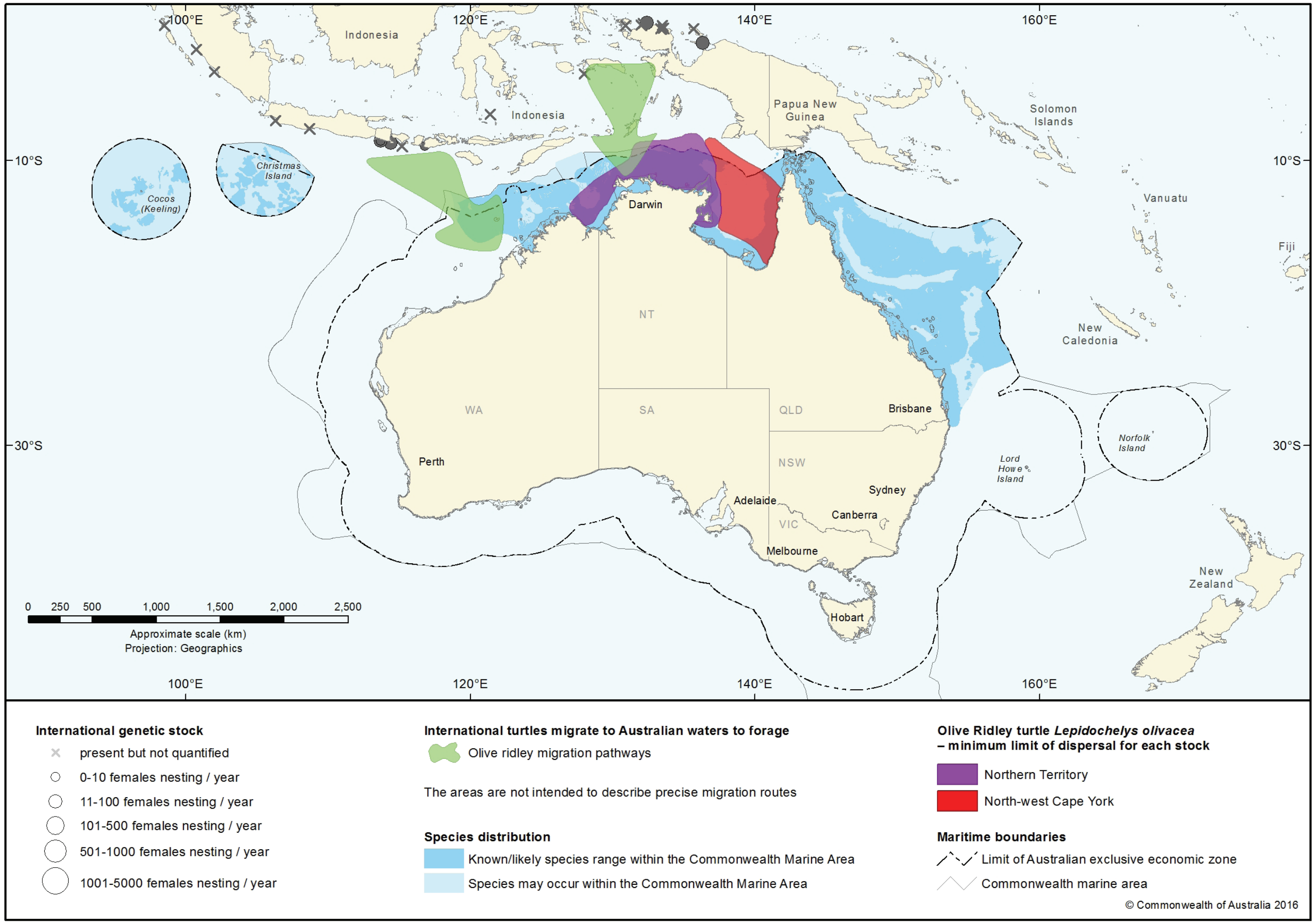


Figure 15. Indicative dispersal for the Northern Territory and north-western Cape York olive ridley turtle (*Lepidochelys olivacea*) stocks based on tag recovery, genetic mixed stock analysis and satellite telemetry. Green arrows represent turtles nesting outside Australia and foraging within Australian waters.

Source data: Queensland Department of Environment and Heritage Protection marine turtle tagging database, Dethmers *et al.* (2015)[49], Dwyer and Campbell (2016)[57], Hamel *et al.* (2008)[88], Jensen *et al.* (2013)[115], McMahon *et al.* (2007)[163], Whiting *et al.* (2007)[247].

## 3.3 Protected marine turtle habitats

Marine turtle habitats are protected through various mechanisms including through state, territory and Commonwealth legislation. For example, the Great Barrier Reef Marine Park (GBRMP) re-zoning design incorporated all very high priority nesting and internesting sites for turtle species nesting in the GBRMP, and 20 per cent of each identified foraging area[53]. Similarly, the bioregional planning process that underpinned the development of the Commonwealth Marine Reserves took into account marine turtle habitat use[56]. Further, the majority of significant marine turtle nesting in eastern Queensland south of Cape York is afforded protection within Queensland National Parks or Regional Parks[136]. Marine Parks and Reserves in the Northern Territory and Western Australia similarly include specific protection for marine turtle nesting and foraging.

Indigenous Protected Areas, Indigenous Land Use Agreements and Traditional Use of Marine Resource Agreements often have a marine turtle management component.

In addition to these protections, the EPBC Act requires all recovery plans to identify habitat critical to the survival of the species. To ensure maintenance of genetic diversity, habitat critical to the survival of marine turtles has been identified in this plan for each genetic stock.

Please note that no "Critical Habitat" as defined under Section 207A of the EPBC Act (Register of Critical Habitat) has been identified and listed for marine turtles.

### Habitat critical to the survival of a species

In accordance with the EPBC Act *Significant Impact Guidelines 1.1 – Matters of National Environmental Significance*, an action is deemed to have a significant impact if there is a real chance or possibility that it will adversely affect 'habitat critical to the survival of a species'. The guidelines define 'habitat critical to the survival of a species' as areas necessary:

- *for activities such as foraging, breeding or dispersal*
- *for the long-term maintenance of the species (including the maintenance of species essential to the survival of the species)*
- *to maintain genetic diversity and long term evolutionary development*
- *for the reintroduction of populations or recovery of the species.*

Habitat critical to the survival of a species for marine turtle stocks has been identified by consensus of a panel of experts in marine turtle biology. Nesting and internesting habitat has been identified for each stock (Table 6) based on the following criteria:

- Nesting habitat critical to the survival of green, loggerhead, flatback and hawksbill turtles includes at least 70 per cent of nesting for the stock (see Section 5.1).
- As olive ridley turtle stocks in Australia are small and likely to have been significantly impacted by egg loss for several decades (see Section 5.4), nesting habitat critical to the survival of olive ridley turtles includes all documented nesting areas in Queensland and Western Australia, and beaches where nesting has been recorded with greater than ten nesting females in the Northern Territory (noting inter-annual fluctuations).
- Nesting habitat critical to the survival of leatherback turtles includes all areas where nesting has occurred in Australia since 1996.
- Nesting habitat critical to survival of marine turtles is of a geographically relevant scale. For example green turtles are known to move between islands of the Capricorn Bunker Group[136] within a nesting season, while leatherback turtles may move up to 400 km within a season[108].
- Where relevant, nesting habitat determined to be critical to the survival of marine turtles includes areas that are: geographically dispersed; major and minor rookeries; mainland and island beaches; and winter or summer nesting.

- To ensure the validity of long-term monitoring programs for assessing trends in nesting turtle abundance, all index beaches are considered habitat critical to survival of marine turtles.
- Internesting habitat critical to the survival of marine turtles is located immediately seaward of designated nesting habitat critical to the survival of marine turtles. The internesting habitat critical buffer for green, loggerhead, hawksbill, olive ridley and leatherback turtles is 20 km[52, 56, 58, 88, 90, 106, 135, 158, 181, 194, 224, 231, 233, 235, 247, 263] and 60 km for flatback turtles[52, 56, 80, 86, 178, 233, 252].

### Index Beaches

Index beaches are those that have been identified by marine turtle managers as important for long-term monitoring and are representative of the stock. They provide the information on which to determine a species conservation status. Index beaches require a statistically relevant number of individuals nesting and consideration is given to economies of scale including the presence of multiple species, feasibility for monitoring (physical access to the location and cost), and ability to repeat observations.

In Australia there are a number of long-term monitoring programs at index beaches that provide vital information underpinning management programs. One example is Mon Repos, Queensland, where loggerhead, green and flatback turtle nesting has been continuously monitored for more than 40 years. For some stocks, establishing index beaches would be beneficial, as there is currently insufficient information to determine the viability of the stock. In addition, long-term monitoring data allows the efficacy of management programs to be tested. It should be noted that to determine the status of a species it is not necessary to monitor index beaches for all stocks.

## Biologically important areas for marine turtles in Australia

Biologically important areas (BIAs) are areas where protected species display biologically important behaviour, such as breeding, foraging, resting and migration. All of the identified 'habitat critical to the survival of a species or ecological community' areas will be included in the BIA database. BIA's were originally identified for marine turtles through a rigorous and robust process as part of the Commonwealth Bioregional Planning Process and are referenced in Commonwealth Marine Bioregional Plans. They represent areas where a specific behaviour is known to occur. The absence of an identified BIA does not mean that an area is not important habitat, just that it wasn't known. This is because BIA maps reflect the best available information at the time of publication.

Specifically, BIAs are based on the following:

a) Behaviour (feeding, nesting, internesting, migration) occurs in the area;
b) Certainty of occurrence (only areas of 'known' or 'likely' occurrence are considered);
c) The level to which species use the BIA;
d) The season(s) during which species use the BIA; and
e) Source(s) of the information upon which the BIA is based.

The BIA maps are a dynamic tool which allow for up-to-date information to be stored and referenced in a geospatial environment, building on information used to inform the recovery plan.

## Tools for assessing important marine turtle habitats

This plan identifies nesting and internesting habitat critical to the survival of marine turtles (Table 6). However, this designation only protects one component of the life cycle. It should be noted that each stock typically uses a broad range of feeding grounds, and feeding grounds can often comprise turtles from multiple stocks and species. Further, marine turtles require migratory corridors between foraging and breeding areas, habitat for mating or courtship, and hatchling dispersal. These habitats have not yet been described such that habitat critical to the survival of the stock can be identified. This knowledge gap is to be addressed during the life of the plan (Section 5.3 Action Areas A1 and B2).

In the interim, any proposed action must also consider any up to date information regarding key foraging areas, migratory corridors, courtship areas and habitat required for hatchling dispersal. There are a number of repositories for this information including the Australian Government's National Conservation Values Atlas (http://www.environment.gov.au/arcgis-framework/apps/ncva/ncva.jsf), which provides an interactive geospatial information source for marine species and the species profile and threat database (SPRAT: http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl).

### Table 6. Nesting and internesting areas identified as habitat critical to the survival of marine turtles listed for each stock

These sites represent known important habitat at the time of publication. For specific geographic locations and updated information please see the National Conservation Values Atlas (NCVA) – http://www.environment.gov.au/arcgis-framework/apps/ncva/ncva.jsf.

| Genetic stock | Nesting location | Internesting buffer | Time of year |
|---|---|---|---|
| **Green turtle** | | | |
| Southern GBR | Islands of the Capricornia- Bunker Group, Bushy Islet, Wreck Rock to Burnett Head | 20km radius | Oct-Apr |
| Coral Sea | Sand cays of the Coringa-Herald National Nature Reserve and Lihou Reef National Nature Reserve | 20 km radius | Oct-Apr |
| Northern GBR | Raine Island, Moulter Cay, Bramble Cay, Murray Island, Dauar Island, Sandbanks No. 7 and No. 8 | 20 km radius | Oct-Mar |
| Gulf of Carpentaria | Bountiful Islands, Rocky Island, Pisonia Island, Cape Shield to Cape Arnhem, Groote Eylandt Archipelago, Sir Edward Pellew Islands | 20 km radius | Jun-Jul |
| Cobourg Peninsula | Black Point to Smith Point, Croker Island and McCluer Island Group | 20 km radius | Oct - Apr |
| North West Shelf | Adele Island, Maret Island, Cassini Island, Lacepede Islands, Barrow Island, Montebello Islands (all with sandy beaches), Serrurier Island, Dampier Archipelago, Thevenard Island, Northwest Cape, Ningaloo coast | 20 km radius | Nov-Mar |
| Ashmore Reef | Ashmore Reef and Cartier Reef | 20 km radius | All year (peak: Dec-Jan) |
| Scott-Browse | Scott Reef (Sandy Islet) and Browse Island | 20 km radius | Nov-Mar |
| Cocos Keeling | Cocos (Keeling) Islands and within the Pulu Keeling National Park | 20 km radius | Oct-Apr |
| **Loggerhead turtle** | | | |
| South-west Pacific | Coastal beaches from the Elliot River to Bustard Head, Swain Reefs<br><br>Tryon, Capricornia- Bunker Group, Pumistone Passage to Double Island Point | 20 km radius | Oct-Mar |
| Western Australia | Dirk Hartog Island, Muiron Islands, Gnaraloo Bay, Ningaloo coast | 20 km radius | Nov-May |
| **Flatback turtle** | | | |
| Eastern Queensland | Peak Island, Avoid Island, Wild Duck Island, Curtis Island, Mon Repos, Broad Sound Islands National Park | 60 km radius | Oct-Mar |

| Genetic stock | Nesting location | Internesting buffer | Time of year |
|---|---|---|---|
| Arafura Sea | Field Island, Crab Island, Bare Sand Island, Tiwi Islands, Quail Island, Hawkesbury Point, Cobourg Peninsula, Wessel Islands, Gove Peninsula, Groote Eylandt Archipelago, Sir Edward Pellew Islands, Wellesley Islands, Deliverance Island, mainland beaches from Jardine River to Edward River, Crocodile Island Group | 60 km radius | All year (peak: Jun-Sep) |
| Cape Domett | Cape Domett, Lacrosse Island | 60 km radius | All year (peak: Jul-Sep) |
| South-west Kimberley | Eighty Mile Beach, Eco Beach, Lacepede Islands | 60 km radius | Oct-Mar (peak: Dec-Jan) |
| Pilbara | Montebello Islands, Mundabullangana Beach, Barrow Island, Cemetery Beach, Dampier Archipelago (including Delambre Island and Huay Island), coastal islands from Cape Preston to Locker Island | 60 km radius | Oct-Mar |
| Unknown genetic stock Kimberley, Western Australia | Maret Islands, Montilivet Islands, Cassini Island, Coronation Islands (includes Lamarck Island), Napier-Broome Bay Islands (West Governor Island, Sir Graham Moore Island – near Kalumbaru), Champagny, Darcy and Augustus Islands (Camden Sound) | 60 km radius | May-July |
| **Hawksbill turtle** | | | |
| North Queensland | Bird Island, Boydong Island, Fife Island, Milman Island, Saunders Island, Aukane Island, Bet Islet (Bara), Bouke (Bak), Dadalai Islet, Kabbikane, Mimi, Saddle Island (Ulu), Sassie Island, Zuizin Island, Adolphis Island, Albany Island, Hawkesbury Island (Warral), Lacey Island, Laoyak Island, Little Adolphis Island (Smol Muri), Woody Wallace Island, Poll Islet (Guiya), Dugong Islet (Atub), Cap Islet (Mukar), Two Brothers Island (Gebar), Mt Adolphus Island (Muri) | 20 km radius | All year (peak: Nov-May) |
| North-east Arnhem Land | English Company Islands (including Truant Island and Bromby Islands), Groote Eylandt Archipelago, Wessel Islands, New Year Island | 20 km radius | All year (peak: Jul-Nov) |
| Western Australia | Dampier Archipelago (including Rosemary Island and Delambre Island), Montebello Islands (including Ah Chong Island, South East Island and Trimouille Island), Lowendal Islands (including Varanus Island, Beacon Island and Bridled Island), Sholl Island | 20 km radius | Oct – Feb |
| **Olive ridley turtle** | | | |
| Western Cape York | Coastal beaches from Jardine River to Chapman River | 20 km radius | Mar-Oct |
| Northern Territory | Tiwi Islands, McCluer Island group, Wessel Group, English Company Island, Crocodile Island Group, Cobourg Peninsula | 20 km radius | All year (peak: Apr-Jun)<br>All year (peak: Jun-Aug) |
| Unknown genetic stock Kimberley, Western Australia | Prior Point, Vulcan Island, Darcy Island, Llangi, Cape Leveque | 20 km radius | May-July[190] |
| **Leatherback turtle** | | | |
| Australia | Cobourg Peninsula to Cape Arnhem (including Danger Point) and adjacent islands (including Wessel Islands and Elcho Island) | 20 km radius | Dec-Jan |

# 4 Threats

Threats impacting on turtles vary by species, stocks and life history stage. The following provides an overview of threats to marine turtles in Australia, noting the current management in place to address the threat.

Threats are listed in order of priority based on the number of stocks found to be at 'high' or 'very high' risk through the threat prioritisation assessment process (Section 4.4), which takes into account existing mitigation.

## 4.1 Description of threats

### 4A Climate change and variability

Climate change is of particular concern to marine turtles because it is likely to have impacts across their entire range and at all life stages. Climate change is expected to cause changes in dispersal patterns, food webs, species range, primary sex ratios, habitat availability, reproductive success and survivorship[69, 83, 96]. Impacts will differ based on the ability of a stock to adapt to changes in suitable nesting beaches and food availability.

Predicted increases in sand temperature may result in changed sex ratios or decreased hatching success[70, 95, 212, 217, 260]. Changes to water temperature may affect ocean circulation and dispersal patterns, timing of breeding, as well as result in coral bleaching and seagrass die off, which may affect turtle foraging [69].

Green and hawksbill turtles in the Arabian Gulf have shown adaptations to high ambient water temperatures[186] and a genetic mechanism has been found in loggerhead turtles that may allow embryos to develop tolerance to higher sand temperatures[216]. Increasing loggerhead and green turtle nesting is being recorded in New South Wales each year (Crocetti, pers. comm. 2016). It is possible that marine turtles may be nesting further south in response to climate change impacts. These findings indicate the possibility that given sufficient time and availability of suitable habitat, those species of marine turtle that nest in summer may be able to behaviourally adapt to changing temperatures[186] by changing the timing of nesting or moving to beaches at higher latitudes. Winter nesting turtles cannot shift to a cooler time of year and may only be able to adapt by shifting their nesting southwards[ 212]. However, sea level rise and associated risk of nests flooding may complicate hatchling success, as the magnitude of sea level rise is expected to be greater at more southerly latitudes, particularly for Western Australia[25].

Increased frequency of extreme weather events may lead to reduced or altered nesting habitat, and increased egg mortality through inundation or scouring[67]. These issues have been identified as a particularly threatening process for the northern Great Barrier Reef green turtle stock (including Raine Island)[70]. Increased frequency and intensity of heavy rain events, also means an increase in the risk of extreme flooding events[61], which can exacerbate the mobilisation of sediment and chemicals into the marine environment.

Changes to ocean circulation patterns and altered marine food webs will have substantial impacts on turtles during multiple phases of their lifecycle. For example, the El Niño Southern Oscillation Index is strongly correlated with the number of green turtles nesting in the Great Barrier Reef each year, presumably due to food resource availability in the two years prior to nesting[143]. Changes to the length and frequency of El Niño periods may therefore influence marine turtle re-migration intervals, potentially reducing a stock's ability to recover from other impacts.

Ocean acidification may have an impact on carbonate sediment production, which in turn will affect the volume and characteristics of nesting beaches, particularly in and around coral reefs[45, 68]. Changes in water pH may also affect foraging habitat and food availability for turtles that forage in coral reefs or feed on calcifying organisms[96].

While some impacts have been observed, such as changes in breeding phenology, altered distribution, and evolution of thermal thresholds[159], there still is uncertainty with regard to how marine turtles will respond to climate change impacts.

To address the broad implications of climate change, the Australian Government is investing in climate change and environmental research through avenues such as the National Environmental Science Programme to help decision-makers understand and manage likely climate change impacts across all ecosystems and species. Within Australia, many business, industries, NGOs, individuals and communities are actively undertaking measures to reduce their carbon footprint.

## 4B Marine debris

Floating non-degradable debris, such as lost or discarded fishing gear (e.g. discarded nets, crab pots, synthetic ropes, floats, hooks, fishing line and wire trace), land-sourced garbage (e.g. plastic bags and bottles) and ship-sourced materials disposed of at sea (e.g. fibreglass, insulation) can pose a threat to marine turtles at all life stages through entanglement and ingestion[9, 28]. Onshore, marine debris can be so extensive that nesting beaches are buried by waste, making it difficult for turtles to nest and creating obstacles for emerging hatchlings[249]. While large numbers of marine turtles are known to ingest plastic[204], the stock level risk from ingestion is, at this stage unknown. The emerging threat from micro-plastics is of particular concern due to exposure to compounds adhered to tiny plastic particles[218].

Marine debris causing entanglement and ingestion was recognised in 2003 as a key threatening process for marine vertebrates under the EPBC Act. This led to the development of the *Threat Abatement Plan for the impacts of marine debris on vertebrate marine life* (Marine Debris TAP).

Community action is a major factor in abating the immediate threats posed to wildlife by marine debris through clean up programs. However, the management of marine debris waste can pose problems once collected. Where clean-up activities have occurred on remote beaches or on beaches with dangerous access issues (i.e. crocodiles), the clean up groups may not be able to remove debris from the area. Also the huge volume of collected waste can be too heavy to move. In these situations, the waste is often burnt to prevent it from re-entering the marine environment, creating a non-biodegradable by-product that is also difficult to remove. This by-product can create an obstruction hazard for nesting and hatchling turtles[215]. While clean-up activities provide a short-term solution to the problem of marine debris, there is now a shift toward programs that seek to address the source of marine debris. Developments in waste management technology are also required to manage and reduce waste from both sea and land sources, as well as innovative uses for collected marine debris. The risks for marine turtles with regard to entanglement in marine debris seem to be based on the frequency of encountering debris rather than their specific foraging behaviour[255].

### Entanglement

Entanglement in marine debris can lead to restricted mobility, starvation, infection, amputation, and drowning. Derelict fishing gear can have an extremely detrimental impact on marine fauna, as it continues to indiscriminately 'fish' passively while in the water column (days to decades)[29].

The prevailing currents and conditions in the Arafura and Timor Seas and the Torres Strait mean that the Gulf of Carpentaria is recognised as a marine debris 'hot spot'[255]. While some nets may be from Australian fisheries, most (greater than 90 per cent) are thought to be of foreign origin[127, 237]. Lost and discarded nets are a specific threat to marine turtles in northern Australia with greater than 80 per cent of animals recorded in nets being turtles[255]. It was estimated that between 4866 and 14,600 turtles were captured in 8690 ghost nets sampled across northern Australia from 2005 to 2012[256]. Ghost nets impact all species, but Wilcox *et al.* (2014) found that olive ridley turtles contributed the highest proportion of turtles captured (42.5 per cent)[256]. Olive ridley stocks in Australia are small, and so mortality in ghost nets is of particular concern. Hawksbill turtles were the second most commonly encountered species (32.6 per cent)[256]. There is concern that juvenile hawksbill turtles foraging in coral reefs are captured in nets snagged on coral reefs[237]. Given the difficulties associated with removing nets from the marine environment, the primary approach to this threat has been determined to be source reduction.

### Ingestion

Marine turtles can ingest non-organic material unintentionally. Ingestion of marine debris can cause internal wounds or suffocation. It can prevent feeding, leading to starvation and can create intestinal blockages that increase buoyancy and stop a turtle from diving[234]. In addition, toxins from ingested plastics may accumulate in marine turtle tissue with possible health implications[218]. Ingestion of marine debris is particularly likely for turtles foraging in coastal waters[204].

## 4C Chemical and terrestrial discharge

Sediment and a wide variety of pollutants can enter marine turtle habitat through processes including dumping, run-off from urban, agricultural or industrial sources, effluents, atmospheric deposition and leakage. In this plan, solid waste is considered in 4B Marine debris.

### Acute chemical and terrestrial discharge

In this plan, acute chemical and terrestrial discharge refers to any release of pollutants and/or sediment into marine turtle habitat, including spills from land sources, vessels, drilling operations, and natural sources.

There is well documented evidence of the detrimental effects from encountering oil either via external contact, ingestion or inhalation, resulting in breathing, sight or gastro-intestinal injuries[154]. Oil present on or near a beach can persist in sticky or toxic forms in the environment (sand and sediments) for many years. Marine turtle nesting behaviour can uncover this resulting in sticky oil adhering to adults, eggs or hatchlings causing both physical (smothering) and physiological (toxic) effects. Oil is highly toxic to turtle eggs, and the toxic components can penetrate the skin and carapace of hatched and older marine turtles affecting respiration, salt gland function and blood chemistry[206].

The oil and gas industry is regulated under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* by the National Offshore Petroleum Safety and Environmental Management Authority in Commonwealth waters beyond three nautical miles off shore and coastal areas where a state or territory has conferred regulatory powers and functions. In addition, the *National Plan for Maritime Environmental Emergencies (2015)* sets out national arrangements, policies and principles for managing maritime environmental emergencies and is managed by the Australian Maritime Safety Authority.

Acute terrestrial discharge includes large sediment pulses due to extreme flooding events. These events can cause considerable loss of seagrass habitat due to light limitation[188] that in turn can result in decreased turtle health, starvation, increased stranding and decreased breeding condition[16]. These pulse events may also deliver sudden high contaminant loads to the system[141]. While the event itself may be of short duration, the loss of the seagrass meadows may continue to impact on turtle health for several years[191].

### Chronic chemical and terrestrial discharge

Anthropogenic contaminants can make their way into the marine environment from a wide range of agricultural, industrial and domestic sources, and can have direct impacts on marine turtles and their habitats. While not always fatal, long-term exposure can compromise health and increase vulnerability to other stressors[60]. Some diseases and pathogens are exacerbated by poor water quality[2].

Runoff of nutrients and sediment from land-based agriculture, urban development and coastal aquaculture can impact water quality, causing changes in light and salinity over coral reefs and seagrass meadows, disease outbreaks, and exposure to biotoxins associated with algal blooms[4, 42]. One of the major contributors to ongoing poor water quality in the Great Barrier Reef has been the sediment and chemical runoff from agricultural land, and while there have been many improvements to the management of agricultural land, the sediment loads entering the system are still double to those occurring before European settlement[73].

Heavy metals and persistent organic pollutants (POPs) have been identified in marine turtles in Australian waters[71, 99, 100, 111, 112]. POPs have been shown to maternally transfer to offspring and have been linked with reduced hatchling condition[226] and decreased immune response in loggerhead turtles[123, 124]. However, the long-term effects of turtle exposure to chemical pollutants are not well understood. Preliminary results from the Rivers to Reef to Turtles Project on the Queensland coast suggest that water quality may have sub-lethal impacts on marine turtle health. This project is ongoing and expected to inform management into the future[261].

Legislation is in place to manage the risks of chemical and terrestrial discharge to the marine environment. There are also mechanisms in place, such as the *Framework for Marine and Estuarine Water Quality Protection (DEWHA 2002)* that has been developed within the National Water Quality Management Strategy to protect the nation's marine environment from the adverse effects of land-based activities.

## 4D International take

Given their highly migratory nature, marine turtles that are part of an Australian stock may be subject to take when they migrate outside Australian waters. There are also anecdotal reports of foreign nationals coming into Australian waters to illegally take turtles[79, 136]. Take of turtles can assume various forms, from collecting animals and eggs on nesting beaches, to taking animals at sea and includes illegal, unreported and unregulated (IUU) fishing[113].

As the actions required to address international take differ based on the jurisdiction in which the take occurs, this plan considers the threat of international take as either take within or take outside Australia's jurisdiction.

Australia combats IUU fishing through aerial surveillance, sea patrols and real-time monitoring of international fishing vessels. Within the South-East Asia and the Pacific region, Australia works with fishing countries and regional fisheries management organisations to improve fisheries management capacity, strengthen surveillance and enforcement programs, share information and data and raise awareness of the impacts of IUU fishing through education and outreach programs. To address the threat from international trade, the Australian Government's a signatory to the *Convention on the International Trade in Endangered Species of Wild Fauna and Flora*.

### International take outside Australia's jurisdiction

For the purposes of this recovery plan, international take outside Australia's jurisdiction involves marine turtle stocks that nest within Australia, but are taken outside Australian waters or turtles that forage within Australian waters, but are impacted by take when they migrate outside Australia's jurisdiction to breed. This take may be legal or illegal depending on the jurisdiction and manner in which the turtle is taken. While information is limited and unevenly available, trade hotspots have been identified within the Indian Ocean and south-east Asia region. Similarly, while all species of marine turtle are at risk from the impacts of illegal take and trade, the take of hawksbill turtles for the tortoiseshell trade is of particular concern[113, 171].

### International take within Australia's jurisdiction

Take of marine turtles by foreign nationals within Australia's economic exclusion zone is illegal except for Traditional Inhabitants of the Papua New Guinea villages detailed in the *Torres Strait Treaty*. Fishing activities in the joint portion of the Torres Strait Protected Zone must be conducted in accordance with the *Torres Strait Fisheries Act 1984*.

There are reports of foreign vessels entering Australian waters to harvest hawksbill turtles for the tortoise shell trade and green turtles are targeted for meat and eggs[136].

## 4E Terrestrial predation

Marine turtles, their eggs, hatchlings and habitat can be impacted by introduced and native terrestrial predators, such as pigs, foxes, cats, dogs, dingoes, crocodiles, monitors and goannas, silver gulls or nankeen night herons, bandicoots, water rats, ghost crabs, tropical fire ants (also known as ginger ants or tramp ants) and hermit crabs[79, 102, 248, 250, 254]. Predation impacts occur either directly through disturbance of the nest and consumption of eggs, or consumption of hatchlings as they emerge. Nests are normally predated by a variety of species, although in some areas individual pigs have been recorded successfully destroying almost every nest on one beach[254].

Pigs not only consume eggs and hatchlings, but in digging up nests can destroy the beach for future nesting by changing the floristic and soil structure[131]. Larger predators such as crocodiles prey on adult turtles either killing or injuring the turtle, thus reducing their reproductive success[250], and also eat the hatchlings. Predation is particularly a concern in remote areas where regular patrols, control measures and monitoring are infrequent or not possible.

Management of terrestrial predators is undertaken by a wide range of groups including: land-holders, community groups, local councils, state/territory/ Commonwealth agencies, Indigenous communities and ranger groups, and Threat Abatement Plans (TAPs) that identify the impact of predators on marine turtle nests. These TAPs are for: *Reduction in impacts of Tramp Ants on Biodiversity in Australia and its Territories (2006)*; *Predation by the European Red Fox (2008)*; and *Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs (2005)*. Management of terrestrial predators is a major component of the work programs of many Indigenous ranger groups and land and sea community based management plans.

Eradication is the permanent removal of every last terrestrial predator. With currently available technology, it is not possible to achieve eradication except on islands and in some highly managed local areas. Similarly, eradication is not appropriate for native species. Consequently, management is aimed at sustainable control of the damage caused by predators. Predator control needs to be ongoing and take into account the biology and behaviour of the predator species, the potential for greatest impact, and targeting known hotspots during the most relevant time period for a given predator.

## 4F Fisheries bycatch

Fisheries bycatch (or incidental catch) includes all non-target interactions between fishing gear and marine turtles. Incidental catch can affect juvenile, sub-adult and adult turtles in foraging areas, along migration routes or in internesting habitat. Interactions can be with commercial or recreational fisheries, and includes shark control programs. Management of the threat differs based on whether the fisheries interaction occurs within or outside Australian waters. Other threats associated with fishing activities such as the impact of discarded or lost gear is discussed in Section 4B Marine debris and impacts to the benthic environment are discussed in Section 4H Habitat modification.

## Domestic fisheries bycatch

The *Recovery Plan for Marine Turtles in Australia – July 2003* identified bycatch as one of the greatest threats to marine turtles in Australia. Since then significant steps have been taken to reduce fishery-turtle interactions in Australian waters. The introduction of turtle excluder devices (TEDs) in trawl fisheries has dramatically reduced turtle mortalities when used correctly, with fewer captures and the majority being released alive[23]. It should be noted that TED's are not mandatory in all state/territory fisheries. In addition, the use of de-hookers and line cutters in long-line fisheries has also improved marine turtle survival as they facilitate the live release of turtles captured on gear[177]. Despite the advances in technologies, the post release survivorship following a fisheries interaction is still not well understood. Other bycatch mitigation initiatives include spatial closures for certain gear types in high risk areas or temporal closure during nesting seasons. Many state run shark control programs had also replaced nets with drum-lines and many fisheries utilise animal release teams.

There are also still 'hot spots' for fishery-turtle interactions, such as the Gulf of Carpentaria where the highest rates of turtle/fishery interactions have been reported. Over a quarter of the turtles captured in Commonwealth trawl fisheries (2000-2013) were not identified to species[196]. There is concern that the olive ridley turtle, which has seen large population reductions in western Cape York, may comprise a large portion of these unidentified turtles. Additionally, 23 per cent of all turtle interactions in Commonwealth fishery logbooks were leatherback turtles[196], with some bycatch being reported in state fisheries[196]. It is important to note that this study only had bycatch data from Commonwealth, Queensland and the Northern Territory fisheries and was lacking fisheries bycatch data from the other five states. Further, discrepancies between fishery logbook reports and observer data/stranding reports suggests that the actual number of marine turtle interactions with fisheries was potentially underestimated[16, 101, 196]. Again, not all fisheries have mandatory monitoring and/or reporting requirements. Technologies such as electronic monitoring in fisheries may enable a better estimation of actual turtle interaction rates.

Novel approaches are also required to minimise interactions with gear types such as pots[164], which continue to be problematic for marine turtles. Of particular concern are the interactions of loggerhead turtles with crab pots in Queensland and leatherback turtles in the South Australian, Victorian and Tasmanian lobster pot fisheries[16, 136]. Leatherback deaths from entanglement in cray pot fisheries may be the 'most significant cause of death from human-related activities' in Australian continental shelf waters[136]. This is concerning considering the decline in the number of nesting female leatherback turtles in Australia.

Fisheries interactions are generally considered on a fishery by fishery basis. There is currently a paucity of information pertaining to the cumulative impact of all fisheries on any given stock[197]. To address this gap consideration must be given to the impacts from all recreational, state/territory, Commonwealth and international fisheries across the entire range of any given stock.

Commonwealth fisheries are managed by the Australian Fisheries Management Authority. State/territory fisheries are managed by the relevant state/territory jurisdiction. The impact of fisheries bycatch on matters of national environmental significance such as threatened and migratory marine turtles is considered in accordance with the EPBC Act and relevant state/territory legislation. While fishing impacts have been greatly reduced on turtles since the *Recovery Plan for Marine Turtles in Australia – July 2003* was made, bycatch impacts are still being reported for all marine turtle species. Improving access and reporting of the most current bycatch information will enhance the assessment of whether current fisheries interactions are of a sufficient scale to impact on stock recovery.

## International fisheries bycatch

Some marine turtles foraging in Australian waters migrate into international waters to breed. Similarly, turtles from Australian stocks may forage outside Australia's jurisdiction. These turtles are at risk from fisheries interactions on the high seas and in neighbouring countries.

Tag recoveries show that loggerhead, green, hawksbill and olive ridley turtles tagged in Australia have been taken by fisheries operating outside Australia's jurisdiction[136]. Genetic evidence indicates that juvenile loggerhead turtles that hatched in southeast Queensland have been captured as bycatch in Peruvian longline fisheries[21].

In 2000, pelagic longline fleets from 40 nations were estimated to set 1.4 billion hooks, resulting in the bycatch of approximately 200,000 loggerhead turtles and approximately 60,000 leatherback turtles globally[132].

Australia engages in international fora to promote and encourage best practice fisheries management. As such, Australia is an active member of three Regional Fisheries Management Organisations (RFMO) that manage impact on marine turtles: the Indian Ocean Tuna Commission; Western and Central Pacific Fisheries Commission; and the Commission for the Conservation of Southern Bluefin Tuna. Measures adopted in RFMOs also acknowledge and draw upon the Food and Agriculture Organization-endorsed *Guidelines to Reduce Sea Turtle Mortality in Fishing Operations*. Australia has been encouraging Western and Central Pacific Fishing Commission fleets to adopt electronic monitoring for their longline fisheries. Australia also works through fora such as the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS) to address threats throughout the species' range. The CMS *Single Species Action Plan for the Loggerhead Turtle* (Caretta caretta) *in the Pacific Ocean* was agreed at the CMS Conference of the Parties in November 2014. This plan identifies fisheries bycatch as a very high threat to loggerhead turtles in the south Pacific and identifies actions required to mitigate the threat of bycatch.

## 4G Light pollution

Artificial light poses a threat to marine turtles because it disrupts critical behaviours. Marine turtles use light as an orientation cue. Artificial light can inhibit nesting by females[200] and can disrupt hatchling orientation and sea finding behaviour[184, 258]. When hatchlings are attracted to light inland they may be exposed to increased mortality from avian and terrestrial predators, trapped in vegetation or killed on roads. If hatchlings do reach the ocean they may have used valuable energy reserves required to reach pelagic feeding areas. Lighting of jetties, vessels or platforms can create pools of light that attract swimming hatchlings and increase their risk of predation[221]. Artificial light can therefore cause a gradual decline in the reproductive output of a nesting area, with changes not evident for decades because of the long life cycles involved.

Marine turtles nesting on beaches in Western Australia and south-east Queensland have been identified as being at highest risk from the effects of light pollution from urban and industrial development[121]. As hatchlings orient towards the lowest light horizon rather than being directly attracted to bright lights, lights of any wavelength can affect behaviour[139, 140, 198] and light glow can disrupt marine turtles when it out-competes natural light sources[103, 120, 221].

Light pollution is managed at the local council level, except in instances where state/territory or Commonwealth environmental approvals require the management of light by a proponent. There are a range of guidelines available to provide advice to proponents, consultants or the general public, but as a general rule turtles require naturally illuminated beaches for successful nesting and sea finding behaviour[140, 198].

## 4H Habitat modification

Habitat modification in this plan refers to physical modification of habitat, and has the potential to spatially displace individuals or modify behaviour. Habitat modification includes the construction of ports and marinas, oil and gas infrastructure, marine aquaculture facilities and coastal urbanisation. In Australia, such developments may be subject to assessment under the EPBC Act and relevant state and territory legislation where the facilities occur in state waters or on land.

Loss or modification of habitat can result in short term impacts such as physical displacement. Where habitat is lost permanently there is likely to be an impact on the viability of the stock utilising that habitat.

### Infrastructure/coastal development

Coastal development around nesting beaches has the potential to reduce the reproductive success of a stock through direct mortality where nests are destroyed; by reducing availability of suitable nesting habitat and thereby reducing the fitness of female turtles that must find other nesting areas; or by impacting the quality of the nesting habitat. For instance, where dune vegetation is removed, the loss of shading can increase sand temperatures and result in increased female-biased sex ratios or greater mortality[119]. Similarly, reclamation of swamps situated behind dunes can directly affect the moisture content of the sand in which eggs are incubated and subsequently the success of incubation[1].

Coastal infrastructure such as ports and marinas, aquaculture facilities, marine energy production, reclamation of swamp land, the presence of jetties or armouring of beaches can reduce the availability of important marine turtle habitat.

Important foraging grounds are often made up of turtles from multiple stocks and therefore developments that affect foraging habitat are likely to impact multiple stocks. Marine turtles show high fidelity to nesting and foraging areas, and displacement from a foraging area is likely to cause reduced fitness and subsequently reduced reproductive output[207].

In this context, threats from infrastructure and coastal development focus on the modification of the physical environment. Threats from pollution, oil spills, light, noise and increased vessel traffic associated with coastal development are discussed at Sections 4C Chemical and terrestrial discharge, 4G Light pollution and 4J Vessel disturbance and 4K Noise interference respectively.

### Dredging and trawling

Both dredging and trawling activities can degrade or irreversibly damage sea floor habitats and the associated benthic flora and fauna. Where recovery is possible, it may take decades, and the extent of trawl damage to the sea floor is dependent on the frequency and coverage of trawl activity[73].

Dredging and trawling can cause physical damage through direct removal of seagrass, coral, rocky reef or muddy substrate or indirectly through changing water quality, particularly by increasing turbidity and sediment deposition killing seagrass and coral habitats[223]. This is particularly problematic for marine turtles in important foraging and internesting areas. As noted earlier, foraging areas generally provide habitat for multiple stocks and thus the loss of foraging habitat will affect multiple stocks. Loss of habitat and/or food could result in slowed turtle growth or females being unable to obtain sufficient body condition to make breeding migrations[24]. Impacts in internesting habitat will affect the local stock, potentially reducing the reproductive output for that stock. As such, dredging and trawling activities in important internesting habitat should be undertaken outside peak nesting seasons.

Dredges can also be a direct source of turtle mortality where animals become caught in the dredge (entrainment). In Australia, the use of soft start guidelines means that direct mortality through dredge operations is only likely to affect individual turtles rather than cause a stock level impact. Recent technological advances to reduce the impacts of dredge operations on marine turtles include turtle deflecting devices, which have been incorporated on some larger dredging operations to reduce the incidence of turtle injury. Dredging in the marine environment is generally also subject to restrictions or permits.

The impact of incidental capture of turtles in trawl nets is considered in Section 4F Fisheries bycatch.

## 4I Indigenous take

Marine turtles are an integral part of many Aboriginal and Torres Strait Islanders' cultural traditions and practice. Traditional take of marine turtles for meat and eggs, and other products has been undertaken for thousands of years and has proceeded on a sustainable basis in the absence of other anthropogenic threats. Today, the take of marine turtles for their meat and eggs continues to be undertaken throughout the marine turtles' range in Australia[136] in accordance with the relevant legislation.

The level of take varies geographically and between species. The take of meat is generally limited to female green turtles while eggs of all species are utilised. Traditional legal and sustainable indigenous harvest of marine turtles occurs in the context of multiple contemporary threats, which have brought new pressures to bear on turtle stocks. At the same time, in some locations, there has been an erosion of traditional Indigenous cultural authority, which had governed the harvest of turtle meat and eggs and ensured the sustainable use of marine resources more generally. Indigenous take arises as a threat requiring management action because three of the 22 stocks are considered at risk from the practices associated with egg harvest (Table 8).

Issues around unsustainable take can be more easily addressed than the more pervasive and systemic threats identified in this plan. For example, community-led management planning and education, such as Indigenous ranger programs, turtle monitoring camps, partnerships between research bodies, community/government agreements, state/territory scientists and environmental organisations, can all contribute towards improved stock management by Indigenous custodians. Providing support to Indigenous peoples for governance and management planning that helps to reinstate cultural authority and reassert rules governing sustainable customary harvest rules is a role that government and others can play to support Indigenous peoples to sustainably manage turtle stocks.

There is a strong desire among Indigenous communities for increased responsibility in managing marine resources[173] to ensure that social, spiritual and cultural customs associated with marine species can be maintained. Many Indigenous plans of management not only identify and set (self-imposed) limits on the community regarding the take of turtles and their eggs, but also set frameworks to enable communities to govern and enforce compliance with the plan. As an example, several Indigenous groups have now imposed moratoriums on hunting where they have perceived the stock to be under severe pressure from other disturbances such as extreme weather events. Management is often undertaken through Indigenous ranger programs, or may be achieved through community based education and consensus decision making such as sea country plans.

As foraging grounds generally include individuals from multiple stocks, it is often difficult to attribute stock level impacts of take on foraging turtles. However, there are a couple of studies that have linked trends at foraging grounds to stocks[117, 156]. Conversely, the take of eggs from a nesting beach is more easily attributed to a given stock.

## 4J Vessel disturbance

Increased commercial and recreational boat traffic results in increased turtle/vessel interactions and disruption to important benthic feeding and internesting behaviours. Impact from vessels can cause serious injury and/or death to individual marine turtles[51]. This is particularly an issue in shallow coastal foraging habitats and internesting areas where there are high numbers of recreational and commercial craft[97, 98], and in areas of marine development[15, 39]. Queensland StrandNet reported that 897 marine turtles died from wounds relating to boat strike between 2000-2011. This represents 12 per cent of all investigated mortalities over this period. Excluding unknown causes of mortality (69 per cent), boat strike was the most commonly determined cause of marine turtle mortality (disease was second with 6 per cent of mortalities) in Queensland waters over this period[164].

Boat strike is a highly visible threat because it more commonly occurs in highly populated areas. 'Go slow' zones have been implemented in a number of marine turtle foraging habitats within high marine vessel traffic areas (e.g. *Marine Park (Moreton Bay) Zoning Plan 2008*). Education and awareness campaigns have also been established to encourage recreational and commercial fishers to 'go slow for those below' in seagrass habitats. Although the outcome can be fatal for individual turtles, boat strike (as a standalone threat) has not been shown to cause stock level declines. In considering the cumulative impacts of threats on small or vulnerable stocks, it is likely to be a contributor to a stock level decline.

The Australian Government is developing a *National Strategy for Mitigating Vessel Strike of Marine Mega-fauna* to provide guidance on reducing the risk of vessel collisions and the impacts they may have on marine fauna.

## 4K Noise interference

The marine environment is becoming increasingly noisy. However, it is not known how noise affects marine turtles[175]. Vibrations and noise from underwater blasting, seismic surveys, pile driving, dredging, vessel movement, live firing exercises and underwater demolitions can create substantial noise pollution in marine turtle habitats - see review by Keevin (1997)[122]. Marine turtles do not have external ears, but potentially use sound for navigation, locating prey and avoiding predators. Dow Piniak (2012), found that green, leatherback and hawksbill turtles can detect stimuli underwater and in air up to 1600 Hz, but their greatest sensitivity appears to be between 50-400Hz depending on the species[55]. Studies have also found that the best sensitivity for loggerhead turtles is also between 100-400Hz[157]. Even with this information, very little is known of the impact of noise on marine turtles. The impact of noise on turtle stocks may vary depending on whether exposure is short (acute) or long term (chronic).

### Acute noise

Acute noise, or temporary exposure to loud noise, may result in avoidance of important habitats and in some situations physical damage to turtles. Acute noise is generated by activities such as pile driving, seismic activity, some forms of dredging, explosions, blasting and sonar. There is little information pertaining to the impacts of acute noise on marine turtles. McCauley *et al.* (2000) reported that exposure to air gun shots that replicate seismic surveys caused green and loggerhead turtles behaviour to become more erratic at 175 dB re1 μPa rms, but that turtles may show behavioural responses to an approaching seismic noise at received sound levels of approximately 166 dB re1 μPa rms[160].

Given that the impacts of noise are unknown, a precautionary approach should be applied to seismic work, such that surveys planned to occur inside important internesting habitat should be scheduled outside the nesting season.

In accordance with the *EPBC Act Policy Statement 2.1 – Interactions between Offshore Seismic Exploration and Whales: Industry Guidelines*, all seismic survey vessels operating in Australian waters must undertake a soft start during surveys irrespective of location and time of year of the survey. Although these guidelines are specifically designed for interactions with cetaceans, the soft start provision may also afford protection for marine turtles. The Great Barrier Reef Marine Park Authority has also committed to developing a guideline for the assessment and management of underwater noise impacts on species in the Great Barrier Reef[6, 41].

### *Chronic noise*

Exposure to chronic (continuous) loud noise in the marine environment may lead to avoidance of important habitat. Sources of chronic noise include port facilities, shipping channels and the operation of some oil and gas infrastructure. Attenuation of noise and therefore scale of impact will vary depending on the volume and frequency of the sound and the dispersal characteristics of the local environment.

Further research is required to understand physical, biological and behavioural impacts of noise on marine turtles before it will be possible to fully assess the impact of this threat on marine turtle stocks in Australia.

## 4L Recreational activities

There are a number of nature-based tourism operations that specifically promote human interactions with marine turtles at nesting beaches (e.g. Mon Repos, Queensland; North West Cape, Western Australia). In addition, other tourism activities, particularly scuba diving can include observations of marine turtles as part of the experience. If managed correctly, these activities can have great conservation value by raising public awareness of the issues relating to marine turtles. However, when mismanaged, these operations have the potential for disturbing marine turtle nesting, internesting and foraging behaviour, ultimately impacting the viability of the stock.

### Off-road vehicle interactions

The use of off-road vehicles on coastal beaches in Australia is a popular recreational activity. However, off-road vehicles can effect marine turtles either by crushing eggs or reducing emergence success via compacting sand over nests, eroding dunes (reducing suitable nesting habitat), and/or creating tyre ruts that can impede hatchlings reaching the sea[227].

Beach access is generally managed by local councils. Some councils have closed marine turtle nesting beaches to the public during the breeding season to reduce the impact on nesting turtles.

## 4M Diseases and pathogens

A number of diseases and infections have been identified in marine turtles, many of which are caused or exacerbated by poor water quality. Marine turtles are commonly affected by spirochiid parasites (blood flukes), and other parasites[66]. Bacterial infections can result from injuries caused by boat strikes and/or entanglement in fishing gear[65]. Disease outbreaks in food sources, such as seagrass, can also indirectly affect the health of marine turtles[51].

Fibropapillomatosis is a common disease in marine turtles that presents as internal and external tumours. The cause of the disease is not fully understood, but the disease has been linked to a herpesvirus[118], and appears to be exacerbated by poor water quality[2, 3]. Progression of tumour development has also been linked to exposure to naturally produced tumour-promoting compounds[4, 129]. Severe tumours around the eyes and mouth can limit vision and ability to forage, and tumours on flippers can inhibit swimming ability.

To date, there are no recorded occurrences of diseases and pathogens affecting the viability of a marine turtle stock in Australia. As marine turtle health is likely closely tied to water quality, management of acute and chronic chemical and terrestrial discharge is the primary mechanism for ensuring sub-lethal impacts of disease does not reach epidemic levels. The impacts of poor water quality, sediment loads and toxic chemicals on marine turtle health are considered in Section 4C Chemical and terrestrial discharge. Further research is required to understand stock level impacts of disease and pathogens.

## 4.2 Cumulative impact of threats

In this plan, the assessment of the risk of any given threat to a stock has been considered in isolation (Section 4.4). However, marine turtles are long lived and have highly dispersed life history requirements. As a result, they are subject to multiple threats acting simultaneously across their entire life cycle causing a cumulative impact on a stock. Similarly, multiple threats may occur at the same time and location and thus provide an interactive impact.

For some stocks there are multiple 'high' and 'very high' risk threats causing a decline. For example, olive ridley turtles nesting on western Cape York have been subject to up to 90 per cent egg loss due to predation by introduced animals and goannas for over a decade[136]. This loss, combined with potentially large numbers of turtles drowning in ghost nets at sea[115] is likely to be resulting in a substantial decline in this stock.

Other stocks may only have a few direct threats rated as 'high' or 'very high' risk, but many 'medium' risk threats that combined could result in the stalled recovery of the stock. For example, flatback turtles nesting in the south-west Kimberley were only determined to be at high risk from acute chemical and terrestrial discharge, but are considered to be at moderate risk from 13 other threats including light glow from urban and industrial development, and fisheries bycatch (Table 8 – F-swKim). Each activity in isolation may not significantly impact the stock, but in concert the reproductive output of the stock may be reduced.

In addition, environmental circumstances may affect the viability of a stock and its ability to withstand existing pressures. For example, where extensive seagrass die off or mass coral bleaching has occurred as a result of an extreme weather event, the loss of adults to ghost nets may exacerbate stock decline.

All stocks in this plan have been identified as being affected by more than one threat and it is only by managing the multiple threats that a stock may be recovered. Cumulative impacts can be difficult to tease apart into constituent threats or individual sources of pressure, especially where threats acting on the stock occur in different jurisdictions.

## 4.3 Existing management

Australia has a long-standing commitment to the conservation of marine turtles. The prioritisation of threats for the purposes of this plan was undertaken in the context of existing research and management that is being undertaken by all levels of government, non-government organisations, universities, industry partners and communities. Existing management activities have been considered when describing each threat at Section 4.1 and management specific to individual stocks is provided in the stock tables at Section 5.4. The following provides a general overview of management in place for all marine turtles species found in Australia.

The Australian Government works regionally through international conventions and agreements to manage these highly migratory species across their range (see Section 2). The Department also liaises with other Commonwealth agencies and collaborates with state and territory governments, and Indigenous and local communities.

Much of the on-ground implementation of pest management, clean-up activities, habitat restoration, compliance and enforcement of regulations, data collection, and development of guidelines is undertaken by state/territory and local governments, and Indigenous community ranger groups. Some state/territories have developed guidelines for reducing boat strike, protecting nesting beaches during important nesting times, and codes of practice for commercial and recreational fishing. State and territory governments have structures in place to facilitate cooperation with landowners, pastoralists and other land managers to help in managing broad scale threats. The relevant government agencies also utilise education and media to raise community awareness. Monitoring and management of marine turtle stocks is undertaken by Commonwealth and state/territory agencies, Indigenous ranger groups, non-government organisations, volunteer groups and community organisations.

State and territory government partnerships also address the protection of marine turtle stocks by improving the knowledge on marine turtles observed within state and territory waters. Some of these include:

- maintaining stranding databases
- undertaking and recording tagging and satellite telemetry data
- promoting data sharing
- undertaking necropsies and reporting.

Important habitat is protected by Commonwealth and state/territory governments through legislated protected areas and marine protected areas in state/territory waters (see examples in Section 3.3).

The Commonwealth marine bioregional planning process was undertaken to improve decisions made under the EPBC Act. Bioregional plans describe the marine environment and conservation values (protected species/places and key ecological features) and set out broad objectives for maintenance of biodiversity. They identify regional priorities, and outline strategies and actions to achieve these.

In accordance with the EPBC Act, all actions likely to have a significant impact on a matter of national environmental significance must be referred to the Australian Government Department administering the EPBC Act for assessment. This process aims to ensure that proposals are adequately assessed and reviewed and that appropriate measures are in place to mitigate any potential impacts on marine turtles from approved activities. Assessments for offshore activities including seismic surveys in the oil and gas sector are now managed by the National Offshore Petroleum Safety and Environmental Management Authority.

Marine turtles have a broad geographic range in Australia, often occurring in remote areas of northern Australia and on islands. Given this, and the cultural significance of marine turtles to Aboriginal and Torres Strait Islander peoples, much of the on-ground management of marine turtles and their habitats is also undertaken by Indigenous rangers and communities. To support these activities, funding for Indigenous management comes through many sources including Working on Country and Indigenous Protected Areas programmes. For example, most sea country ranger programs across the Northern Territory, the Gulf of Carpentaria, the Torres Strait and western Cape York undertake the regular retrieval and destruction of ghost nets as part of their ongoing work plans[81]. Communities in Queensland and the Torres Strait have also received support through the Nest to Ocean Program to manage pig predation and turtle monitoring.

In the Northern Territory, Sea Ranger groups cover most of the coastline and are involved in management activities, marine turtle monitoring and surveillance. In Western Australia, coastal ranger groups span the coast from Cambridge Gulf to Eighty Mile Beach and have been involved in management and monitoring, including the removal of noxious weeds on beaches and satellite tagging of turtles.

In the Torres Strait, the Land and Sea Rangers of the Torres Strait Regional Authority work on several aspects of turtle monitoring, conservation and research. In Queensland, several Traditional Owner groups within the Great Barrier Reef Marine Park have voluntarily developed, or are developing, Traditional Use of Marine Resources Agreements with the Great Barrier Reef Marine Park Authority that include management of marine turtles.

There are also many other community-based programs aimed at conserving marine turtles, including clean-up programs and rehabilitation programs, as well as community run monitoring and education programs.

Industry groups contribute to the management of some marine turtle stocks through Commonwealth or state/territory environmental approval conditions or environmental offsets. For example, the Northwest Shelf Flatback Turtle Conservation Program, which is administered by the West Australian Government and funded by the Gorgon Joint Venturers, increases the conservation, protection and research on flatback turtles in Western Australia.

Collaborations between governments, industry and Indigenous land owners are aimed at conserving and managing marine turtle stocks that are at high risk of extinction. For example, the Raine Island Recovery Project is a collaboration with the Queensland Government, BHP Billiton, Traditional Owners, the Australian Government, and the Great Barrier Reef Foundation.

In addition to existing management actions, there are a number of research and development advancements that have directly led to improved protection of marine turtles in Australian waters. Research is undertaken by government agencies, research institutions, non-government organisations and community groups.

## 4.4 Threat prioritisation

Each of the threats outlined above has been assessed using a risk matrix approach. The risk assessment was applied to each recognised stock and was used to evaluate the likelihood of a threat occurring and the consequences of that threat for the stock (see Appendix B for individual stock risk assessments). The outcome of this process is summarised in Table 8.

Threat risk assessments were undertaken for each stock separately to account for the differences in exposure to threats and the stock's ability to withstand impacts. Threats were considered in terms of the life stage they affect and the duration of the threat. Threats were also considered in the context of the current management regimes in place. The impact of that threat has been assessed assuming that existing management measures continue to be applied appropriately. The threat is then considered, taking into account:

a) knowledge of effectiveness of the mitigation/management measure
b) the coverage of the mitigation/management measure
c) the scope of the mitigation/management measure.

The risk matrix and ranking of threats was based on information in the peer reviewed literature, expert opinion and community consultation. Definitions used for the risk assessment are:

Likelihood of threat occurring is defined as follows:

- Almost certain – expected to occur every year.
- Likely – expected to occur at least once every five years.
- Possible – might occur at some time.
- Unlikely – such events are known to have occurred on a worldwide basis but only a few times.
- Unknown – it is currently unknown how often the incident will occur.

Consequences of threats are defined as follows:

- No long-term effect – no long-term effect on individuals or stock.
- Minor – individuals are affected, but no effect at stock level.
- Moderate – stock recovery stalls or reduces.
- Major – stock declines.
- Catastrophic – stock at risk of extinction.

Table 7. Risk assessment matrix framework

| Likelihood of occurrence (relevant to species) | Consequences | | | | |
|---|---|---|---|---|---|
| | No long-term effect | Minor | Moderate | Major | Catastrophic |
| Almost certain | Low | Moderate | Very high | Very high | Very high |
| Likely | Low | Moderate | High | Very high | Very high |
| Possible | Low | Moderate | High | Very high | Very high |
| Unlikely | Low | Low | Moderate | High | Very high |
| Unknown | Low | Low | Moderate | High | Very high |

Levels of risk and the associated priority for action are defined as follows:

- Very High – immediate additional mitigation action required.
- High – additional mitigation action and an adaptive management plan required, the precautionary principle should be applied.
- Moderate – obtain additional information and, where multiple threats receive a moderate rating, develop additional mitigation action if required.
- Low – monitor the threat occurrence and reassess threat level if likelihood or consequences change.

The outcomes of threat risk assessments for each stock are provided at Appendix B and summarised in Table 8. Table 8 provides a visual representation of those threats that pose the greatest threat across all stocks. It also provides insight into those threats about which little is known (e.g. the long-term impacts of noise).

The risk assessment process was used to determine the priority for conservation and/or management actions (Section 5). Priority actions have been developed for any threat for which the risk to any stock was deemed to be 'high' or 'very high'. For threats with an 'unknown' risk outcome, their status will be reassessed as part of the five year review of the plan.

Table 8. Summary of the threat risk assessment process undertaken for each genetic stock of marine turtle in Australian waters. Risk matrices for each stock are provided at Appendix B. Threats are prioritised based on the number of stocks found to be at 'high' or 'very high' risk from a threat. Please see key below for stock abbreviations.

| Species-Stock: | G-sGBR | G-CS | G-nGBR | G-GoC | G-Cobourg | G-NWS | G-AR | G-ScBr | G-CK | LH- swPac | LH-WA | F-eQld | F-ArS | F-CD | F- swKim | F-Pil | H-nQld | H-neArn | H-WA | O- nwCY | O- NT | LB nesting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Stock Status** | ↗ | ? | ↘ | ? | ? | → | ? | ? | ↗ | ↘ | → | → | ? | ? | ? | ? | ↓ | ? | ? | ↓ | ? | ↓ |
| **THREAT** | | | | | | | | | | | | | | | | | | | | | | |
| A. Climate change and variability | yellow | yellow | pink | blue | yellow | blue | pink | yellow | pink | yellow | yellow | pink | yellow | yellow | blue | yellow | yellow | yellow | yellow | pink | pink | yellow |
| B. Marine debris – entanglement | blue | green U | yellow | pink | pink | blue | pink | blue U | blue | yellow | blue U | blue | pink | blue | blue | blue | pink | pink | blue | pink | pink | blue |
| B. Marine debris – ingestion | yellow | blue | blue | blue | blue | green U | blue | blue | blue | yellow | blue U | blue | blue U | blue | green | green | blue | blue | green U | green U | blue U | yellow |
| C. Chemical and terrestrial discharge – acute | blue | green | green | green | yellow | yellow | yellow | yellow | green | blue | yellow | blue | blue | yellow | yellow | yellow | green | green | blue | blue | yellow | green |
| C. Chemical and terrestrial discharge – chronic | yellow | green | blue | blue | blue | blue | yellow | yellow | green | green | green | blue | blue | blue | blue | blue | blue | blue | blue | blue | blue | green U |
| D. International take – outside Australia's jurisdiction | blue | blue | blue | yellow | blue | blue U | blue | blue U | blue | blue | blue | green | green | green | green | green | pink | pink | pink | green | blue | yellow |
| D. International take – within Australia's jurisdiction | green | green | blue | blue | blue | blue U | blue | blue U | green | green | green | green | green | green | green | green | blue | blue | blue | green | blue | green |
| E. Terrestrial predation | green | green | blue | blue | blue U | blue | yellow U | blue U | green | blue | blue | blue | yellow | blue | blue | blue | yellow | yellow | blue | pink | blue U | blue U |
| F. Fisheries bycatch – international | blue | blue | green | blue | blue | blue | blue | blue | blue | pink | blue | green U | green U | green | green | green | blue | blue | blue | blue | blue | yellow |
| F. Fisheries bycatch – domestic | blue | blue | green | blue | blue | blue | blue | blue | blue | blue | yellow | green | blue | blue | blue | blue | blue | blue | blue | yellow | yellow | yellow |
| G. Light pollution | blue | green | green | green | green | yellow | blue | blue | green | yellow | blue | yellow | blue | blue | blue | yellow | green | green | yellow | blue | blue | green |
| H. Habitat modification – infrastructure/coastal development | blue | green | yellow * | blue | green | blue | green | yellow | blue | blue | blue | blue | green | blue | blue | yellow | green | green | blue | green | green | blue |
| H. Habitat modification – dredging/trawling | blue | green | blue | blue | blue | blue | green | green | yellow | blue | blue | blue | green | blue | blue | blue | green | green | blue | green | green | green |
| I. Indigenous take | blue | blue | blue | yellow | blue U | blue | blue | blue | green | green | blue | green | yellow | blue | blue | blue | blue | yellow | blue | blue | blue | green |
| J. Vessel disturbance | blue | blue | blue | blue | blue | blue | blue | blue | blue | blue | blue | green | blue | blue | blue | blue | green | blue | blue | blue | blue | blue |
| K. Noise interference – acute | green | green | green | blue | blue | blue U | green | blue | green | green | blue | green U | blue | blue | blue | blue | green U | blue | blue | green | green | green U |
| K. Noise interference – chronic | blue U | green | green | blue U | green | blue U | green | blue U | green | blue U | blue U | blue U | green | blue U | blue U | blue U | green U | green U | blue U | green U | green U | green U |
| L. Recreational activities | green | blue | green | green | green U | blue | green | green | green | green | green | green | green | green | blue | green | green | green | green | green | green | green |
| M. Diseases and pathogens | blue U | green U | blue U | green U | green U | green | green U | green U | green | green | green U | blue U | green U | green U | green U | green U | green U | green U | green U | green U | green U | green U |

Stock Status: **?** = unknown, → = stable, ↗ = recovering, ↘ = early stages of decline, ↓ = declining
Risk rating: pink = very high, yellow = high, blue = moderate, green = low, U = unknown
* Historical guano mining

***Key for stocks listed in Table 8***
G-sGBR = green turtle southern Great Barrier Reef
G-CS = green turtle Coral Sea
G-nGBR = green turtle northern Great Barrier Reef
G-GoC = green turtle Gulf of Carpentaria
G-Cobourg = green turtle Cobourg
G-NWS = green turtle North West Shelf
G-AR = green turtle Ashmore Reef
G-ScBr = green turtle Scott Reef – Browse Island
G-CK = green turtle Cocos Keeling
LH-swPac = loggerhead turtle south-west Pacific
LH-WA = loggerhead turtle Western Australia
F-eQld = flatback turtle eastern Queensland
F-ArS = flatback turtle Arafura Sea
F-CD = flatback turtle Cape Domett
F-swKim = flatback turtle south-west Kimberley
F-Pil = flatback turtle Pilbara
H-nQld = hawksbill turtle north Queensland
H-neArn = hawksbill turtle north-east Arnhem Land
H-WA = hawksbill turtle Western Australia
O-nwCY = olive ridley turtle north-western Cape York
O-NT = olive ridley turtle Northern Territory
LB = leatherback turtle

# 5 Recovering Marine Turtles

## 5.1 Recovering a stock

As a result of their life history traits, marine turtles have the capacity to recover when important threats are removed. For example, green turtles in Hawaii were near extinction in the 1970s and have rebounded to approximately 4000 nesting females in 2015 after 40 years of protection from large scale commercial harvest[10]. Similarly, the south-west Pacific loggerhead turtle stock had declined from approximately 3500 adult females nesting on the east coast of Australia to approximately 500 by 2000. The compulsory use of turtle excluder devices introduced in the trawl fisheries of eastern Australia in 2001 may have resulted in an increase in nesting turtles over subsequent nesting seasons[138].

To achieve recovery, it is necessary to remove threats that cause direct mortality and to maximise stock reproductive output. Marine turtle experts have developed a general principle, based on age-specific growth models for southern Great Barrier Reef green turtles and south-west Pacific loggerhead turtles[30-32] that a minimum of 70 per cent of nests must produce hatchlings to maintain the stock. Where there has been significant decline in a stock, a greater proportion would be required to achieve recovery.

## 5.2 Summary of actions to be implemented

The threat risk assessment process identified the threats with highest priority for action. Only actions that address the most notable threats, those rated as 'high' (yellow) or 'very high' (pink) priority and those that measure recovery or address knowledge gaps are included. It is expected that every action will be progressed or completed during the life of this plan.

It is also recognised that during the life of this plan new information will become available. This may include the emergence of new threats or changes in relative risk, changes in stock classification, or due to increased knowledge about a threat. As new information becomes available it must be taken into consideration in the context of this plan.

The following tables provide actions to build on existing management (Section 4.3). While there are overarching pressures affecting the majority of turtle stocks, due to the regionalisation of each stock and their life cycle requirements, actions that are specific to a stock and its recovery have been described in the individual stock tables provided at Section 5.4.

### Indicative cost of implementing actions

The cost of implementing the actions outlined in this recovery plan are, already to a large extent, borne by the Commonwealth, state and territory governments in the delivery of their core business, plans and programs, both domestically and internationally. It is not practicable to determine with a high degree of certainty what each action costs to be implemented. State, territory and Commonwealth governments also collaborate with universities, scientific institutions, industry, business, NGO's and communities in the delivery of their programs and research activities. While Indigenous communities and rangers receive some support from a variety of government programs to undertake management for marine turtles and their environments, many communities undertake a large degree of management without outside support. There is also significant investment from industry, the general community and non-government organisations towards additional programs, managing and conserving marine turtle habitats.

## 5.3 Assessing and addressing key threats

| Action Area A1 | Number of stocks with threat rated as 'very high' or 'high' |
|---|---|
| Maintain and improve efficacy of legal and management protection | All stocks |

**Action**

- Align the threat status of marine turtles in range jurisdictions through the operation of the Intergovernmental Memorandum of Understanding: agreement on a common assessment method for listing of threatened species and ecological communities.
- Maintain, implement and improve efficacy of existing management arrangements as listed at Sections 2 and 4.3.
- Maintain and improve biological information, including spatial information, used to inform robust decision making.
- Develop and implement nationwide significant impact guidelines for marine turtles.
- Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival as per section 3.3 Table 6.
- Manage anthropogenic activities in Biologically Important Areas to ensure that biologically important behaviour can continue.
- Develop robust criteria for the identification of habitat critical to the survival of each stock for foraging, migration, mating and hatchling dispersal.

| Recovery targets addressed | Threats to be mitigated |
|---|---|
| 1.1, 1.2, 2.1 | A,B,C,D,E,F,G,H,I,J,K,L,M |

**Description**

Australia maintains its position promoting recovery of all marine turtle stocks both domestically and in all relevant international agreements and fora. All management decisions and supporting tools continue to be informed by current and robust evidence, noting the precautionary principle. Decisions take into account the cumulative impacts of multiple pressures and resulting actions do not affect listed marine turtles such that they cannot continue to utilise important habitats. Actions undertaken in or adjacent to (i.e. causing 'downstream impacts' such as light spill) designated habitat critical to the survival of the species or biologically important areas do not change important behaviours such that the recovery of the stock is compromised. During the life of the plan important foraging grounds, migratory corridors, mating areas and habitat for hatchling dispersal should be identified. All plans of management for marine parks, fisheries and developments promote the recovery of marine turtles and take into account the objectives of this plan. All community based management plans, or land and sea management plans that make reference to marine turtles, have a sustainable management objective. Planning and implementation processes will be supported by the consistent assessment and listing of marine turtles by range jurisdictions according to their national threat status.

*Responsible agencies and potential partners*: Australian Government, state and territory governments, local governments, parks and fisheries managers, offset managers, industry partners and Indigenous communities.

**Within the life of this plan**

*Measure of success:* Australia continues to promote and improve the protection of marine turtles in international fora and through appropriate domestic legislation. Management decisions are made on the basis of best available robust information.

*Risks*: There is a lack of coordination across the multijurisdictional management of marine turtles. Cumulative impacts can be difficult to tease apart into constituent threats or individual sources of pressure, especially where threats acting on the stock occur in different jurisdictions.

*Likelihood of success*: Moderate to high

| Action Area A2 | Number of stocks with threat rated as 'very high' or 'high' |
|---|---|
| Adaptively manage turtle stocks to reduce risk and build resilience to climate change and variability | 6 |
| | 13 |

**Action**

- Continue to meet Australia's international commitments to address the causes of climate change.
- Identify and protect areas for range expansion and identify areas of refugia.
- Identify, test and implement climate based adaptation measures.
- Increase understanding of the evolutionary capacity of marine turtles to adapt to a changing environment.

| Recovery targets addressed | Threats to be mitigated |
|---|---|
| 1.1, 3.1, 3.2 | A |

**Description**

Climate change has been predicted to negatively impact marine turtle habitats and all phases of their life cycle. Many of the long-term consequences for stock viability are yet to be fully tested, but the potential consequences require a precautionary approach. Australia's broader policy actions attempt to mitigate climate change globally. In the interim, it is necessary to identify and monitor stocks at high risk from changes in ambient temperatures (sand and water), sea level, frequency of extreme weather events, ocean circulation and acidification. Where climate change effects are deemed to be having an impact on stock viability, impacts should be mitigated utilising an adaptive management approach. Appropriate monitoring must be undertaken to evaluate and modify management actions to ensure efficacy. Areas for turtle range expansion should be recognised to build refugia, resilience and capacity to adapt within the environment and afforded some measure of protection. Knowledge gaps to be filled in relation to climate change impacts on marine turtles include, but are not limited to: resilience of stocks to environmental change; time required for adaptation; and capacity for physiological adaptation.

*Responsible agencies and potential partners*: Australian Government, state and territory governments, research institutions, industry partners and relevant non-government organisations.

**Within the life of this plan**

*Measure of success:* Australia continues its commitment to mitigate climate change. Measures required to help stocks adaptively manage impacts from climate change are better understood. Areas for range expansion and refugia are identified and protected.

*Risks*: Actions at the global scale are not sufficient to affect the current rate of climate change.

*Likelihood of success*: Moderate

| Action Area A3 | Number of stocks with threat rated as 'very high' or 'high' |
|---|---|
| Reduce the impacts from marine debris | 8 |
| | 4 |

**Action**

- Maintain and expand international and domestic partnership arrangements for the source reduction, collection and management of marine debris.
- Compare marine debris hotspots with important foraging areas, post hatchling dispersal and adult migratory pathways to identify high priority areas for mitigation to reduce turtle/debris interactions.
- Genetic samples are taken from animals caught in ghost nets.
- Describe and quantify the impact of ingestion of debris on marine turtles, particularly those life phases using the open ocean.
- Support the implementation of the EPBC Act *Threat Abatement Plan for the impacts of marine debris on vertebrate marine life.*

| Recovery targets addressed | Threats to be mitigated |
|---|---|
| 1.1, 1.2, 2.1, 2.2, 3.1,3.2 | B |

**Description**

Given the costs and challenges associated with clean up of marine debris, the primary approach to management must be source reduction. Clean-up initiatives are still necessary to reduce existing onshore and offshore marine debris, to prevent waste re-entering the marine environment. There is scope to build collaboration or expand on any regional partnership arrangements between communities and industry in the more remote areas in Australia. International engagement, as well as domestic programs, are necessary to achieve a reduction in discarded fishing gear, other marine debris, plastics and microplastics entering the environment.

Ghost net hot spots and turtle habitat use are known to overlap, however those stocks most affected are unknown. More information is required to quantify the impact of marine debris (both ghost nets and plastic ingestion) on stock viability[230] and to identify management hotspots.

*Responsible agencies and potential partners*: Australian Government, state and territory governments, research institutions, relevant non-government organisations, industry partners, Indigenous rangers and community groups.

**Within the life of this plan**

*Measure of success:* International agreements and domestic mechanisms are in place to reduce the source of marine debris. Local communities are supported to manage the source and clean up of marine debris, and government agencies work collaboratively to manage marine waste. The impact of marine debris on stock viability is better understood. The implementation of the *Threat Abatement Plan for Impacts of Marine Debris on Vertebrate Marine Life* is supported.

*Risks*: Most marine debris is plastic and will persist in the environment (up to decades). It is difficult to remove, and continues to break down into microplastics that are also hazardous. Plastic is increasingly being used in all aspects of production, so will remain prevalent as a commercial product.

*Likelihood of success*: Moderate

| Action Area A4 | Number of stocks with threat rated as 'very high' or 'high' |
|---|---|
| Minimise chemical and terrestrial discharge | 0 |
| | 10 |

**Action**

- Implement best practice industrial, urban and agricultural runoff and storm water management for new and existing developments in coastal catchments to minimise impacts to marine turtle health and habitats.
- Ensure spill risk strategies and response programs adequately include management for marine turtles and their habitats, particularly in reference to 'slow to recover habitats', e.g. nesting habitat, seagrass meadows or coral reefs.
- Quantify the impacts of decreased water quality on stock viability.
- Quantify the accumulation and effects of anthropogenic toxins in marine turtles, their foraging habitats and subsequent stock viability.

| Recovery targets addressed | Threats to be mitigated |
|---|---|
| 1.1, 1.2, 2.2, 3.1 | C |

**Description**

Reduced water quality resulting from pollutants, including sediment, entering the marine environment have the potential to affect marine turtle health directly or reduce the viability of habitats necessary for survival, which has implications for stock viability. Once pollutants enter the marine environment it is difficult to limit marine turtle exposure to these compounds, or the impacts of poor water quality on their habitats. As such, the most effective mitigation is to manage pollutants at the source and limit the amount entering the marine environment. Where primary mitigation fails, rigorous emergency response plans must be in place to minimise the impact of acute chemical and terrestrial discharge.

To address chemical and terrestrial discharge, best practice guidelines should be implemented with all existing and new developments. Research is required to improve our understanding of the extent to which marine turtles are exposed to, and affected by, anthropogenically derived toxins and heavy metals and the implications of exposure to stock viability.

*Responsible agencies and potential partners*: Australian Government, state and territory governments, research institutions, relevant non-government organisations, land holders and industry partners.

**Within the life of this plan**

*Measure of success:* Programs aimed at minimising runoff impacts on the coastal environment are being implemented and environmental management standards regarding water quality are improved. Exposure to, and effects of, heavy metals and other anthropogenically derived toxins is quantified for stocks considered to be at high risk from this threat. Spill risk strategies and response programs consider marine turtles.

*Risks*: Urban, agricultural and industrial development pressures continue to undermine the overall health of the coastal ecosystems, despite implementing management strategies.

*Likelihood of success*: Moderate to high

| Action Area A5 | Number of stocks with threat rated as 'very high' or 'high' |
|---|---|
| Address international take within and outside Australia's jurisdiction | 3 |
| | 2 |

**Action**

- Engage through CITES and other signatory mechanisms to highlight and reduce the illegal trade in marine turtle products.
- Maintain and expand collaborative partnerships with other countries, domestic governments, non-government organisations, researchers, managers and fishers in range states to increase education and communication of marine turtle conservation.
- Work on a regional scale to reduce illegal, unreported and unregulated take and trade of turtles.

| Recovery targets addressed | Threats to be mitigated |
|---|---|
| 1.1, 1.2, 3.1 | D |

**Description**

Marine turtles are subject to take by foreign nationals in Australian waters and when they migrate outside Australia's jurisdiction. Regulation of take varies between countries and levels of take range from being sustainable to highly unsustainable.

Australia will work with regional partners to promote sustainable management of marine turtles through locally relevant programs and work through existing multi-lateral agreements, such as the *Convention on the Conservation of Migratory Species of Wild Animals* and the *Convention on the International Trade of Endangered Species of Wild Fauna and Flora*, to address the illegal trade of turtles.

*Responsible agencies and potential partners*: Australian Government and relevant non-government organisations.

**Within the life of this plan**

*Measure of success:* Australia continues its commitment to liaise and negotiate collaborative partnerships with its regional partners to sustainably manage marine turtle stocks, within and outside Australian waters.

*Risks*: In areas outside Australia's jurisdiction, the Australian Government can only provide support to address marine turtle take where requested.

*Likelihood of success*: Moderate

| Action Area A6 | Number of stocks with threat rated as 'very high' or 'high' |
|---|---|
| Reduce impacts from terrestrial predation | 1 |
| | 4 |

**Action**

- Reduce predation pressures such that all egg mortality doesn't exceed 30 per cent of all clutches for all stocks except the western Cape York olive ridley, which should be reduced to less than 10 per cent of clutches laid.
- Support the implementation of the EPBC Act Threat Abatement Plans for: *Predation by European Red Fox*; *Reduction in Impacts of Tramp Ants on Biodiversity in Australia and its Territories* and *Predation, habitat degradation, competition and disease transmission by feral pigs.*
- Engage directly with, or work through regional agreements, to address predation pressure on nesting beaches in other countries.

| Recovery targets addressed | Threats to be mitigated |
|---|---|
| 1.1, 1.2, 2.1, 2.2, 3.1, 3.2, 4.1 | E |

**Description**

The approach taken to management of terrestrial predators on marine turtle nests will vary depending on the accessibility of the beach and the type of predator involved. Programs to reduce terrestrial predation of turtle nests must be targeted and ongoing. The success of the program must be quantified in terms of egg and hatching success rather than predator reduction targets because total eradication is not possible for most predator species. As the stock of olive ridley turtles that nests on western Cape York is small and has been subject to up to 90 per cent clutch loss for a number of decades, this stock requires a higher rate of intervention than other stocks.

*Responsible agencies and potential partners*: Australian Government, state and territory governments, relevant non-government organisations, landholders, Indigenous rangers and community groups.

**Within the life of this plan**

*Measure of success:* Strategic management of nest predation is implemented in high risk areas. Monitoring associated with predator control programs indicates predation pressure is reduced such that all egg loss is reduced to less than 30 per cent of all clutches (less than 10 per cent for western Cape York olive ridley turtle stock). Australia continues its commitment to liaise and negotiate collaborative partnerships with its regional partners to manage marine turtle nesting beaches.

*Risks*: The remote regions where predators are often a problem presents difficulty with maintaining access and support to predator control programs. Eradication programs are generally not possible due to the geographic extent that many exotic species occupy.

*Likelihood of success*: Moderate

| Action Area A7 | Number of stocks with threat rated as 'very high' or 'high' |
|---|---|
| Reduce international and domestic fisheries bycatch | 1 |
| | 4 |

**Action**

- Engage in, and implement, bi- and multi- lateral agreements to improve the protection of Australia's marine turtles through best practice fisheries management throughout their range.
- Promote and implement best practice and continued innovation of turtle bycatch mitigation in all Australian fisheries.
- Quantify fishery interactions by species, and where necessary, improve reporting processes.
- Design reporting frameworks to quantify the cumulative impacts of all fishing pressure on any given stock. Depending on range, this will require consideration of recreational, state/territory, Commonwealth and international fisheries.
- Support and expand research collaborations with commercial fishers on improving management of bycatch.
- Quantify post release mortality of live caught turtles, and where necessary, improve success rates.

| Recovery targets addressed | Threats to be mitigated |
|---|---|
| 1.1, 1.2, 3.1, 3.2 | F |

**Description**

Australia will continue to promote and encourage best practice fisheries management through relevant international fora and agreements throughout the species' range, such as the *CMS Single Species Action Plan for the Loggerhead Turtle* (Caretta caretta) *in the Southern Pacific Ocean*. Domestic Australian fisheries should continue to implement best practice management including compliance with fisheries legislation in regard to turtle excluder and bycatch reduction devices. Fisheries management should be undertaken in accordance with the *FAO Guidelines to Reduce Sea Turtle Mortality in Fishing Operations*[59]. Improved bycatch reporting, particularly marine turtle species identification, will assist in understanding the impact of fisheries on marine turtle stocks. Priority fisheries research includes novel approaches to bycatch mitigation, which may include gear modifications, spatial and temporal closures and assessment of post release viability.

*Responsible agencies and potential partners:* Australian Government, state and territory governments, fisheries management agencies, relevant non-government organisations, and industry groups.

**Within the life of this plan**

*Measure of success:* The Australian Government is engaging in regional fora and meeting international obligations to reduce threats from bycatch across the entire stock range. Domestic fisheries are compliant with fisheries legislation pertaining to bycatch. Marine turtle species are accurately recorded in 90 per cent of reported fishery interactions within Australia's jurisdiction. Marine turtle bycatch is reduced such that it does not impact stock recovery.

*Risks:* May not be possible to reach agreement on closure areas or achieve a change in management or improvement in the reduction of bycatch in fisheries.

*Likelihood of success:* Moderate

| Action Area A8 | Number of stocks with threat rated as 'very high' or 'high' |
|---|---|
| Minimise light pollution | 0 |
| | 5 |

**Action**

- Artificial light within or adjacent to habitat critical to the survival of marine turtles will be managed such that marine turtles are not displaced from these habitats as per section 3.3 Table 6.
- Develop and implement best practice light management guidelines for existing and future developments adjacent to marine turtle nesting beaches.
- Identify the cumulative impact on turtles from multiple sources of onshore and offshore light pollution.

| Recovery targets addressed | Threats to be mitigated |
|---|---|
| 1.1, 1.2, 2.1, 2.2, 3.1, 3.2 | G |

**Description**

Artificial light poses a threat to marine turtles because it disrupts critical behaviours such as nesting, hatchling orientation, sea finding and dispersal behaviour, which may reduce the overall reproductive output of a stock and therefore recovery. To address artificial light, guidelines need to be in place to reduce or avoid adverse impacts on marine turtle behaviour. This includes not only direct light shining on nesting beaches or dispersal areas (including in-water dispersal), but the impact of sky glow. Urban, industrial and commercial developments should be separated from nearby nesting habitat by a buffer that is appropriate to the topography of the dune system, presence of vegetation and the amount of light emitted from the project[180]. Consideration should be given to retro-fitting lighting where existing light sources are found to cause behavioural changes in nesting turtles or hatchlings.

*Responsible agencies and potential partners*: Australian, state, territory and local government, relevant non-government organisations, industry partners and community groups.

**Within the life of this plan**

*Measure of success:* Impacts of artificial lighting are managed such that marine turtle stock recovery is not impeded. Guidelines are developed and implemented. Cumulative impact of light is better understood.

*Risks*: Light increasingly impacts sensitive turtle habitats and is not managed holistically.

*Likelihood of success*: Moderate

| Action Area A9 | Number of stocks with threat rated as 'very high' or 'high' |
|---|---|
| Address the impacts of coastal development/infrastructure and dredging and trawling | 0 |
| | 4 |

**Action**

- Manage infrastructure, coastal development, dredging and trawling to ensure ongoing biologically important behaviours for marine turtle stocks continues.
- Use up-to-date information regarding nesting, internesting and foraging habitat to inform future development proposals and approval decisions.
- Assess the impact of trawling on the benthic environment in marine turtle foraging habitat and determine whether it is likely to have an impact on stock viability.

| Recovery targets addressed | Threats to be mitigated |
|---|---|
| 1.1, 1.2, 2.1, 2.2, 3.1, 3.2, 4.1 | A,C,E,G, H, K, L |

**Description**

Activities resulting in degradation in nesting, internesting and foraging habitats may directly cause turtle mortality, or indirectly contribute to a decreased stock viability by reducing food availability, reducing growth rates or fecundity, or increasing susceptibility to injury and disease. Marine turtles show high fidelity to important foraging grounds that are often used by multiple stocks and species, and when impacted, can reduce the health of multiple stocks, subsequently affecting fecundity. To minimise the loss and degradation of habitats, any proposed action needs to consider habitat requirements at early stages of planning, and fisheries need to consider improving education and best practice management. Infrastructure and development should be managed to ensure marine turtles continue to utilise habitat critical to the survival of marine turtles without injury and are not displaced as a result of these activities. In particular, management of both dredging and trawling must take into account the impact of changes to the benthic environment in terms of the flow-on implications for marine turtle stock viability.

*Responsible agencies and potential partners*: Australian, state, territory and local government, relevant non-government organisations, industry partners, fisheries managers and developers.

**Within the life of this plan**

*Measure of success:* The recovery of marine turtle stocks and the functionality of their habitat is not adversely affected by coastal development, infrastructure, dredging or trawling activities.

*Risks*: New information is not distributed and decisions are made without the benefit of robust information.

*Likelihood of success*: Moderate

| Action Area A10 | Number of stocks with threat rated as 'very high' or 'high' |
|---|---|
| Maintain and improve sustainable Indigenous management of marine turtles | 0 |
| | 3 |

**Action**

- Continue to support Aboriginal and Torres Strait Islanders to sustainably manage the traditional take of turtles and eggs through a collaborative approach between government agencies and Indigenous communities.
- Support Indigenous ranger and community groups to implement management plans and other mechanisms, and build capacity to undertake monitoring, education, and compliance management regarding harvest of marine turtles and their eggs.
- Ensure scientific information is shared with communities and government to inform management decisions.
- Develop mechanisms by which conservation management and other skills are accredited and linked to vocational outcomes for Indigenous rangers.

| Recovery targets addressed | Threats to be mitigated |
|---|---|
| 1.1, 1.2, 2.1, 2.2, 3.1, 3.2, 4.1 | B, E, I |

**Description**

Indigenous harvest of eggs and turtle meat occurs across northern Australia and is managed by communities. Community management of marine turtles has been successful in many areas and this approach should be supported and expanded across northern Australia. In general, management is costly, requiring ongoing support through government programs and initiatives with specific emphasis on the management of threats to marine turtles. An increased focus should be placed on the provision of scientific information to Indigenous groups to assist in making informed decisions regarding take. Several ranger groups articulated their desire for long-term funding (e.g. 10-15 years) versus the current five year funding commitment, to provide certainty of future management capacity. To facilitate a shift to independent self-management, there is a desire amongst many Indigenous rangers to gain a range of skills, experiences, qualifications and certifications to improve long-term employability. While management structures and capacity varies between communities, a collaborative approach that includes community members, rangers, researchers and government support to facilitate local custom and lore, and education to enable communities to establish and enforce plans of management, appears to be a positive approach.

*Responsible agencies and potential partners:* Australian, state and territory government agencies, Indigenous community groups, Indigenous rangers, land councils and research institutions.

**Within the life of this plan**

*Measure of success:* Government agencies work with Indigenous communities to develop or expand community management mechanisms. Programs are funded to support the implementation of sustainable management. Mechanisms are created to accredit skills acquired for vocational qualifications and certifications for Indigenous rangers.

*Risks:* Communities do not have the capacity to undertake targeted management of threats to marine turtles.

*Likelihood of success:* Moderate

## Enabling and measuring recovery

| Action Area B1 | Stocks identified for monitoring[1] |
|---|---|
| Determine trends at index beaches | 16 |
| **Action** | |
| • Maintain or establish long-term monitoring programs at index beaches to collect standardised data critical for determining stock trends, including data on hatchling production.<br>• Investigate options for making data publicly available. | |
| **Recovery targets addressed** | **Threats to be mitigated** |
| 1.1, 1.2, 2.1, 2.2, 3.2, 4.1, 4.2 | A,B,C,D,E,F,G,H,I,J,K,L,M |
| **Description** | |
| Due to the long life cycle of marine turtles, data needs to be collected over decades to establish trends in stock demographic parameters such as the abundance of nesting turtles. Long-term monitoring of nesting and hatchling production at index beaches provides insight into the viability of a stock. Combined with foraging ground information, these metrics provide trends in stock abundance and evidence for the success of threat mitigation programs. Trends from multiple index beaches are used to assess proposed changes to the EPBC Act listing status of the species. While it is not necessary to monitor all stocks to assess the EPBC Act status of the species, access to ongoing monitoring information provides important support for both strategic and day to day management decisions for the stock. Long-term monitoring at nesting beaches is also required to assess the efficacy of threat mitigation in place for the stock. Monitoring must be specifically designed to test threat mitigation, with monitored parameters specific to the stock, current trends, threats and existing management. Monitoring should be sufficient to allow for modelling purposes. All monitoring should be undertaken in a statistically robust manner. There are a number of existing long-term monitoring programs and Section 5.4 notes priority areas for the establishment of index beach monitoring.<br>*Responsible agencies and potential partners*: Australian, state, territory and local government, relevant non-government organisations, industry partners and community groups. | |
| **Within the life of this plan** | |
| *Measure of success:* Long-term monitoring programs are in place for 16 of the 22 stocks as identified in stock specific action tables (Section 5.4). Nesting data is more publicly available.<br>*Risks*: Insufficient resources to fund the monitoring of key marine turtle index beaches.<br>*Likelihood of success*: Moderate | |

1 Please see stock specific actions at Section 5.4

| Action Area B2 | Stocks identified for monitoring[2] |
|---|---|
| Understand population demographics at key foraging grounds | 7 |

**Action**

- Maintain existing population demographic studies at key foraging grounds and expand to monitor high priority stocks (identified at section 5.4).
- Identify important foraging habitat for flatback, hawksbill and olive ridley turtles and initiate foraging ground studies at key locations.
- Investigate options for making data publicly available.

| Recovery targets addressed | Threats to be mitigated |
|---|---|
| 1.1, 1.2, 2.1, 2.2, 3.2, 4.1, 4.2 | A,B,C,D,E,F,G,H,I,J,K,L,M |

**Description**

Many of the foraging grounds monitored have not necessarily been recently or continuously surveyed. Understanding the population demographics of marine turtles in a foraging ground provides more information about the viability of a species than relying on nesting ground information alone, because foraging grounds support turtles of both sexes, turtles at most life history stages (excluding pelagic juveniles), and turtles of all conditions of health. Long-term monitoring programs are also required to assess the efficacy of threat mitigation in place for the stock. Monitoring must be specifically designed to test threat mitigation, with monitored parameters specific to the stock, current trends, threats and existing management. Monitoring should be sufficient to allow for modelling purposes. All monitoring is to be undertaken in a statistically robust manner. As there is a paucity of data on foraging grounds for flatback, hawksbill and olive ridley turtles in particular, it is a high priority to identify and monitor key foraging grounds.

As is the case for index beaches, selection of key foraging habitats to monitor should include consideration of the number of species present, accessibility of the site for repeatable monitoring and knowledge of major foraging areas.

Foraging ground information should be available to decision makers to ensure that robust and well informed environmental decisions that may affect any key foraging grounds can be made.

Currently known key foraging grounds have been identified in stock specific tables (Section 5.4).

*Responsible agencies and potential partners:* Australian, state, territory and local governments, research institutions, relevant non-government organisations, industry partners and community groups.

**Within the life of this plan**

*Measure of success:* Demographic parameters at foraging grounds are better understood for all species. Important foraging habitat is identified for hawksbill, flatback and olive ridley turtles. Foraging ground data is more publicly available.

*Risks:* Insufficient resources to fund the monitoring of foraging areas.

*Likelihood of success:* Moderate

Recovering Marine Turtles

2 Please see stock specific actions at Section 5.4

| Action Area B3 | |
|---|---|
| Address information gaps to better facilitate the recovery of marine turtle stocks | |
| **Action** | |
| • Fill knowledge gaps in the life history of all species such that threats can be assessed and addressed throughout the entire life cycle.<br>• Understand the impacts of anthropogenic noise on marine turtle behaviour and biology.<br>• Describe disease and pathogen prevalence and assess the implications for stock viability. Where necessary, identify causal factors and appropriate management responses.<br>• Finalise the genetic delineation of flatback, hawksbill and olive ridley turtle stocks in Western Australia and determine the stock composition of turtles foraging in New South Wales. | |
| **Recovery targets addressed** | **Threats to be mitigated** |
| 1.2,2.1, 2.2, 3.2, 4.1, 4.2 | K, M |
| **Description** | |
| Recovering marine turtle stocks requires an understanding of the threats impacting on all life history phases. There are currently large knowledge gaps in terms of neonate ecology, pelagic post-hatchling life phase, triggers for reproductive migration and mating areas for all species. In addition, better understanding of the foraging ecology of olive ridley, hawksbill and flatback turtles is required. Knowledge gaps should be filled to enable whole-of-life-cycle management. Greater understanding of all demographic parameters will facilitate the development of stock viability models for high priority stocks to better assess management approaches, particularly designation of habitat critical to the survival of each stock.<br><br>Noise in the marine environment is expected to increase in areas of expanding industrial development and increased shipping. Acute noise results from temporary exposure to loud noises and may lead to avoidance of important habitat areas[160], and in some situations, physical damage[122]. Long-term exposure to noise may lead to avoidance of important habitat areas. There is a need to better understand the effects of noise on marine turtles, especially from seismic survey activity[175] and to assess the efficacy of current noise management.<br><br>Disease and pathogens have been described for individual turtles, however, there is limited understanding of how disease affects overall stock health and long-term viability. Research should focus on sub-lethal implications of disease, such as reduced reproductive output, and identify at what point poor health may lead to adverse outcomes for the species.<br><br>The genetic relatedness of flatback, hawksbill and olive ridley turtles nesting in Western Australia needs to be resolved[63], particularly for stocks nesting in the Kimberley. This will enable appropriate management regimes to be implemented for each determined stock. Similarly, there is a need to determine the stock origins of green, loggerhead and hawksbill turtles foraging in New South Wales, and of hawksbill turtles foraging in Western Australia to support more effective management. Tissue or biopsied samples should be collected when taking data on stranded animals to help define baselines. Standard procedures should be developed to provide guidance on appropriate tissue collection techniques. This should also be used to inform blood chemistry research.<br><br>*Responsible agencies and potential partners:* Australian, state, territory and local government, research institutions, relevant non-government organisations, industry partners and community groups. | |
| **Within the life of this plan** | |
| *Measure of success:* Improved understanding of knowledge gaps, including whole-of-life-cycle threats and habitat necessary for protection, the impacts of noise, disease/pathogens, and the genetic relatedness of flatback, olive ridley and hawksbill turtles.<br><br>*Risks*: The availability of funding to undertake research.<br><br>*Likelihood of success*: Moderate | |

## 5.4 Individual stocks

To ensure the preservation of genetic diversity, threats are considered on an individual stock basis (Table 8). The following tables provide an overview of each stock and identify specific actions to manage these stocks. As described at Section 3.2, 21 stocks are described for green, loggerhead, flatback, hawksbill and olive ridley turtles. As there is no genetic basis on which to distinguish leatherback turtles nesting in Australia from stocks in neighbouring countries, all leatherback turtles nesting in Australia are considered as one stock. In addition, there is a separate table with management actions for those turtles that nest in neighbouring countries, but are known to forage in Australian waters.

Priority actions are provided for the recovery of each stock in the following tables and give greater context to the overarching actions described in Section 5.3. The tables also provide justification as to why some stocks are considered to be at a greater risk of decline and therefore a higher priority for implementation of management actions.

### Stock trends

The conservation status of marine turtles in Australia is determined on a species basis and provided under relevant Commonwealth, state and territory legislation (Table 4). To ensure conservation of genetic diversity, this plan considers the management of turtles on a stock basis. Trends in nesting numbers at index beaches, combined with demographic information from foraging grounds (where available) and known sources of mortality are used to infer trends in stock viability. These trends are noted in the top right hand corner of the stock tables.

### Measure of success

A measure of success is provided for each stock in terms of demographic trends in turtle abundance over the life of the plan.

## Specific actions to recover each stock

| Green – southern Great Barrier Reef (G-sGBR) | | Recovering[34] |
|---|---|---|
| **Threats** | A. Climate change and variability | High |
| | B. Marine debris – ingestion | High |
| | C. Chemical and terrestrial discharge – chronic | High |
| **Important nesting areas** | | **Internesting Buffer: 20 km** |
| *Major*: Northwest, Wreck, Hoskyn, Tryon, Heron, Lady Musgrave, Masthead, Erskin, Fairfax, North Reef and Wilson Islands[136].<br>*Minor*: Bushy Is., the Percy Islands, Bell Cay, Lady Elliott Is., Swains Reef, North Fraser Is., mainland coast from Bustard Head to Bundaberg[136].<br>*Index beaches monitored*: Heron Island (1944- ), Wreck Island (1977- ), North West Island (1977- ), Lady Musgrave (1972- )[145]. | | *Mating*: Sept–Nov<br>*Nesting*: Oct–Apr (peak: late Dec–early Jan)<br>*Hatching*: Dec–May (peak: Feb–Mar) |

**Foraging habitat**

*Post-hatchling/young juveniles:* Spend the first 5-10 years in oceanic waters of the southern Pacific Ocean, utilising floating seaweed rafts and opportunistically feeding on gelatinous organisms, before returning to inshore foraging habitat[18].

*Juvenile-adult:* Tidal/sub-tidal habitats with coral reef, mangrove, sand, rocky reefs and mudflats where algal turfs or seagrass meadows are present[18]. A proportion of turtles may also remain resident in the open ocean[92].

*Foraging grounds monitored*: Moreton Bay, Heron/Wistari Reefs, Shoalwater Bay[145], Hervey Bay[225].

*Distribution*: See Figure 11.

**Stock description**

This stock was subject to commercial harvest up until 1959[136]. The stock now appears to be recovering well, with good survivorship rates amongst juveniles at foraging grounds and adults at nesting beaches[34]. Combined nesting and foraging ground monitoring means that the demographics of this stock are relatively well understood[30, 145]. Given the longevity of monitoring, it is important to continue monitoring the progress of the stock. The southern Great Barrier Reef green turtle stock is largely managed by the Queensland Parks and Wildlife Service and the Great Barrier Reef Marine Park Authority, with considerable contributions from volunteers, and local and Indigenous communities.

Large numbers of green turtle strandings along the Queensland coast in 2010-11 were attributed to pulse flooding after extreme weather events which damaged seagrass – their main food source[141]. These events are predicted to increase as a result of climate change[67]. Climate change is also predicted to increase sand temperatures which may adversely affect this stock[70].

Due to its proximity to agricultural and urban areas, the stock is at a high risk from the impacts of poor water quality. The proximity to large urban areas also means that turtles are exposed to marine debris from local sources of urban rubbish and fishing gear, which may be ingested. Both water quality and marine debris are currently addressed through the Reef 2050 Plan, of which continued implementation will help manage these threats. This stock is also subject to 'international fisheries bycatch' and 'international take', both of which are largely unquantified.

The accessibility of this stock means that there are opportunities to research impacts of less well understood threats, such as disease, poor water quality and toxin exposure, which can be used to extrapolate outcomes for other, less accessible, stocks.

*Continued over*

| Green – southern Great Barrier Reef (G-sGBR) | Recovering[34] |
|---|---|
| **Priority actions specifically required to recover this stock** | **Action Area** |
| Quantify and predict the frequency of pulse flood events, their impacts on seagrass meadows, and implement relevant mitigation measures. | A2, A4 |
| Identify and protect suitable beaches and islands that could be used as nesting habitat under a rising sea level model/scenario, to ensure that these are suitable for colonisation in the future. | A2 |
| Manage land-based pollution and recreational activities to reduce marine debris at the source. | A3 |
| Quantify the impact of marine debris ingestion on stock viability. | A3 |
| Understand the sub-lethal impacts of poor water quality and exposure to toxins. | A4, B3 |
| Continue long-term monitoring of index beaches and key foraging areas. | B1, B2 |
| Support implementation of the *Reef 2050 Long Term Sustainability Plan* to build on existing turtle monitoring and water quality management programs in Queensland. | A4 |
| **Measure of success** | |
| *Stock continues to recover* | B1, B2 |

| Green – Coral Sea (G-CS) | | Unknown |
|---|---|---|
| **Threats** | A. Climate change and variability | High |

| **Important nesting areas** | **Internesting Buffer: 20 km** |
|---|---|
| Sand cays of Coringa-Herald National Nature Reserve and islands in the Lihou Reef National Nature Reserve.<br>*Index beaches monitored:* Coringa-Herald National Nature Reserve (1991/92-2003/04)[91]. | *Mating*: Unknown<br>*Nesting*: Oct–Apr (peak: Nov–Feb)<br>*Hatching*: Dec–Jun |

**Foraging habitat**

*Post-hatchling/young juveniles:* Spend the first 5-10 years in oceanic waters of the southern Pacific Ocean, utilising floating seaweed rafts and opportunistically feeding on gelatinous organisms, before returning to shallow foraging habitats: reefs, mangroves or seagrass meadows.

*Juvenile-adult:* Tidal/sub-tidal habitats with coral reef, mangrove, sand, rocky reefs and mudflats where there are algal turfs or seagrass meadows present[18]. A proportion of turtles may also remain resident in the open ocean[92].

*Foraging grounds monitored:* New Caledonia[192], Moreton Bay, Heron/Wistari Reefs, Shoalwater Bay[145], Hervey Bay[225].

*Distribution*: See Figure 10.

**Stock description**

A large proportion of this stock nests on remote coral cays protected within the Coral Sea Commonwealth Marine Reserve and forages within the Great Barrier Reef Marine Park. As such, this stock is considered likely to be robust, despite a lack of longitudinal monitoring. Further, there is a close genetic association with the Chesterfields Island nesters (New Caledonia), suggesting that the stock may be larger than previously thought[192]. Management of this stock is primarily undertaken by Parks Australia, the Great Barrier Reef Marine Park Authority and the Queensland Government.

The main uncertainty surrounding this stock is its resilience to predicted changes in cyclone activity as a result of climate change and how quickly low lying coral cays will recover after extreme weather events. Due to the remote nature of its nesting and foraging habitats, it is also not known to what extent this stock is affected by 'marine debris', 'international take' and 'fisheries bycatch'.

| Priority actions specifically required to recover this stock | Action Area |
|---|---|
| Assess long-term impacts of extreme weather on nesting beaches. | A2 |
| Identify and protect suitable beaches and islands that could be used as nesting habitat under a rising sea level model/scenario to ensure that these are suitable for colonisation in the future. | A2 |

**Measure of success**

*Due to its inaccessibility, long-term monitoring has not been advocated for this stock, and therefore, an appropriate measure of success cannot be determined.*

| Green – northern Great Barrier Reef (G-nGBR) | | Early stages of decline[33] |
|---|---|---|
| **Threats** | A. Climate change and variability | Very high |
| | H. Habitat modification – extractive industries (historical) | Very high |
| | B. Marine debris – entanglement | High |

| **Important nesting areas** | **Internesting Buffer: 20 km** |
|---|---|
| *Major*: Raine Island, Moulter Cay[142].<br>*Minor*: Murray Is., Bramble Cay, Sandbanks No. 7 and 8, Dauar Is., Milman Is., mainland coast from Cape Grenville to Torres Strait.<br>*Index beaches monitored*: Raine Island (1974- ), Moulter Cay[142], Bramble Is., Dauar Island (2006- )[87]. | *Mating*: Aug–Dec<br>*Nesting*: Oct–Mar (peak: late Dec–early Jan)<br>*Hatching*: Dec–May |

**Foraging habitat**

*Post-hatchling/young juveniles:* Spend the first 5-10 years in oceanic waters of the southern Pacific Ocean, utilising floating seaweed rafts and opportunistically feeding on gelatinous organisms, before returning back to inshore foraging habitat.

*Juvenile-adult:* Tidal/sub-tidal habitats with coral reef, mangrove, sand, rocky reefs and mudflats where there are algal turfs or seagrass meadows present[18]. A proportion of turtles may also remain resident in the open ocean[92].

*Foraging grounds monitored:* Torres Strait (aerial surveys), Shoalwater Bay[145], Edgecumbe Bay, (Gudjuda Rangers) and the Howick Group.

*Distribution:* See Figure 9.

**Stock description**

Raine Island and Moulter Cay support greater than 90 per cent of nesting for this stock[142]. Raine Island, Moulter Cay and MacLennan Cay make up the Raine Island National Park (Scientific). Raine Island is surrounded by a separate marine national park zone. Access to the island is restricted by a 'Restricted Area – Special Management Area' designated under the *Great Barrier Reef Marine Park Zoning Plan 2003*. It is also subject to an Indigenous Land Use Agreement. There is concern that reproductive output at Raine Island has decreased with low nesting success and hatchling production and large numbers of adult turtles dying on the island as a result of heat exhaustion and cliff falls[142]. The cause of the low hatchling production is not fully understood, although changes to the landscape of the island and changes in extreme weather causing tidal inundation, and ocean acidification due to climate change may be affecting the availability of suitable nesting habitat[45, 185]. The Queensland Government has initiated the Raine Island Recovery Project (2015-2020) aimed at addressing these issues.

The Torres Strait provides important foraging habitat for green turtles from this stock[202], although the foraging range for this stock does extend into Northern Territory waters (Groom *et al.* 2017, in press). Foraging in these waters and the Gulf of Carpentaria increases the risk of entanglement by ghost nets[255]. Turtles in this stock support the Torres Strait Turtle Fisheries – a traditional subsistence fishery that is limited to Traditional Inhabitants of the Torres Strait and Papua New Guinea, and are hunted in the Northern Territory (Groom *et al.* 2017, in press). Traditional take in the Torres Strait is managed through community-based management plans. The Torres Strait Regional Authority (TSRA) employs Indigenous rangers and a dedicated Sea Team to support the implementation of community-based management plans. The TSRA in conjunction with Australian Border Force works to address additional pressures of 'international illegal take'.

| Priority actions specifically required to recover this stock | Action Area |
|---|---|
| Continue demonstrably successful intervention at Raine Island (Recovery Project), including reducing adult mortality and increasing hatchling production. | A2, B1 |
| Support and expand community based management programs in the Torres Strait and northern Australia. | A10 |
| Continue monitoring nest and hatching success at Bramble Cay and Dauar Island to assess these islands as potential areas of refugia for this stock. | A2, B1 |
| Undertake genetic testing of foraging populations to support assessment of Raine Island population demographics. | B2 |

| Measure of success | |
|---|---|
| *Reproductive output from Raine Island increases over the life of Plan* | B1 |

| Green – Gulf of Carpentaria (G-GoC) | | Unknown |
|---|---|---|
| **Threats** | B. Marine debris – entanglement | Very high |
| | I. Indigenous take | High |
| | E. International take – outside Australia's jurisdiction | High |

| Important nesting areas | Internesting Buffer: 20 km |
|---|---|
| *Major*: Wellesley Islands (Bountiful, Pisonia and Rocky Islands), Binanangoi Point to Cape Shield, Gove, Borroloola, Groote Eylandt, Sir Edward Pellew Islands[136]. | *Mating*: Unknown |
| *Minor*: Drysdale, Burbidge, Dudley, Hawksnest, Sandy, Watson, Pearce Islands and Isle Woodah, Wedge Rock, North East Isle[136]. | *Nesting*: year round (peak: Jun–Jul) |
| *Index beaches monitored*: No ongoing monitoring. Census: Wellesley Group, Groote Eylandt and Sir Edward Pellew Islands[136]. | *Hatching*: peak: Aug–Sep |

**Foraging habitat**

*Post-hatchling/young juveniles:* Unknown, likely to disperse through oceanic waters of the Indo-Pacific.

*Juvenile-adult:* Tidal/sub-tidal habitats with coral reef, mangrove, sand, rocky reefs and mudflats where there are algal turfs or seagrass meadows present[18]. A proportion of turtles may also remain resident in the open ocean[92].

*Foraging grounds monitored*: None.

*Distribution*: See Figure 10.

**Stock description**

Management of this stock is primarily undertaken by community groups and Indigenous rangers with the support of the Northern Territory and Queensland Governments. Green turtle nesting in the Gulf of Carpentaria was estimated to be approximately 5000 per year in 2008, and at 1000's per year for the north-east Arnhem Land rookeries[136]. The majority of this stock nests within Indigenous Protected Areas including: Laynhapuy (Yirralka), Dhimurru, Anindilyakwa (Groote Eylandt Archipelago), Yanyuwa (Li-Anthawirriyarra), Barni-Wardimantha Awara Yanyuwa (Sir Edward Pellew), and Thuwathu/Bujimulla (Wellesley Islands). Management activities include ghost net and marine debris patrols and clean up, monitoring of nesting turtle abundance, and satellite tracking of adult females.

Historically, this stock is likely to have been heavily impacted by bycatch in the trawl fisheries until turtle excluder devices were introduced in 2001[23]. The Gulf of Carpentaria is considered to be a ghost net hotspot with estimates of 672-2015 green turtles being captured each year in ghost nets[3]. Similarly, fishery bycatch hotspots have been identified in the Gulf of Carpentaria, with pelagic gillnets particularly problematic for green turtles in the Northern Territory[196]. Concerns were raised during community consultation about the potential for impacts of trawling, where the nets damage the benthic environment in this region[4].

Historically, there has also been a reported high level of egg take in some parts of this region over time[36, 125]. Communities that identified take as a potential concern have proposed increasing education and support for ranger groups as the most effective means to manage this threat[5].

The potential for future oil and gas expansion in the Gulf of Carpentaria poses a threat to this stock from increased noise, lighting, and risk of oil and chemical spills. Anecdotal evidence suggests that an increase in foreign fishing vessels entering the Gulf peaked in 2005, but by 2011 had declined due to enforcement and education[6].

There is no long-term monitoring data from index beaches available for this stock. To determine whether the stock is recovering from historical threats it is necessary to establish long-term monitoring at appropriate index beaches.

*Continued over*



3 Based on greens turtles being 13.8 per cent of 4866-14600 turtles captured (Wilcox *et al*., 2014).

4 Community consultation – Cairns 27 May 2015

5 Indigenous Consultation, Northern Territory, 22-27 June 2015

6 Paul Sutherland (10 November 2011). "Less illegal fishing in the Gulf of Carpentaria". ABC News (Australian Broadcasting Corporation)

| Green – Gulf of Carpentaria (G-GoC) | Unknown |
|---|---|
| **Priority actions specifically required to recover this stock** | **Action Area** |
| Ensure clean-up activities are timed appropriately to coincide with on-shore peaks in marine debris (i.e. prior to wet season). | A3 |
| Devise innovative methods for the early identification and intervention of ghost nets entering the Gulf of Carpentaria. | A3 |
| Develop and support alternate technologies for the disposal of collected waste. | A3 |
| Support collection of tissue samples from stranded marine turtles. | A3 |
| Support and expand indigenous ranger and community management programs. | A10 |
| Engage in and implement bi- and multi- lateral agreements to improve the protection of Australia's marine turtles through best practice fisheries management. | A7 |
| Better understand risk from fisheries interactions. | A7 |
| Commence long-term monitoring of index beaches and key foraging areas. | B1, B2 |
| **Measure of success** | |
| *Trends in nesting turtle abundance are assessed for this stock* | B1 |

| Green – Cobourg (G-Cobourg) | | Unknown |
|---|---|---|
| **Threats** | B. Marine debris – entanglement | Very high |
| | A. Climate change and variability | High |
| | C. Chemical and terrestrial discharge – acute | High |

| Important nesting areas | Internesting Buffer: 20 km |
|---|---|
| *Major*: Black Point and Smith Point and McCluer, Croker and Lawson Islands[36, 107].<br>*Index beaches monitored*: None currently monitored.<br>Census data: Cobourg Peninsula[36, 107]. | *Mating:* Sep–Nov (peak: Oct)<br>*Nesting*: Oct–Apr (peak: Dec–Jan)<br>*Hatching*: peak: Dec–May (peak: Feb–Mar) |

**Foraging habitat**

*Post-hatchling/young juveniles:* Unknown. Hatchlings likely disperse through waters of the Indian Ocean/Arafura Sea region.

*Juvenile-adult:* Tidal/sub-tidal habitats with coral reef, mangrove, sand, rocky reefs and mudflats where there are algal turfs or seagrass meadows present[18]. A proportion of turtles may also remain resident in the open ocean[92].

*Foraging grounds monitored:* None.

*Distribution*: See Figure 11.

**Stock description**

The Cobourg stock has only recently been delineated as a separate genetic stock[63]. It appears to have a geographically limited nesting range within an area co-managed by the Northern Territory Government and the Djelk, Garngi, Mardbalk, Garig Gunak Barlu, and Crocodile Island Ranger groups. Cobourg is a national park comprising the entire Peninsula and surrounding waters of the Arafura Sea and Van Diemen Gulf, and some of the neighbouring islands. In addition to the Peninsula, green turtles have also been recorded nesting on the Tiwi Islands albeit in low numbers[36], but the genetic stock of these turtles is currently unknown. There is no long-term nesting or foraging habitat data available for this stock, so long-term trends are unknown. Turtles from this stock nest and forage in areas that have been identified as ghost net 'hotspots'[256] and although not quantified, it is likely that turtles from this stock are impacted. While a large proportion of the marine debris found around Cobourg is ghost nets, there is also urban rubbish of international origins[237]. Due to the location of this stock's preferred nesting habitat, its capacity to expand into other areas in the event of sand temperature increases is limited, although it does have the potential to change the timing of nesting to cooler months. This stock also has a limited capacity to compensate for habitat loss as a result of extreme weather events and climate change. Nest predation is not quantified, but across the recorded range of this stock, predation by pigs, dogs/dingoes and goannas occurs. Pigs at Cobourg National Park are managed directly by the rangers on site.

| Priority actions specifically required to recover this stock | Action Area |
|---|---|
| Support the implementation of management plans and build capacity to undertake monitoring, education, and compliance management of marine turtles. | A1, A2, A3, A6, A10 |
| Understand the risk of entanglement for this stock. | A3 |
| Quantify predation of eggs and hatchlings by terrestrial predators. | A6 |
| Ensure that spill risk strategies include management for marine turtles and their habitats. | A4 |
| Initiate long term monitoring of nesting turtle abundance at index beaches. | B1 |
| **Measure of success** | |
| *Long-term monitoring is established for this stock.* | B1 |

| Green – North West Shelf (G-NWS) | | Stable[136] |
|---|---|---|
| **Threats** | C. Chemical and terrestrial discharge – acute | High |
| | G. Light pollution | High |

| **Important nesting areas** | **Internesting Buffer: 20 km** |
|---|---|
| *Major*: Lacepedes, Montebello, Barrow, Muiron, Browse Islands and Northwest Cape[136].<br><br>*Minor*: Boodie, Middle, Serrurier, Thevenard, Lowendal, Rosemary, Legendre, Delambre Islands and various mainland beaches, Shark Bay to Ningaloo and Kimberley Coast[136].<br><br>*Index beaches monitored*: Gnaraloo Bay[94], Lacepedes (1990s- ), Ningaloo Coast (2000s- ), Montebello, Barrow[39], Muiron, and Browse Islands, Northwest Cape[136]. | *Mating:* Sep–Dec<br><br>*Nesting*: Nov–Mar (peak: Dec–Feb)<br><br>*Hatching*: Jan–May (peak: Feb–Mar) |

**Foraging habitat**

*Post-hatchling/young juveniles:* Unknown. Likely to disperse through much of the Indian Ocean/Arafura Sea.

*Juvenile-adult:* Tidal/sub-tidal habitats with coral reef, mangrove, sand, rocky reefs and mudflats where there are algal turfs or seagrass meadows present[18]. A proportion of turtles may also remain resident in the open ocean[92].

*Foraging grounds monitored*: Ningaloo[195], Uunguu Rangers monitor Wunambal Gaamera sea country using ITracker[114]. A small proportion of green turtles foraging at Cocos Keeling are from the North West Shelf stock[249]. Genetic analysis[50] indicates this stock is found foraging at Ashmore Reef, Fog Bay, Cobourg and Field Island, and also at Shark Bay and Cocos Keeling[117].

*Distribution*: See Figure 9.

**Stock description**

The North West Shelf stock is one of the largest green turtle stocks in the world and the largest in the Indian Ocean[205]. Historically, green turtles were harvested in the region by early explorers and as part of a commercial fishery (1870 to 1973)[82] and a large number of juvenile and adult turtles died as a result of atomic bomb testing in the Montebello Island Group in the 1950's[181]. More recently, bycatch of turtles in trawls was problematic until the introduction of turtle excluder devices in trawl fisheries.

Nesting occurs over a large geographic range with nesting on offshore islands and the mainland. Management is overseen by the Western Australian Government through the *Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007-2017*[46], *Barrow Group Nature Reserves Management Plan*[48], and *Eighty Mile Beach Marine Park Management Plan 2014-2024*[47]. Indigenous communities along the coast monitor foraging grounds through a variety of programs such as I-tracker[114]. Offshore nesting is considered largely secure from terrestrial predation. Mainland terrestrial predation is controlled through initiatives such as the Ningaloo Coast Fox Control Program.

The stock appears stable[136], but given its range overlaps with high intensity oil and gas industry activities, it may be increasingly subject to impacts from artificial light[121], habitat modification and oil spills. The impacts of noise are poorly understood for marine turtles. This stock provides an opportunity to address this knowledge gap as it is subject to seismic and other industrial noise[175]. Many of the mainland beaches are subject to tourism activities such as beach driving, which has proven to be difficult to manage during the nesting and hatchling season.

Turtles remain an important part of Indigenous culture and a food source for many communities across north-western Australia. Eggs are harvested at beaches and adult turtles are taken for meat when they return to foraging grounds. Anecdotal reports have noted a decrease in size of foraging turtles[7]. Most Indigenous groups are actively managing or have started to manage community expectations about sustainable take. Turtles foraging out in the open ocean are also at risk from ghost nets carried along the currents from Indonesian waters towards the Gulf of Carpentaria[255]. The combined impacts of multiple threats may have a cumulative impact on the stock.

*Continued over*

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| Green – North West Shelf (G-NWS) | Stable[136] |
|---|---|
| **Priority actions specifically required to recover this stock** | **Action Area** |
| Artificial light within or adjacent to habitat critical to the survival of marine turtles will be managed such that marine turtles are not displaced from these habitats as per section 3.3 Table 6. | A8 |
| Ensure that spill risk strategies and response programs include management for turtles and their habitats. | A4 |
| Given this is a relatively accessible stock that is likely to be exposed to anthropogenic noise - Investigate the impacts of anthropogenic noise on turtle behaviour and biology and extrapolate findings from the North West Shelf stock to other stocks. | B3 |
| Support the implementation of management plans and build capacity to undertake monitoring, education, and compliance management of marine turtles. | A1, A2, A3, A6, A10 |
| Understand the threat posed to this stock by marine debris. | A3 |
| Continue long-term monitoring of index beaches. | B1 |
| **Measure of success** | |
| *Trends in nesting turtle numbers for this stock continue to be stable or increasing* | B1 |

| Green – Ashmore Reef (G-AR) | | Unknown |
|---|---|---|
| **Threats** | A. Climate change and variability | Very high |
| | B. Marine debris – entanglement | Very high |
| | C. Chemical and terrestrial discharge – acute and chronic | High |
| | D. Terrestrial predation | High |

| **Important nesting areas** | **Internesting Buffer: 20 km** |
|---|---|
| *Major*: Ashmore and Cartier Reefs[79]. | *Mating:* Sep–Nov |
| *Index beaches monitored*: Census data for West Island[79]. | *Nesting*: year round (peak: Dec–Jan) |
| | *Hatching*: Sep–May |

**Foraging habitat**

*Post-hatchling/young juveniles:* Unknown. Likely to disperse through the waters of the Indian Ocean/Arafura Sea.

*Juvenile-adult:* Tidal/sub-tidal habitats with coral reef, mangrove, sand, rocky reefs and mudflats where there are algal turfs or seagrass meadows present[18]. A proportion of turtles may also remain resident in the open ocean as adults[92].

*Foraging grounds monitored*: Ashmore Reef foraging population is likely to be mixed genetic stock[50].

*Distribution*: See Figure 10.

**Stock description**

The Ashmore Reef stock nests in a localised area of the Indian Ocean in the Ashmore Reef and Cartier Island Commonwealth Marine Reserves areas. Management of this stock is the responsibility of Parks Australia.

Climate change may decrease hatchling production in this rookery through increased erosion at West Island and changes in sand temperature profiles. Although pivotal and lethal temperatures are not known for this stock, sand temperatures at Ashmore Reef have been recorded approaching lethal limits for successful incubation[167, 242]. Loss of *Argusia* spp. has been noted to be contributing to increases in sand temperatures on Ashmore Reef. It is not known whether this loss of vegetation will result in changes to the sex-ratio of hatchlings emerging from nesting beaches. A planting program was undertaken in 2005 with limited success, and has been suggested as a way to manage increases in sand temperature[161].

Egg predation by tropical fire ants (*Solenopsis geminata*) has been identified on West Island, and could be an increasing problem[79]. A tropical fire ant baiting survey conducted in December 2015 by Parks Australia in association with Australian Border Force and Monash University, concluded that the distribution and abundance of tropical fire ants have recovered to pre-baiting levels on Middle Island, with increasing activity on East Island and high coverage on West Island affecting nesting on those islands[104]. Given the localised nature of this stock, it would be beneficial to monitor impacts to nesting success.

The exposure to marine debris is not well quantified in Western Australia. However, turtles foraging in the open ocean are at risk from ghost nets in the Arafura-Timor Sea[255]. While the risk of an oil spill is generally considered low, the consequences would be substantial due to the small range and localised nature of this stock, and the risk increases with each new activity. The consequences of an oil spill have implications for the immediate health of marine turtles and their nesting, future nesting activities, water quality and general turtle health[206].

It has been reported that non-permitted harvest of female turtles by non-Australian fishers has occurred from the Ashmore Reefs and Cartier Islands[239]. Similarly, an unknown proportion of the stock feeds outside Australian waters and is likely subject to foreign harvest[136].

*Continued over*

| Green – Ashmore Reef (G-AR) | Unknown |
|---|---|
| **Priority actions specifically required to recover this stock** | **Action Area** |
| Understand pivotal temperatures and thermal tolerance for this stock and where necessary investigate management approaches to mitigating impacts from increased sand temperatures. | A2, A9, B3 |
| Support tropical fire ant management program at Ashmore Reef. | A1, A6 |
| Liaise at a regional scale to address and reduce the source of marine debris in Australian waters. | A3 |
| Ensure that spill risk strategies and response programs include management for turtles and their habitats. | A4 |
| Identify the proportion of this stock subject to international take and determine whether further action is required. | A5 |
| **Measure of success** | |
| *Due to its inaccessibility, long-term monitoring has not been advocated for this stock and therefore an appropriate measure of success cannot be determined.* | |

| Green – Scott Reef - Browse Island (G-ScBr) | | Unknown |
|---|---|---|
| **Threats** | A. Climate change and variability | High |
| | C. Chemical and terrestrial discharge – acute and chronic | High |
| | H. Habitat modification – infrastructure/coastal development | High |
| **Important nesting areas** | | **Internesting Buffer: 20 km** |
| *Major*: Scott Reef and Browse Island[77]. | | *Mating:* Oct |
| *Index beaches monitored*: None currently monitored. Census – Sandy Islet, Browse Island[77]. | | *Nesting*: Nov–Mar (peak Jan–Feb) |
| | | *Hatching*: Peak Mar–Apr |

**Foraging habitat**

*Post-hatchling/young juveniles:* Unknown. Likely disperse through waters of the Arafura-Timor Seas.

*Juvenile-adult:* Tidal/sub-tidal habitats with coral reef, mangrove, sand, rocky reefs and mudflats where there are algal turfs or seagrass meadows present[18]. A proportion of turtles may also remain resident in the open ocean[92].

*Foraging grounds monitored*: Census (2006)[79]. Monitoring of foraging turtles at Cocos Keeling identified some resident turtles from the Scott-Browse genetic stock[249].

*Distribution*: See Figure 11.

**Stock description**

The Scott-Browse stock is a discrete genetic unit known to nest at two locations within a localised area in the Indian Ocean. Sandy Islet at Scott Reef is an un-vegetated sand cay, while Browse Island is vegetated[79]. The environment at Scott Reef has been subject to multiple events since 1998 including three cyclones (one category 5), an outbreak of disease and two bleaching events[72] before 2013 and another in 2016[8], which potentially have reduced the resilience of Sandy Islet. The accumulation of sand and its subsequent removal during cyclonic wash-overs and the frequency of thermal plumes associated with increasing sea temperatures and the anticipated rise in sea level due to climate change make the rookery at Sandy Islet extremely vulnerable (Guinea, pers. comm. 2017). The survival of the islet is further in doubt with the subsidence and compaction of rock strata underlying the reef as the oil and gas reserves of the Torosa Field are extracted (Guinea, pers. comm. 2017). Management of this stock's environment is undertaken by the Western Australian Government in conjunction with Industry partners working in the region. There is a lack of data regarding the status of this stock and a better understanding of the trends in nesting abundance would assist in identifying appropriate management measures. This stock is considered likely to be restricted in its capacity to expand into other nesting areas in the event that nesting beaches are lost or sand temperatures increase as a result of climate change. It is not known whether loss of vegetation occurring at Browse Island will result in changes to the sex-ratio of hatchlings emerging on nesting beaches[77]. While the risk of an oil spill is generally considered low, the consequences would be substantial due to the small range and localised nature of this stock, and the risk increases with each new activity. The consequences of an oil spill have implications for the immediate health of marine turtles and their nesting, future nesting activities, water quality and general turtle health[206].

The extent to which marine debris impacts this stock is not known. However, marine turtles foraging in the open ocean are at risk from ghost nets carried along the currents from Indonesian waters towards the Gulf of Carpentaria[255]. An unknown proportion of the stock forages outside Australian waters and is likely subject to harvest in Indonesia[136]. There are also anecdotal reports of illegal harvest of adults and eggs at Browse Island and Sandy Island (Pendoley, pers. comm. 2015), however the extent of take is currently unknown. Predation by tropical fire ants (*Solenopsis geminata*) has been recorded at Ashmore Reef[79] and as the ants can move from island to island they may also colonise Browse Island.

*Continued over*

8 http://www.aims.gov.au/-/western-australian-reefs-feel-the-heat-from-global-bleaching-event (accessed 31/01/2017)

| Green – Scott Reef - Browse Island (G-ScBr) | Unknown |
|---|---|
| **Priority actions specifically required to recover this stock** | **Action Area** |
| Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival as per section 3.3 Table 6. | A9 |
| Understand the implications of sea level rise for this stock. | A2, B3 |
| Establish a long-term monitoring program at index beaches to assess trends in nesting turtle abundance. | B1 |
| Understand the impact of international take on the Scott-Browse stock. | A5, B3 |
| **Measure of success** | |
| *Trends in nesting turtle abundance are assessed for this stock* | B1 |

| Green – Cocos Keeling (G-CK) | | Recovering[155] |
|---|---|---|
| **Threats** | A. Climate change and variability | Very high |
| | H. Habitat modification – dredging and trawling | High |

| **Important nesting areas** | **Internesting Buffer: 20 km** |
|---|---|
| *Major*: North Keeling Island[241].<br>*Index beaches monitored*: North Keeling Island (1999-2010)[241]. | *Mating:* Sep–Nov (peak: Oct)<br>*Nesting*: Oct–Apr (peak: Dec–Jan)<br>*Hatching*: Dec–May (peak: Feb–Mar) |

**Foraging habitat**

*Post-hatchling/young juveniles:* Unknown. Likely disperse through waters of the Indian Ocean.

*Juvenile-adult:* Tidal/sub-tidal habitats with coral reef, mangrove, sand, rocky reefs and mudflats where there are algal turfs or seagrass meadows present[18]. A proportion of turtles may also remain resident in the open ocean[92].

*Foraging grounds monitored*: Studies of turtles foraging at Cocos (Keeling) (north island and south lagoon) have occurred annually since 1999 (except 2008 and 2013)[249].

*Distribution*: See Figure 11.

**Stock description**

The Cocos (Keeling) Islands are part of a remote Australian territory in the Indian Ocean (1000 km from Indonesia and 2100 km from Australia). The Cocos (Keeling) nesting aggregation is a small, but genetically unique stock[63, 249]. A large proportion of green turtles remain resident (juvenile and adult), foraging around the southern atoll[249]. Approximately 70 per cent of marine turtles foraging in the Cocos (Keeling) islands lagoon are from this stock with the remainder from the North West Shelf and Scott-Browse stocks[116]. North Keeling Island is protected within the Pulu Keeling National Park, which is managed by Parks Australia. While this stock appears to be recovering, given its small size and restricted range of nesting, it is susceptible to anthropogenic impacts such as rising sea level and increased sand and water temperatures resulting from climate change. Similarly, dredging and increased water temperature are likely to decrease the availability of seagrass habitat[249]. Development activities that have occurred on the island with potential for impacts to the resident turtles include the dredging for jetties and boat access[249]. Given the localised nature of this stock and history of monitoring, ongoing monitoring of nesting and foraging populations should continue.

| Priority actions specifically required to recover this stock | Action Area |
|---|---|
| Understand how changes in sand and water temperature affect reproductive and foraging success. | A2 |
| Manage dredging and trawling such that marine turtles continue to utilise seagrass habitat without injury and are not displaced as a result of these activities. | A9 |
| Continue long-term monitoring of nesting and foraging populations. | B1, B2 |
| **Measure of success** | |
| *The stock continues to recover* | B1 |

| Loggerhead – south-west Pacific (LH-swPac) | | Early stages of decline[138] |
| --- | --- | --- |
| **Threats** | F. Fisheries bycatch – international | Very high |
| | A. Climate change and variability | High |
| | B. Marine debris – entanglement and ingestion | High |
| | G. Light pollution | High |

| **Important nesting areas** | **Internesting Buffer: 20 km** |
| --- | --- |
| *Major*: Mainland coast Mon Repos to Wreck Rock[144]. | *Mating:* Oct–Dec (peak: Nov) |
| *Minor*: Wreck, Heron, Lady Musgrave, Tryon, Eskine and Northwest Islands, Swains Reef, New Caledonia[144]. | *Nesting*: Oct–Mar (peak: Dec–Jan) |
| *Index beaches monitored*: Mon Repos (1969- ), Wreck Rock (1978- ), Capricorn Bunker Group (1977- )[144]. | *Hatching*: Dec–May (peak: Feb–Mar) |

**Foraging habitat**

*Post-hatchling/young juveniles:* Hatchlings disperse through the southern Pacific Ocean as far as South America[21].

*Juvenile-adult:* Tidal/sub-tidal habitats with hard and soft substrates including rocky and coral reefs, muddy bays, sand flats, estuaries and seagrass meadows[18]. A proportion of turtles may also remain resident in the open ocean.

*Foraging grounds monitored*: Moreton Bay, Heron, Wistari.

*Distribution*: See Figure 12.

**Stock description**

Nesting of loggerhead turtles in the South Pacific Ocean occurs almost entirely on beaches of the east coast of Australia and New Caledonia[136]. Hatchlings disperse through the south Pacific gyre reaching waters off Peru, Chile and Ecuador[21]. Post-hatchlings spend approximately 16 years at sea before returning to the Coral Sea-Tasman Sea region of the south-west Pacific. There has been a severe reduction in the number of turtles recruiting to Australian foraging grounds from this oceanic phase[144]. This could be a result of small turtles being captured as bycatch in fisheries or in marine debris whilst at sea. The decreased recruitment of animals comes on top of a severely reduced population caused by trawling in internesting habitat during the 1980/90s. The introduction of mandatory use of turtle excluder devices in the East Coast Otter Trawl Fishery in 2001 led to a rebound in the nesting turtle abundance[136]. Similarly, fox control measures on mainland beaches has increased hatchling production in Australia[144].

Mainland nesting occurs adjacent to urbanised areas and is at risk from the impacts of anthropogenic light[121]. Climate change impacts also appear to be affecting nesting beaches with changes in hatchling sex ratios and emergence success[40] and increased extreme weather events resulting in erosion of nesting sites[136].

Management of the stock in Australia is primarily undertaken by the Queensland Government and greater than 80 per cent of nesting in Australia occurs in protected areas[144]. In 2014, the *Convention on the Conservation of Migratory Species of Wild Animals* agreed a framework for the regional management of this stock through the *Single Species Action Plan for Loggerhead Turtles (*Caretta caretta*) in the South Pacific Ocean*. This plan addresses threats to this stock throughout their range. Given the longevity of existing nesting and foraging ground monitoring, continued monitoring will allow the assessment of efficacy of threat management and demonstrate stock recovery[32, 34, 35].

*Continued over*

| Loggerhead – south-west Pacific (LH-swPac) | Early stages of decline[138] |
|---|---|
| **Priority actions specifically required to recover this stock** | **Action Area** |
| Implement the *Single Species Action Plan for Loggerhead Turtles* (Caretta caretta*) in the South Pacific Ocean*. | A1, A3, A5, A7, A8 |
| Quantify the impact of international fishery bycatch on this stock. | A7 |
| Assess the impacts of marine debris, particularly on post-hatchling life phase. | A3 |
| Manage artificial light from onshore and offshore sources to ensure that biologically important behaviour of nesting adults and dispersing hatchlings can continue. | A8 |
| Understand changes in stock trends through monitoring of nesting beaches and demographics at key foraging areas to assess recruitment of juveniles from the pelagic life phase. | B1, B2 |
| Identify potential nesting and foraging areas and ensure they are being protected and managed to provide refugia and range expansion opportunities. | A2, B3 |
| **Measure of success** | |
| *New recruits to foraging grounds are returning in increasing numbers* | B2 |

| Loggerhead – Western Australia (LH-WA) | | Stable[84] |
|---|---|---|
| **Threats** | A. Climate change and variability | High |
| | C. Chemical and terrestrial discharge – acute | High |
| | F. Fisheries bycatch – domestic | High |
| **Important nesting areas** | | **Internesting Buffer: 20 km** |
| *Major*: Dirk Hartog Island, South Muiron Island, North West Cape, Gnaraloo Bay[136].<br>*Minor*: Mainland from Shark Bay to southern North-West Shelf (Northern end Ningaloo Marine Park)[136].<br>*Index beaches monitored*: Dirk Hartog Island (1993-2000; 2011- ), South Muiron Island (1986-1999), North West Cape (1986-2000), Gnaraloo Station (2011- )[11, 93, 94, 193]. | | *Mating:* Unknown<br>*Nesting*: Nov–Mar (peak Jan)<br>*Hatching*: Jan–May |
| **Foraging habitat** | | |
| *Post-hatchling/young juveniles:* Unknown. Likely to disperse through waters of the Indian Ocean.<br>*Juvenile-adult:* Tidal/sub-tidal habitats with hard and soft substrates including rocky and coral reefs, muddy bays, sand flats, estuaries and seagrass meadows[18]. A proportion of turtles may also remain resident in the open ocean.<br>*Foraging grounds studied*: Shark Bay[220].<br>*Distribution*: See Figure 12. | | |
| **Stock description** | | |
| The Western Australian loggerhead turtle stock is one of the largest in the world[136]. The majority of nesting is provided protection by the Shark Bay Marine Park and Shark Bay World Heritage Area and the Ningaloo Coast World Heritage Area[84].<br>Increased industrial development on the Western Australian coast has the potential to impact this stock, particularly through artificial lighting[121] and reduced water quality. While the risk of an oil spill is generally considered low, the consequences could be severe and the risk increases with the level of activity[206]. The consequences of an oil spill have implications for the immediate heath of marine turtles and their nesting, future nesting, water quality and general turtle health.<br>Temperature-dependent sex determination parameters for this stock are similar to those of other loggerhead turtle stocks[260]. Given changes in hatchling sex ratios and emergence success have already been observed in the south-west Pacific stock[40, 216, 217], it is likely that climate change poses a similar threat to the Western Australia stock.<br>Little is known about the foraging distribution of this stock, however loggerhead turtles in the region interact with long-line, trawling and lobster pot fisheries[136]. Loggerhead turtle/fishery interactions have been reported throughout the extent of the Commonwealth long-line fisheries operational ranges[196]. Loggerhead turtles are also occasionally found by Indigenous communities and rangers in ghost nets washed up on Northern Territory beaches[9]. However, mortality associated with ghost nets is not well quantified for this species.<br>In the past, this stock was subject to intense predation by foxes of eggs on mainland beaches[84]. Fox control management has been undertaken by the Western Australian Government in key coastal areas. Ghost crabs are also a major native predator for eggs and hatchlings. | | |

*Continued over*



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| Loggerhead – Western Australia (LH-WA) | Stable[84] |
|---|---|
| **Priority actions specifically required to recover this stock** | **Action Area** |
| Quantify and model how changes in ambient temperatures (sand and water), sea level, frequency of extreme weather events, ocean circulation and acidification affect marine turtle nesting, sex ratios, hatching success, habitats, food availability and their ability adapt to these changes. | A2 |
| Ensure that spill risk strategies and response programs include management for turtles and their habitats, particularly in reference to slow to recover habitats, e.g. seagrass meadows or corals. | A4 |
| Promote best practice bycatch mitigation and innovation in all Australian fisheries. | A7 |
| Understand post-hatchling movements and assess threats in the Indian Ocean. | B3 |
| Determine the extent to which marine debris is impacting loggerhead turtles. | A3, B3 |
| Continue long-term monitoring of nesting and foraging populations. | B1,B2 |
| **Measure of success** | |
| *Trends in nesting turtle abundance for this stock remain stable or are increasing* | B1 |

| **Flatback – Eastern Queensland (F-eQld)** | | **Stable**[148] |
|---|---|---|
| **Threats** | A. Climate change and variability | Very high |
| | G. Light pollution | High |
| **Important nesting areas** | | **Internesting Buffer: 60 km** |
| *Major*: Peak Island, Wild Duck Island, Avoid Island and Curtis Island[148].<br>*Minor*: Woongarra Coast[148].<br>*Index beaches monitored*: Peak Island (1980- ), Wild Duck Island (1981- ), Curtis Island (1980- ), Avoid Island (2007, 2012- ) and Woongarra Coast (Mon Repos) (1968- )[62, 64, 148]. | | *Mating:* Unknown<br>*Nesting*: Oct–Jan (peak: late Nov–early Dec)<br>*Hatching*: Dec–Mar (peak: Feb) |
| **Foraging habitat** | | |
| *Post-hatchling/young juveniles:* Remain on Australian continental shelf from Hervey Bay to the Torres Strait and up to the Gulf of Papua[74].<br>*Juvenile-adult:* Little is known of foraging habitat although trawl captures indicate flatbacks feed in turbid inshore (10-40 m) soft bottom habitats over the continental shelf of northern Australia[199].<br>*Foraging grounds monitored*: Foraging grounds currently unknown.<br>*Distribution*: See Figure 14. | | |
| **Stock description** | | |
| Breeding for this stock is predominantly in the southern Great Barrier Reef around Peak, Wild Duck, Avoid, Curtis and Facing Islands. Low density nesting also occurs on many mainland beaches and offshore islands north of Gladstone. This stock appears to be stable at Wild Duck and Curtis Islands, and on the Woongarra Coast, however tagging data from Peak Island (the largest rookery) has shown a decline over the last three decades[148]. The cause of this decline is not known. Most of the threats facing this stock and their habitats are the result of increased coastal development, particularly with regard to light pollution[121], which is likely to continue to increase into the future. This stock may be susceptible to increased sand temperature associated with climate change as egg survival is reduced when temperatures exceed 32°C[165]. This stock is largely managed by Queensland Parks and Wildlife Service and the Great Barrier Reef Marine Park Authority with considerable contributions from local and Indigenous communities. | | |
| **Priority actions specifically required to recover this stock** | | **Action Area** |
| Understand the decline in nesting numbers at Peak Island, including impacts of light. | | A8, B1 |
| Quantify and model how changes in ambient temperatures (sand and water), sea level, frequency of extreme weather events, ocean circulation and acidification affect marine turtle nesting, sex ratios, hatching success, habitats, food availability and their ability adapt to these changes. | | A2 |
| Develop and implement best practice light management guidelines for existing and future developments adjacent to marine turtle nesting beaches. | | A1, A8 |
| Support retrofitting of lighting at coastal communities and industrial developments, including imposing restrictions around nesting seasons. | | A8 |
| Understand flatback turtle foraging requirements and identify key foraging areas for this stock. | | B2, B3 |
| Continue long-term monitoring of index beaches. | | B1 |
| **Measure of success** | | |
| *The decline in nesting numbers at Peak Island is understood*<br>*Trends in nesting turtle abundance for this stock remain stable or are increasing* | | B1 |

| Flatback – Arafura Sea (F-ArS) | | Unknown[136] |
|---|---|---|
| Threats | B. Marine debris – entanglement | Very high |
| | A. Climate change and variability | High |
| | D. Terrestrial predation | High |
| | I. Indigenous take – eggs | High |

| Important nesting areas | Internesting Buffer: 60 km |
|---|---|
| *Major*: Bare Sand, Field, Deliverance, Crab and Sir Edward Pellew Islands[136]. | *Mating:* Unknown |
| *Minor*: Cobourg Peninsula, Wellesley, Flinders Beach, Jardine River to Edward River and in western Torres Strait[136]. | *Nesting*: all year (peak: Jun–Aug) |
| *Index beaches monitored*: Bare Sand (1996-2016), Field (1990-2016), Deliverance (1987), Crab (1991- ) and Sir Edward Pellew Islands (2000-2002)[201, 243] (Donehue *et al*. 2017, in press; Martin 2017, in press). | *Hatching*: all year (peak: Jul–Sep) |

**Foraging habitat**

*Post-hatchling/young juveniles:* Remain on Australian continental shelf.

*Juvenile-adult:* Little is known of foraging habitat although trawl captures indicated flatback turtles feed in turbid inshore (10-40 m) soft bottom habitats over the continental shelf of northern Australia[199].

*Foraging grounds monitored*: Foraging grounds currently unknown.

*Distribution*: See Figure 14.

**Stock description**

This genetic stock encompasses flatback turtles nesting in the western Torres Strait, around the Gulf of Carpentaria, north-east Arnhem Land, Cobourg Peninsula and into western Northern Territory. The stock is managed by the Queensland and Northern Territory Governments in collaboration with the Torres Strait Regional Authority and a wide range of community and ranger groups. Crab Island, in the Gulf of Carpentaria, is one of the largest flatback turtle rookeries, and it is estimated that approximately 3000 turtles nesting there per year[214]. Recent studies have reported that numbers of nesting flatbacks at Field Island appear to be relatively stable (Groom *et al.* 2017, in press). Monitoring at Bare Sand Island had indicated a three per cent decline per year[243], but ongoing monitoring is to be analysed soon (Groom *et al.* 2017, in press). The decline may be due to cumulative impacts from multiple sources of mortality. Ghost net hotspots have been identified throughout this stock's nesting and likely foraging habitats[255]. Approximately 10 per cent of all turtles captured in ghost nets are flatback turtles[256]. The main source of egg mortality is from terrestrial predation by dogs, dingoes and goannas, with up to 52 per cent of clutches affected at Fog Bay[20, 36]. Pig predation occurs on Bathurst Island[36]. Historically the collection of eggs by humans has been unsustainable[36, 125]. Indigenous communities who identified take as a potential concern have proposed increasing education and support for ranger groups as the most effective means to manage this threat[10].

Peak nesting for this stock occurs in winter and the high pivotal temperatures and high nest incubation temperatures suggest that this stock may have some resilience to climate change[109], noting that further temporal shifts in nesting are not possible due to the stock nesting in winter[76]. Future seabed mining is considered a potential high risk for the ongoing viability of this stock. Currently, the moratorium on seabed mining in the Northern Territory has been extended for another three years to 2018. This may provide a future threat to turtle foraging habitats. There are also planned port developments for the Gulf of Carpentaria in Weipa, MacArthur River, Groote Eylandt and Gove.

*Continued over*

| Flatback – Arafura Sea (F-ArS) | Unknown[136] |
| --- | --- |
| **Priority actions specifically required to recover this stock** | **Action Area** |
| Support Indigenous and Torres Strait community programs to manage turtles and the implementation of their land and sea country management plans. | A1, A3, A6, A10 |
| Determine important flatback turtle foraging areas across northern Australia and compare marine debris hotspots foraging areas, post hatchling dispersal and migratory pathways to identify high priority mitigation areas. | A3, B3 |
| Quantify predation of eggs and hatchlings by terrestrial predators and implement terrestrial predator management programs. | A6 |
| Continue long-term monitoring of index beaches to assess trends in nesting abundance. | B1 |
| **Measure of success** | |
| *Trends in nesting turtle abundance for this stock are reversed* | B1 |

| Flatback – Cape Domett (F-CD) | | Unknown |
|---|---|---|
| **Threats** | A. Climate change and variability | High |
| | C. Chemical and terrestrial discharge – acute | High |
| **Important nesting areas** | | **Internesting Buffer: 60 km** |
| *Major*: Cape Domett[238].<br><br>*Index beaches monitored:* Cape Domett, WA (2005-2010)[238]. | | *Mating:* year round<br><br>*Nesting*: all year (peak: Aug–Sept)<br><br>*Hatching*: all year |
| **Foraging habitat** | | |
| *Post-hatchling/young juveniles:* Unknown, likely to remain in waters over the Australian continental shelf.<br><br>*Juvenile-adult:* Flatback turtles favour soft sediment habitats that support benthic invertebrates[199]. Important foraging habitat has not been identified for this stock.<br><br>*Foraging grounds monitored:* None.<br><br>*Distribution*: See Figure 14. | | |
| **Stock description** | | |
| Cape Domett is an important high density nesting area. Combined with a smaller site at Lacrosse Island, this stock is likely one of the largest flatback turtle stocks. Average nesting abundance at Cape Domett is estimated at 3250 females per year[238], which is comparable to the largest known flatback turtle aggregation at Crab Island in the Gulf of Carpentaria[214]. The nesting habitat for the Cape Domett stock has been recommended for protection within the Western Australian Ord River Nature Reserve. This Nature Reserve is managed in collaboration with the Balanggarra and Miriuwung Gajerrong people.<br><br>A study on climate change impacts suggests that male-biased sex ratios are more likely at Cape Domett than at other rookeries, but like other rookeries, the projected warming trend over the longer term may result in feminisation[212]. There are also concerns that this stock may not have range expansion opportunities if nesting habitat is impacted by sea level rise. Similarly, the highly localised nature of this stock means that they are also more at risk from stochastic events. For example, impacts from chemical and terrestrial discharge are a concern due to the increasing number of oil and gas installations occurring along the Western Australian coast. While the risk of an oil spill is generally considered low, the consequences could be substantial and the risk increases with each activity. The consequences of an oil spill have implications for the immediate heath of marine turtles and their nesting, future nesting, water quality and general turtle health[206]. Cape Domett is currently considered remote, however, the impacts of marine debris are increasing from local and international sources, and marine turtles foraging in these waters are likely to encounter ghost nets[255]. Nest predation by dingoes has been observed at a rate of one clutch per night[238]. There is a suggestion that night herons have the potential to be a major impact because of the large numbers of hatchlings observed being predated[238]. Aboriginal communities have also raised concerns regarding the impacts of tourism, fishing and industrial developments on nesting turtle numbers[11]. | | |
| **Priority actions specifically required to recover this stock** | | **Action Area** |
| Identify and protect areas likely to provide refugia and range expansion. | | A2 |
| Ensure that spill risk strategies and response programs include management for turtles and their habitats, particularly in reference to slow to recover habitats, e.g. nesting beaches and important foraging grounds. | | A4 |
| Continue long-term monitoring of index beaches to assess trends in nester abundance. | | B1 |
| **Measure of success** | | |
| *Trends in nesting turtle abundance are assessed for this stock.* | | B1 |

11 Community consultation, 11 August 2015

| Flatback – south-west Kimberley (F-swKim) | | Unknown |
|---|---|---|
| **Threats** | C. Chemical and terrestrial discharge – acute | High |

| **Important nesting areas** | **Internesting Buffer: 60 km** |
|---|---|
| *Major*: Eco Beach, Eighty Mile Beach.<br><br>*Index beaches monitored*: Eco Beach (2008- )[162], Eighty Mile Beach (2008- )[47]. | *Mating:* year round<br><br>*Nesting*: all year (peak: Dec–Jan)<br><br>*Hatching*: all year |

**Foraging habitat**

*Post-hatchling/young juveniles:* Unknown, likely to remain in waters over the Australian continental shelf.

*Juvenile-adult:* Flatback turtles are known to favour soft sediment habitats that support benthic invertebrates[199]. Important foraging habitat has not been identified for this stock.

*Foraging grounds monitored*: None.

*Distribution*: See Figure 14.

**Stock description**

The genetic relationship between this nesting aggregation and the Cape Domett and Pilbara stocks is currently under review. Aboriginal communities whose sea and land country overlap at Eighty Mile Beach collaborate with the CSIRO and Western Australian Department of Parks and Wildlife to manage and monitor the south-west Kimberley stock. The *Management Plan for the Eighty Mile Beach Marine Park Reserve* also includes management and monitoring of turtles[47].

The likelihood of impacts from chemical and terrestrial discharge is rising due to the increasing number of oil and gas installations occurring along the Western Australian coast. While the risk of an oil spill is generally considered low, the consequences could be substantial and the risk increases with each activity. The consequences of an oil spill have implications for the immediate health of marine turtles and their nesting, future nesting, water quality and general turtle health[206]. Aboriginal communities have raised concerns regarding the increasing impacts of tourism, fishing and industrial developments on nesting turtle numbers[12]. Turtles nesting at Eco Beach demonstrate low embryonic mortality at high nest temperatures, suggesting some resilience to increased sand temperatures resulting from climate change[162]. Although important foraging areas for this stock have not been identified, it is likely that turtles from this stock encounter ghost nets when at sea as the prevalence of marine debris in the region is increasing from local and international sources[255]. Work undertaken as part of the North West Shelf Flatback Turtle Conservation Program to manage foraging grounds for the Pilbara stock are likely to benefit turtles from the south-west Kimberley stock as turtles will probably overlap at foraging grounds. Existing nest monitoring programs should continue to enable assessment of the efficacy of management programs.

| Priority actions specifically required to recover this stock | Action Area |
|---|---|
| Determine the relatedness of genetic stocks among Western Australian flatback turtle rookeries. | B3 |
| Ensure that spill risk strategies and response programs include management for turtles and their habitats, particularly in reference to slow to recover habitats, e.g. seagrass meadows or corals. | A4 |
| Continue the implementation of the North West Shelf Flatback Turtle Conservation Program. | A1, A6, A8, A9, B3 |
| Continue long-term monitoring of index beaches to assess trends in nesting abundance. | B1 |

| Measure of success | |
|---|---|
| *Trends in nesting turtle abundance are assessed for this stock* | B1 |

12 Indigenous Consultation, Broome 7 May 2015

| Flatback – Pilbara (F-Pil) | | Unknown |
|---|---|---|
| **Threats** | A. Climate change and variability | High |
| | C. Chemical and terrestrial discharge – acute | High |
| | G. Light pollution | High |
| | H. Infrastructure/coastal development | High |

| Important nesting areas | Internesting Buffer: 60 km |
|---|---|
| *Major*: Barrow Island, Mundabullangana Station[182], Delambre Island[136]. | *Mating:* Sep–Jan |
| *Minor*: Thevanard, Varanus, Muiron Islands, Montebello Group, Cemetery Beach, Dampier Archipelago[136, 228]. | *Nesting*: Oct–Mar (peak: Nov–Jan) |
| *Index beaches monitored:* Barrow Island (2005- ), Mundabullangana Station (1992- ) [182], Cemetery Beach (2009-2014)[110] | *Hatching*: Feb–Mar |

**Foraging habitat**

*Post-hatchling/young juveniles:* Unknown, likely to remain in waters over the Australian continental shelf.

*Juvenile-adult:* Flatback turtles are known to favour soft sediment habitats that support benthic invertebrates. Post-nesting satellite tracking indicates foraging occurs along the Western Australian coast in water shallower than 130 m and within 315 km of shore. High use areas included water around Thevenard Island, adjacent to Eighty Mile Beach and Quondong Point, Lynher Banks and the Holothuria Banks[253].

*Foraging grounds monitored:* Ningaloo (Coral Bay)[195].

*Distribution:* See Figure 14.

**Stock description**

This stock nests on many islands in the Pilbara and southern Kimberley, although the extent of genetic relatedness of flatback turtles along the Western Australian coast is currently under review. Post migration satellite tracking indicates this stock is likely to forage along the coast of Western Australia and north to the Gulf of Carpentaria, and a number of likely important foraging grounds have been identified[253].

Infrastructure for oil/gas storage and processing has been developed on islands used by nesting turtles, including Barrow, Thevenard and Varanus Islands and on the mainland at Cape Lambert. These developments have resulted in altered light horizons, increased boat and human activity, increased noise and altered beach profiles[38, 179, 259]. Changes to the benthic environment have occurred through the installation of pipelines and dredging[46]. Port developments also increase the risk of boat strike, benthic disturbance, oil spills, chemical spills and marine debris. Nesting on Barrow Island is monitored through approval conditions for the Chevron Gorgon Project[39] and the whole of stock is managed by Western Australian Government through the North West Shelf Flatback Turtle Conservation Program. Both programs are required to continue through the life of this plan. Monitoring of nesting near Cape Lambert (Bells Beach) and on Delambre Island is conducted by Rio Tinto[17].

Hatchling success at Cemetery Beach and Mundabullangana in 2011-2012 were the lowest recorded for any flatback turtle rookery, and may be attributed to the high temperatures occurring during incubation at these rookeries. This stock appears to be nesting close to the limit of the thermal tolerance of the embryos, which is around 32˚C[182, 228]. Alternatively, storm surges associated with high cyclonic activity in the region affecting the embryonic development may also be a factor[182].

In the past, predation by foxes had impacted this stock on mainland beaches, although management by government agencies and community groups has largely controlled foxes at key sites (Whiting, pers. comm. 2015).

*Continued over*

| Flatback – Pilbara (F-Pil) | Unknown |
|---|---|
| **Priority actions specifically required to recover this stock** | **Action Area** |
| Quantify and model how changes in ambient temperatures (sand and water), sea level, frequency of extreme weather events, ocean circulation and acidification affect marine turtle nesting, sex ratios, hatching success, habitats, food availability and their ability to adapt to these changes. | A2 |
| Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival as per section 3.3 Table 6. | A9 |
| Ensure that spill risk strategies and response programs include management for turtles and their habitats, particularly in reference to slow to recover habitats, e.g. seagrass meadows or corals. | A4 |
| Manage artificial light from onshore and offshore sources to ensure biologically important behaviours of nesting adults and emerging/dispersing hatchlings can continue. | A8 |
| Continue the implementation of the North West Shelf Flatback Turtle Conservation Program. | A1, A6, A8, A9, B3 |
| Continue long-term nest monitoring program at Barrow Island, Mundabullangana Station and Delambre Island. | A1, B1 |
| Quantify predation of eggs and hatchlings by terrestrial predators. | A6, B1 |
| Determine genetic stock relatedness among Western Australian flatback turtle rookeries. | B3 |
| **Measure of success** | |
| *Trends in nesting turtle abundance are stable or increasing* | B1 |

Recovering Marine Turtles

| Hawksbill – north Queensland (H-nQld) | | Declining[54, 146] |
|---|---|---|
| **Threats** | B. Marine debris – entanglement | Very high |
| | E. International take – outside Australia's jurisdiction | Very high |
| | D. Terrestrial predation | High |
| | A. Climate change and variability | High |

| **Important nesting areas** | **Internesting Buffer: 20 km** |
|---|---|
| *Major*: Long (Sassie), Hawkesbury, Dayman, Milman, Boydong, Mt Adolphus, Albany, Zuizin, Mimi, Bourke, Aukane, Layoak, Bet, Saddle and Dadalai Islands[136].<br><br>*Minor*: Islands in Great Barrier Reef and Torres Strait, and mainland coast of western Cape York Peninsula north of Cotterell River.<br><br>*Index beaches monitored*: Milman Island (1991-2010)[54]. | *Mating:* year round<br><br>*Nesting*: year round (peak: Dec–Feb)<br><br>*Hatching*: year round (peak: Feb–May) |

**Foraging habitat**

*Post-hatchling/young juveniles:* Little is known, but likely to forage in waters of the Coral Sea[146].

*Juvenile-adult:* Tidal and subtidal coral and rocky reef habitats where they feed on algae, sponges and soft corals. Hawksbill turtles can be found in clear or turbid water, on reefs, seagrass meadows or on soft-bottom habitats[18].

*Foraging grounds monitored*: Clack Reef, Howick Group, Heron and Wistari Reefs, Moreton Bay[146].

*Distribution*: See Figure 13.

**Stock description**

Hawksbill turtles nesting in Queensland and the Torres Strait appear to be from the same genetic stock as those nesting in east Arnhem Land[63]. However, given the seasonal separation in nesting between these two nesting aggregations[136], for the purposes of this plan they are considered separate stocks.

In Queensland, there was a large-scale commercial harvest and trade of hawksbill turtles (for tortoiseshell) from the 1700s ceasing in 1968, which is likely to have substantially depleted the stock[136]. In 2000, nesting in north Queensland and the Torres Strait was estimated to be approximately 4000 females[134]. Milman Island provides the only long-term monitoring data for this stock and a three per cent decline was described for this nesting aggregation between 1990-1999[54]. It is not known whether this decline is representative across the stock. This species' ability to recover from a decline is hampered by its unusually long interval between nesting seasons (approximately five years) and late maturation (greater than 30 years)[134].

Management of this stock is undertaken by the Queensland Parks and Wildlife Service, Great Barrier Reef Marine Park Authority and Torres Strait Regional Authority in conjunction with local non-government organisations and Indigenous communities.

Hawksbill turtles that breed in Australia migrate to foraging grounds across northern Australia, the Great Barrier Reef, Indonesia, Papua New Guinea, Solomon Islands and Vanuatu[134]. In the broader Coral Sea region there is an ongoing substantial harvest of hawksbill turtles for the black market tortoiseshell trade that is likely to be a current major source of mortality in this stock[134]. Ghost nets are responsible for the death of many hundreds of turtles annually with immature hawksbill turtles being the most frequently reported in nets washed ashore in the Northern Territory[136, 237].

On western Cape York, there are high levels (90 per cent egg loss) through dog, pig, and varanid predation on nests for all species of turtle, which means that the low density hawksbill turtle nesting in this region will be affected[136]. Rates of terrestrial predation are not known throughout the remainder of their range. However, goannas are known to occur on most islands throughout the Torres Strait, and anecdotal evidence suggests that predation by goannas is high. Hawksbill turtles foraging in the Great Barrier Reef have high survivorship but appear to be in decline in as a result of breeding migrations outside Australian waters[13]. Changes in ocean circulation, ocean acidification and increased coral bleaching will directly affect the availability of hawksbill turtle foraging habitat and food availability[83].

*Continued over*

| Hawksbill – north Queensland (H-nQld) | Declining[54, 146] |
|---|---|
| **Priority actions specifically required to recover this stock** | **Action Area** |
| Work on a regional scale to understand market supply chains and to reduce unsustainable harvest and illegal and unregulated trade. | A5 |
| Liaise at a regional scale to address and reduce the source of marine debris in Australian waters. | A3 |
| Ensure clean-up activities are timed appropriately to coincide with on-shore peaks in marine debris (i.e. prior to wet season). | A3 |
| Determine the extent of terrestrial predation on hawksbill turtle nests on islands and where necessary undertake nest protection programs. | A6 |
| Quantify and model how changes in ambient temperatures (sand and water), sea level, frequency of extreme weather events, ocean circulation and acidification affect marine turtle nesting, sex ratios, hatching success, habitats, food availability and their ability adapt to these changes. | A2 |
| Initiate and continue long-term monitoring of multiple index beaches to assess trends in nester abundance and determine whether trends observed at Milman Island are representative of the stock. | B1 |
| Continue and initiate long-term monitoring at important foraging grounds to assess efficacy of management programs. | B2 |
| **Measure of success** | |
| *Determine whether trends observed at Milman Island are representative of the stock* | B1 |

Recovering
Marine Turtles

| Hawksbill – north-east Arnhem Land (H-neArn) | | Unknown[146] |
|---|---|---|
| **Threats** | B. Marine debris – entanglement | Very high |
| | E. International take – outside Australia's jurisdiction | Very high |
| | A. Climate change and variability | High |
| | D. Terrestrial predation | High |
| | I. Indigenous take | High |

| Important nesting areas | Internesting Buffer: 20 km |
|---|---|
| *Major*: Truant and Bromby Islands, and the Groote Eylandt area[105, 136]. | *Mating:* year round |
| *Minor*: Many minor nesting areas in close proximity to major nesting beaches, also mainland beaches in north-east Arnhem Land and Cobourg Peninsula[136]. | *Nesting*: May–Nov (peak Aug)[105] |
| *Index beaches monitored*: None currently monitored. Census data: Groote Eylandt (1997, 2009-2010)[105], Cobourg Peninsula[136]. | *Hatching*: year round (peak: Aug–Nov) |

**Foraging habitat**

*Post-hatchling/young juveniles:* Unknown.

*Juvenile-adult:* Tidal and sub-tidal coral and rocky reef habitats where they feed on algae, sponges and soft corals. Hawksbill turtles can be found in clear or turbid water, on reefs, seagrass meadows or on soft-bottom habitats[18].

*Foraging grounds monitored*: Fog Bay (1990-1997)[239].

*Distribution*: See Figure 13.

**Stock description**

Hawksbill turtles nesting in north-east Arnhem Land appear to be from the same genetic stock as those nesting in Queensland and the Torres Strait[63]. Given the seasonal separation in nesting between these two nesting aggregations[136], for the purposes of this plan they are considered separate stocks.

Hawksbill turtles in the Northern Territory were subject to a large-scale commercial harvest and trade during the 1600 and 1700's, which is likely to have substantially depleted the stock[136]. In 2000, the number of nesting females in eastern Arnhem Land was estimated to be approximately 2500[134]. There has been no long-term monitoring for this stock and its status is currently unknown. Recent monitoring undertaken on three islands (Hawk, Lane and North East) off north eastern Groote Eylandt indicated over 200 nesting females in 2009, and nearly 600 in 2010, highlighting the importance of these islands to this stock[105].

This stock is co-managed by the Northern Territory Government and local Indigenous communities and ranger groups. The loss of eggs to both human egg harvest and terrestrial predators has historically been observed to be unsustainable[36, 125]. Communities who identified it as a potential concern have proposed increasing education and support for ranger groups as the most effective means to manage this threat[13]. There is also an ongoing substantial international harvest of hawksbill turtles for the black market tortoiseshell trade in the broader region that is likely to be a major source of mortality in this stock[134].

Ghost nets are likely to be responsible for the death of many hundreds of turtles annually with immature hawksbill turtles being the most frequently reported in nets washed up on beaches in the Northern Territory[136, 237]. Ranger groups have expressed a concern at the potential for foraging hawksbill turtles to be captured and drown in nets that are snagged on coral reefs and identified the rangers' inability to retrieve a net when submerged. Changes in ocean circulation, ocean acidification and increased coral bleaching will directly affect the availability of hawksbill turtle foraging habitat and food availability[83]. Where nesting occurs on the mainland, a low level of predation by feral dogs and goannas has been reported[36], however this has not been quantified. Potential future threats to this stock also include seabed mining in internesting and foraging habitat[106].

Establishing long-term nest monitoring will inform whether declines observed in the northern Queensland stock are also occurring in the north-east Arnhem Land stock.

*Continued over*

13 Indigenous Consultation, Northern Territory, 22-27 June 2015

| Hawksbill – north-east Arnhem Land (H-neArn) | Unknown[146] |
|---|---|
| **Priority actions specifically required to recover this stock** | **Action Area** |
| Liaise with countries throughout the region to address and reduce the source of marine debris in Australian waters. | A3 |
| Ensure clean-up activities are timed appropriately to coincide with on-shore peaks in marine debris (i.e. prior to wet season). | A3 |
| Work on a regional scale to understand market supply chains and to reduce unsustainable harvest and illegal and unregulated trade. | A5 |
| Quantify and model how changes in ambient temperatures (sand and water), sea level, frequency of extreme weather events, ocean circulation and acidification affect marine turtle nesting, sex ratios, hatching success, habitats, food availability and their ability adapt to these changes. | A2 |
| Support communities in their management of terrestrial predators. | A6 |
| Support the implementation of management plans and build capacity to undertake monitoring, education, and compliance management of marine turtles. | A1, A3, A6, A10 |
| Establish long-term monitoring programs at index beaches and key foraging areas to assess trends in nester abundance. | B1 |
| **Measure of success** | |
| *Trends in nesting turtle abundance are assessed for this stock* | B1 |

| Hawksbill – Western Australia (H-WA) | | Unknown[136] |
|---|---|---|
| **Threats** | E. International take – outside Australia's jurisdiction | Very high |
| | A. Climate change and variability | High |
| | G. Light pollution | High |
| **Important nesting areas** | | **Internesting Buffer: 20 km** |
| *Major*: Dampier Archipelago (Rosemary Island), Delambre Island and Montebello Islands[136].<br>*Minor*: Ah Chong, South East and Timouille, Sholl Island, Lowendal Islands including Varanus, Beacon, Bridled, Barrow, Muiron Islands and mainland beaches from Cape Range to Ningaloo and Gnaraloo to Red Bluff[136].<br>*Index beaches monitored*: Varanus (1987-2015), Rosemary (1994-2015) Islands[136]. | | *Mating:* all year<br>*Nesting*: all year (peak: Oct–Jan)[189]<br>*Hatching*: all year (peak: Dec–Feb) |
| **Foraging habitat** | | |
| *Post-hatchling/young juveniles:* Unknown.<br>*Juvenile-adult:* Tidal and sub-tidal coral and rocky reef habitats where they feed on algae, sponges and soft corals. Hawksbill turtles can be found in clear or turbid water, on reefs, seagrass meadows or on soft-bottom habitats[18].<br>*Foraging grounds monitored*: None.<br>*Distribution*: See Figure 13. | | |
| **Stock description** | | |
| The Western Australia hawksbill turtle stock is one of the largest in the world and the largest in the Indian Ocean[136]. Most of the nesting for this stock is located in the Pilbara. Some hawksbill turtle nesting occurs at Scott Reef and Ashmore Reef, but genetic affiliations are unknown. The Dampier Archipelago has the largest nesting aggregation recorded with approximately 1000 nesting females per year at Rosemary Island[136]. Surveys undertaken at Varanus and Rosemary Islands suggest that survivorship of nesting females has remained high (0.95) and constant over the past 20 years[189]. A major proportion of nesting for this stock is protected within the Dampier Archipelago, Thevenard and Barrow Island Nature Reserves, and the Montebello Conservation Area. However, Delambre Island (major nesting) is not protected. Historically, there was a large-scale commercial harvest and trade of hawksbill turtles for tortoiseshell in east and northern Australia. The commercial harvest was smaller in Western Australia than in the Northern Territory and Queensland, however this stock may have also been affected[134, 136]. Due to substantial harvest of hawksbill turtles for the tortoiseshell trade in other jurisdictions throughout its range, it is likely that the greatest threat to this stock is the take outside Australian waters[136, 171].<br>Important foraging habitat has not been documented for this stock, however reefs within the Ningaloo Marine Park, Rowley Shoals Marine Park and the Montebello/Barrow Islands Marine Park likely provide protection for hawksbill turtles. This stock also occurs within areas of high industrial development, which is likely to continue to increase into the future. Associated changes in light horizons affect nesting beach selection and hatchling dispersal[121]. Changes in ocean circulation, ocean acidification and increased coral bleaching will directly affect the availability of hawksbill turtle foraging habitat and food availability[83]. | | |

*Continued over*

| Hawksbill – Western Australia (H-WA) | Unknown[136] |
|---|---|
| **Priority actions specifically required to recover this stock** | **Action Area** |
| Maintain long-term monitoring programs at index beaches and establish monitoring at a key foraging area. | A5 |
| Work on a regional scale to understand market supply chains and to reduce unsustainable harvest and illegal and unregulated trade. | A4 |
| Manage artificial light from onshore and offshore sources to ensure biologically important behaviours of nesting adults and dispersing hatchlings can continue. | A8 |
| Quantify and model how changes in ambient temperatures (sand and water), sea level, frequency of extreme weather events, ocean circulation and acidification affect marine turtle nesting, sex ratios, hatching success, habitats, food availability and their ability adapt to these changes. | A2 |
| Understand foraging ground requirements and identify priority areas for protection. | B3 |
| Assess mixed stock genetics at foraging grounds. | B3 |
| **Measure of success** | |
| *Trends in nesting turtle abundance are stable or increasing* | B1 |

Recovering Marine Turtles

| Olive Ridley – north-western Cape York (O-nwCY) | | Likely to be in decline[147] |
|---|---|---|
| Threats | A. Climate change and variability | Very high |
| | B. Marine debris – entanglement | Very high |
| | D. Terrestrial predation | Very high |
| | F. Fisheries bycatch – domestic | High |

| **Important nesting areas** | **Internesting Buffer: 20 km** |
|---|---|
| *Major*: None. | *Mating:* Feb–Sep |
| *Minor:* Low density nesting occurs on western Cape York Peninsula between Weipa and Bamaga, particularly Pennefather River, Jannie Creek, Mapoon to Aurukun[136]. | *Nesting*: Mar–Oct (peak: Aug) |
| *Index beaches monitored*: None currently monitored. | *Hatching*: May–Dec |

**Foraging habitat**

*Post-hatchling/young juveniles:* Unknown.

*Juvenile-adult:* Forage over soft-bottomed substrates (shallows - 200 m depth) along coastal zone of northern Australia[248].

*Foraging grounds monitored*: None.

*Distribution*: See Figure 15, noting this represents data from a small number of satellite tracked turtles.

**Stock description**

The olive ridley turtle stock nesting in Queensland is a small aggregation that is genetically distinct from olive ridley turtles nesting in the Northern Territory and neighbouring countries[115]. This stock is believed to be in decline as inferred from multiple decades of egg loss to terrestrial predators (estimated to occur in more than 90 per cent of nests)[136], likely entanglement in ghost nets[255], and fisheries bycatch[196]. There is limited monitoring at nesting beaches and currently no long-term monitoring occurring at foraging grounds. The majority of the existing management and research is undertaken by Indigenous ranger groups and communities, with some support through collaborations with industry and government. The Australian and Queensland governments jointly fund a targeted pig management program (2014-2017). However, management must be ongoing to successfully address nest predation.

The Gulf of Carpentaria is considered to be a ghost net hotspot with estimates that each year between 2043-6132 olive ridley turtles are captured in ghost nets[14]. While olive ridley turtles are the least frequently reported species in fishery logbooks, there is also a large proportion of unidentified turtles, which could include olive ridley turtles[196]. This combined with the small size of the stock means that fisheries interaction may be affecting the viability of the stock.

It is not known the extent to which olive ridley turtles will be able to adapt to environmental changes associated with climate change, however, the small size and limited region in which this stock nests makes them susceptible to sea level rise, increased extreme weather and changes in sand and water temperature. Given the assumed long-term decline in this stock, it is important to establish longterm monitoring to assess the efficacy of management actions and to track recovery of the stock.

*Continued over*



14 Based on olive ridley turtles being 42.5 per cent of 4866-14600 (Wilcox *et al.*, 2014)

| Olive Ridley – north-western Cape York (O-nwCY) | Likely to be in decline[147] |
|---|---|
| **Priority actions specifically required to recover this stock** | **Action Area** |
| Support ongoing implementation of terrestrial predation management programs. | A6 |
| Liaise at a regional scale to address and reduce the source of marine debris in Australian waters. | A3 |
| Maintain and expand partnership arrangements for the collection of marine debris (both onshore and offshore). | A3 |
| Support collection of tissue samples from stranded marine turtles. | A3 |
| Devise innovative methods for the early identification and intervention of ghost nets entering the Gulf of Carpentaria. | A3 |
| Quantify and model how changes in ambient temperatures (sand and water), sea level, frequency of extreme weather events, ocean circulation and acidification affect marine turtle nesting, sex ratios, hatching success, habitats, food availability and their ability to adapt to these changes. | A2 |
| Identify and protect areas likely to provide refugia and range expansion. | A2 |
| Support and expand research collaborations with commercial fishers. | A7 |
| Establish long-term monitoring at index beach to assess trends in nesting abundance and efficacy of terrestrial predator control programs. | B1 |
| **Measure of success** | |
| *Trends in nesting turtle abundance for this stock are understood* | B1 |

| Olive Ridley – Northern Territory (NT) | | Unknown[147] |
|---|---|---|
| **Threats** | A. Climate change and variability | Very high |
| | B. Marine debris – entanglement | Very high |
| | C. Chemical and terrestrial discharge – acute | High |
| | F. Fisheries bycatch – domestic | High |

| **Important nesting areas** | **Internesting Buffer: 20 km** |
|---|---|
| *Major*: English Company, Wessel, Crocodile, Elcho and Tiwi Islands of north-east Arnhem Land and Grant Islands, McCluer Island Group, Cobourg Peninsula, Melville Island and Bathurst Island off north-western Arnhem Land[136].<br><br>*Minor*: western Northern Territory, eastern Arnhem Land and Dhimurru Indigenous Protected Areas[136].<br><br>*Index beaches monitored*: None currently monitored. | *Mating:* Unknown<br><br>*Nesting*: year round (peak: Apr–Jun)<br><br>*Hatching*: year round (peak: Jun–Aug) |

**Foraging habitat**

*Post-hatchling/young juveniles:* Unknown.

*Juvenile-adult:* Forage over soft-bottomed substrates (shallows to 200 m) along coastal zone of northern Australia[248].

*Foraging grounds monitored*: None.

*Distribution*: See Figure 15.

**Stock description**

While the Northern Territory olive ridley turtle stock is relatively small and has a limited geographic range, it is likely that the Northern Territory has the most significant olive ridley population remaining in the Asia-Pacific region (Groom *et al.* 2017, in press). This stock is co-managed by the Northern Territory Government and the Dhimurru, Djelk, Laynhapuy, Anindilyakwa, Yanyuwa (Li-Anthawirriyarra) communities. These Indigenous communities have Indigenous Protected Areas in the region and nesting on the Cobourg Peninsula is provided protection within the Garig Gunak Barlu National Park. A lack of long-term monitoring has precluded stock status estimates. Many Indigenous ranger groups are now monitoring nesting in their local areas as part of land and sea management activities.

Large numbers of olive ridley turtles are reported drowned each year in ghost nets that have washed up in the Northern Territory[256]. Historically, olive ridley turtles are likely to have made up a major proportion of turtles captured in trawl bycatch and the introduction of compulsory turtle excluder devices in Australian trawl fisheries has substantially reduced this threat[136]. Olive ridley turtle nests on the Tiwi Islands are frequently inundated by high tides, and cyclones have impacted nesting success[244, 246]. Infrastructure for oil/gas storage and processing is currently limited in Northern Territory waters, but is projected to expand. These types of developments can result in altered light horizons, increased boat and human activity, altered beach profiles, and changes to the benthic environment. Associated port developments also increase the risk of pollutant spills and marine debris. While olive ridley turtles are the least frequently reported species in fishery logbooks, there is a large proportion of unidentified turtles, which could include olive ridley turtles[196]. This combined with the small size of the stock means that fisheries interaction may be affecting the viability of the stock. Terrestrial predation of nests is severe across northern Australia[36, 107]. It is not known the extent to which this stock is impacted by terrestrial predation. Given this is one of only two stocks of olive ridley turtles nesting in Australia it is important to understand trends in nesting abundance to better understand the status of the species and assess the efficacy of management programs.

*Continued over*

| Olive Ridley – Northern Territory (NT) | Unknown[147] |
|---|---|
| **Priority actions specifically required to recover this stock** | **Action Area** |
| Liaise at a regional scale to address and reduce the source of marine debris in Australian waters. | A3 |
| Devise innovative methods for the early identification and intervention of ghost nets entering the Gulf of Carpentaria. | A3 |
| Support collection of tissue samples from stranded marine turtles. | A3 |
| Ensure clean-up activities are timed appropriately to coincide with on-shore peaks in marine debris (i.e. prior to wet season). | A3 |
| Maintain and expand partnership arrangements for the collection of marine debris (both onshore and offshore). | A3 |
| Quantify and model how changes in ambient temperatures (sand and water), sea level, frequency of extreme weather events, ocean circulation and acidification affect marine turtle nesting, sex ratios, hatching success, habitats, food availability and their ability adapt to these changes. | A2 |
| Identify and protect areas likely to provide refugia and range expansion. | A2 |
| Ensure that spill risk strategies and response programs include management for turtles and their habitats, particularly in reference to slow to recover habitats, e.g. seagrass meadows or corals. | A4 |
| Quantify the extent to which terrestrial predation effects this stock. | A6, B3 |
| Establish a long-term monitoring program at an index beach to assess trends in nesting abundance and assess efficacy of management programs. | B1 |
| **Measure of success** | |
| *Trends in nesting turtle abundance are assessed for this stock* | B1 |

Recovering Marine Turtles

| Leatherback – Nesting in Australia (LB) | | Unknown |
|---|---|---|
| **Threats** | A. Climate change and variability | High |
| | B. Marine debris – ingestion | High |
| | E. International take – outside Australia's jurisdiction | High |
| | F. Fisheries bycatch – domestic and international | High |

| Important nesting areas | Internesting Buffer: 20 km |
|---|---|
| *Major*: None.<br>*Minor*: Cobourg Peninsula, Maningrida and Croker Island (Northern Territory) and unconfirmed nesting in Western Australia.<br>*Historic*: Wreck Rock, Moore Park, Mon Repos (Queensland) and Ballina (New South Wales). | *Mating:* Unknown<br>*Nesting*: Dec–Jan[85]<br>*Hatching*: Jan–Feb |

**Foraging habitat**

*Post-hatchling/young juveniles:* Unknown.

*Juvenile-adult:* Leatherback turtles forage in oceanic waters on gelatinous prey (i.e. jellyfish)[136]. They occur in waters over Australia's continental shelf year round. They are commonly observed in waters of the Northern Territory and south-western Western Australia. On the east coast they are most commonly reported from the Sunshine Coast (Queensland) to central New South Wales and southeast Australia (from Tasmania, Victoria and eastern South Australia)[136] with a foraging hot-spot identified in the Tasman Sea between New South Wales/Victoria and New Zealand[14].

*Foraging grounds monitored*: None.

*Distribution*: See Figure 8.

**Stock description**

While Leatherback turtles have been known to sporadically nest in low numbers in Australia, they have not been recorded nesting on the east coast since 1996[85], or in the Northern Territory since 2011, although one nesting track was observed in the Gulf of Carpentaria in 2016 (Groom, pers. comm. 2017). It is likely that this nesting aggregation is functionally extinct[149]. It is currently unknown which genetic stock(s) these turtles represent[63], further work is being planned to provide clarification on their genetic relationships (FitzSimmons, pers. comm. 2017). Leatherback turtles nesting in winter in Papua New Guinea migrate towards the east Australian current and there appears to be a foraging 'hotspot' between Australia and New Zealand[14]. It is likely that turtles observed in waters off Western Australia are part of the subpopulation nesting in the Andaman and Nicobar Islands (India)[63].

Leatherback turtles are found foraging in waters over Australia's continental shelf and are most frequently captured as bycatch in longline fisheries where they are often released alive[177]. All Australian longline vessels are required to carry de-hookers and line cutters to facilitate quick release of turtles caught on longlines. Leatherback turtles were also commonly captured in the Queensland shark control program, but mortalities were generally low, and they have been rarely captured since 1992[136]. Leatherback turtles are also often entangled in pot fisheries, particularly in Victoria, Tasmania, South Australia and Western Australia[136]. Due to their dietary preference for soft bodied animals, such as jellyfish, leatherback turtles are at risk from plastic ingestion[172, 203]. Many of the major threats to leatherback turtles occur outside Australia's jurisdiction and therefore require international collaboration to address and manage threats.

| Priority actions specifically required to recover this stock | Action Area |
|---|---|
| Liaise at a regional scale to address and reduce the source of marine debris. | A3 |
| Promote best practice bycatch mitigation and innovation in all Australian fisheries and continue to meet international obligations including conservation management measures under regional fisheries management organisations. | A7 |
| Determine genetic affiliations of leatherback turtles nesting in Australia. | B3 |
| Monitor nesting activity in historically known nesting areas. | B1 |
| **Measure of success** | |
| *The genetic relatedness of leatherback turtles nesting in Australia with those nesting in neighbouring countries is understood* | B3 |

| All species – International stocks foraging in Australian waters | |
|---|---|
| **Threats** | B. Marine Debris – entanglement and ingestion |
| | C. Terrestrial predation (international nesting) |
| | D. International take (eggs and meat) |
| | F. Fisheries bycatch – international |

**Green turtles**

*Known shared stocks*: New Caledonia, Vanuatu, Solomon Islands, Papua New Guinea, Indonesia, Malaysia, Borneo, Palau, Marshal Islands and French Polynesia[50, 63, 117, 136, 137, 192].

*Known foraging areas*: Cobourg (Northern Territory), One Arm Point (Western Australia)[136], Torres Strait, Clack Reef, Howicks Group, Edgecombe Bay, Shoalwater Bay, Princess Charlotte Bay south to Moreton Bay (Queensland)[117], Norfolk Island (stock unknown)[183].

*Major threats outside Australia's jurisdiction*: These turtles face threats from harvest for meat and eggs at nesting beaches, and adults at internesting areas; entanglement in marine debris; and interaction with high seas or neighbouring countries' fisheries[136].

**Loggerhead turtles**

*Known shared stocks*: New Caledonia has a small nesting aggregation that is thought to be the same genetic stock as those nesting in Queensland[63]. The degree of relatedness between the Sri Lankan, and the Western Australia stock is not currently known[63, 136]. A small number of loggerhead turtles had been described foraging at Cocos (Keeling) islands that may be part of the Northern Indian Ocean stock[136], however, a long-term study of turtles foraging at the Cocos (Keeling) islands did not record loggerhead turtles foraging[249].

*Known foraging areas*: Only a small number of loggerhead turtles tagged in eastern Australia have been recorded migrating outside Australia to breed. These turtles travelled to New Caledonia[136], and were captured at Heron Reef and Moreton Bay.

*Major threats outside Australia's jurisdiction*: These turtles face threats from harvest for meat and eggs at nesting beaches, and adults at internesting areas; entanglement in marine debris; and interaction with high seas or neighbouring countries' fisheries[136].

**Hawksbill turtles**

*Known shared stocks*: Solomon Islands, Papua New Guinea and Vanuatu[63, 136].

*Known foraging areas*: Howick Group[13] and northern Great Barrier Reef[136]. Hawksbill turtles from unknown stocks forage on the reefs of Christmas Island[136], Cocos (Keeling) Islands[251] and Norfolk Island[183]. The Great Barrier Reef supports a major foraging population of hawksbill turtles from the south-west Pacific[134]. These turtles may be part of the north Queensland genetic stock or they could come from neighbouring genetic stocks such as the Solomon Islands[63].

*Major threats outside Australia's jurisdiction*: Hawksbill turtles foraging in the Howick Group in the northern Great Barrier Reef have high foraging ground survivorship, but this foraging population may be in a decline indicative of impacts to eggs or harvest for meat when turtles migrate outside Australian waters[13]. There was an extensive harvest of hawksbill turtles from Cocos (Keeling) Islands (genetic stock unknown) in the 1800s and early 1900s, which likely depleted the population, but it appears to now be recovering[240]. The greatest threat to hawksbill turtles outside Australia's jurisdiction is take for the tortoiseshell trade[128, 134]. Hawksbills are also subject to entanglement and ingestion of marine debris on the high seas and fisheries bycatch[170].

**Olive ridley turtles**

*Known shared stocks*: Unknown, likely to include Indonesia and Papua New Guinea[115].

*Known foraging areas*: The Arafura Sea and Gulf of Carpentaria provides shared foraging grounds for olive ridley turtles from both Australian and Indonesian stocks[63, 115].

*Major threats outside Australia's jurisdiction*: The once large breeding populations of olive ridley turtles in Peninsula Malaysia and Thailand have been reduced through long-term overharvest of eggs. There is low density nesting in Indonesia, the Philippines and Papua New Guinea, however linkages with Australian foraging stocks are currently unknown[136]. Olive ridley turtles captured foraging in the Arafura Sea have been shown to come from Australian and Indonesian stocks[115].

*Continued over*

| All species – International stocks foraging in Australian waters | |
|---|---|
| **Leatherbacks turtles** | |
| *Known shared stocks*: Likely to include the Solomon Islands, Papua New Guinea, Indonesia and the Andaman and Nicobar Islands (India)[63]. | |
| *Known foraging areas*: Indo-Pacific region, particularly the Tasman Sea[14]. Leatherback turtles observed foraging in Australian waters are likely to include turtles that nest in the Solomon Islands and Papua New Guinea. Leatherback turtles nesting during winter in Papua New Guinea migrate towards the east Australian current and there appears to be a foraging 'hotspot' between Australia and New Zealand[14]. It is likely that turtles observed in waters off Western Australia are part of the subpopulation nesting in the Andaman and Nicobar Islands (India)[63]. While the leatherback turtle post nesting migrations are highly dispersed and they do not appear to centre on spatially restricted foraging grounds, they have been recorded exhibiting area-restricted search behaviours in up to five areas (globally) including in south-eastern Australia[8]. | |
| *Major threats outside Australia's jurisdiction*: Threats to leatherback turtles in the Indo-Pacific region include fisheries bycatch, egg take, consumption of turtle meat and coastal development[236]. Currently international mitigation measures include: marine protected areas; measures to reduce harvest of turtles for meat and eggs; control of terrestrial predators; and fisheries bycatch reduction (including gear changes and spatial and temporal closures)[176]. | |
| **Priority actions specifically required to recover turtle populations foraging in Australia** | **Action Area** |
| Liaise at a regional scale to address and reduce the source of marine debris. | A1, A3 |
| Work on a regional scale to reduce unsustainable harvest and illegal and unregulated take of marine turtles. | A1, A5 |
| Liaise at a regional scale to promote best practice fishery management to reduce marine turtle bycatch outside Australian jurisdiction. | A1, A7 |

## 5.5 Stocks at highest risk

Within each of the six marine turtle species that occur in Australian waters, there are six stocks that are considered a priority for management action. These stocks are in decline or likely to be in decline due to multiple, continuing threats occurring on a substantial scale.

*Olive ridley turtles (both stocks)* – This species has only small nesting aggregations in Australia, which have been affected by up to 90 per cent nest predation at some beaches for multiple decades[136]. In addition, they are likely to be heavily impacted by ghost nets in the Arafura-Timor Seas and the Gulf of Carpentaria[255].

*Hawksbill turtles (north Queensland and international stocks)* – Nesting at Milman Island has been declining at three per cent per year (1990-1999)[54], the cause of which is largely unknown. Hawksbill turtles foraging in the Great Barrier Reef but nesting outside Australia have also declined[13]. There is likely to be substantial take of hawksbill turtles outside Australia's jurisdiction for the illegal tortoise shell trade[134].

*Loggerhead turtles (south-west Pacific)* – There is an apparent lack of recruitment of juveniles to benthic foraging areas indicative of a cohort loss on the high seas[144].

*Leatherback turtles* – May be moving towards local extinction. The only known nesting at present is at Danger Point, Cobourg Marine Park, Northern Territory. There are important foraging grounds around Australia that are likely to include turtles from Australia, Papua New Guinea, the Solomons, and possibly the Andaman and Nicobar Islands. Leatherback turtles are likely to be heavily impacted by fisheries bycatch and habitat loss at nesting beaches[85].

*Green turtles (northern Great Barrier Reef)* – Although this is one of the world's largest green turtle stocks there is evidence of low hatchling production at Raine Island, the primary rookery for this stock[142], and evidence of decline in the proportion of northern Great Barrier Reef green turtle juveniles present at foraging areas[117].

# 6 Implementation of the Recovery Plan

## 6.1 Responsible agencies and partners

The Australian Government is responsible for managing and coordinating policy and program implementation for marine turtles. It builds networks through its collaboration with other government agencies and by attending and negotiating at international fora. The Australian Government is responsible for ensuring that issues regarding marine turtle management and protection are raised at international fora, and for influencing policy and programs being implemented across Australia. The Australian Government has the ability to collaborate with state and territories either directly or through fora such as round table discussions and to assess the progress of implementing the recovery plan objectives and targets.

Many of the actions identified in this plan will fall under the jurisdiction of state and territory governments. Similarly, actions will be undertaken by industry groups, research institutions, non-government organisations and the broader community. As a result, while the plan may identify activities that need to be ongoing, the mechanisms that support those activities may not be delivered through the Australian Government.

### Consultation process

The *Recovery Plan for Marine Turtles in Australia* has been developed through extensive consultation with a broad range of stakeholders and affected interests. In March 2014, an expert workshop was convened to prioritise threats that impact on each marine turtle stock and actions required to promote recovery. In July 2016, another expert workshop was held to determine habitat critical to the survival of marine turtles and to provide feedback on a draft version of the plan.

Between May and August 2015, the Australian Government consulted with Indigenous community groups from the Pilbara, Kimberley, across the Northern Territory, Cape York and Cairns (Appendix A). Consultation was undertaken with representatives, rangers and elders from the various communities. The views presented were those of the individuals present and did not necessarily represent the views of the entire community.

The Department of the Environment and Energy's Threatened Species Scientific Committee reviewed the plan prior to public consultation. The plan was made available for public consultation from 30 September 2016 – 13 January 2017.

A complete list of government agencies, non-government organisations, community groups and affected parties consulted during the development of the plan is provided at Appendix A. These key interested parties may be involved in the implementation of the *Recovery Plan for Marine Turtles in Australia*. This list includes organisations likely to be affected by the implementation of actions proposed in this plan.

## 6.2 Duration and cost of the recovery process

The recovery of marine turtles in Australia is likely to take longer than the 10 year period of this plan. A plan should remain in place until all six species of Australian marine turtles have recovered to such an extent that the conservation status of all species no longer meets the criteria for being listed as a threatened species under the EPBC Act.

The cost of implementing this plan will be met through various direct and indirect funding providers. These include Commonwealth, state and territory governments, non-government organisations such as marine turtle conservation groups and research organisations, and marine based industries. It is expected that state, territory and Commonwealth agencies will use this plan to help prioritise actions to protect the species and enhance their recovery, and that projects will be undertaken according to agency priorities and available resources.

## 6.3 Biodiversity benefits

Implementation of the recovery plan is unlikely to have negative impacts on other native species or ecological communities, although research activities associated with monitoring marine turtles may disturb other protected species, such as seabirds and should therefore be conducted in a way that minimises disturbance to other species.

Key threats to marine turtles are often shared by other marine and migratory species. Therefore reducing threats to marine turtles such as ghost nets, fisheries interactions, vessel strike and pollutants is also likely to have flow-on benefits for other species such as cetaceans (whales and dolphins), dugongs, pinnipeds (seals and sea lions), seabirds and elasmobranchs (sharks and rays). The reduction of introduced fauna predation, particularly pig predation, will also benefit native species including freshwater and estuarine crocodiles and freshwater turtles and their associated coastal wetlands communities.

Marine turtles fulfil a broad ecological role within marine and coastal ecosystems as grazers of seagrass and algal pastures, and as predators of marine sponges, molluscs, crustaceans and jellyfish[19, 219]. They also contribute to cycling of nutrients between marine and terrestrial systems when laying eggs and they influence plant communities in the coastal areas where they nest[89]. During various parts of their life cycle, marine turtles are important prey to other species and contribute nutrients to coastal and island beaches. Hatchlings are prey to several species of birds and fish, varanids and ghost crabs, and larger turtles are prey to sharks and crocodiles. Protecting and maintaining marine turtle stocks may therefore benefit other threatened marine species sharing the same ecosystems.

## 6.4 Social and economic considerations

The implementation of this plan is unlikely to cause adverse social and economic impacts. Instead, it is likely that the implementation of the actions outlined in this plan will provide positive social, economic and educational impacts. Marine turtles are of economic value for ecotourism with large numbers of visitors to beaches across northern Australia during the Australian summer to view nesting turtles and emerging hatchlings. For example, Mon Repos, Bundaberg, Queensland attracted more than 25,000 visitors during the 2011/12 nesting season. Such tourism ventures not only provide economic revenue, but education opportunities to increase the public awareness of the threats faced by marine turtles and their habitats.

Many turtles and their rookeries in Australia are located in the traditional territories of Aboriginal and Torres Strait Island peoples. Marine turtles play an important role in the traditions and culture of these people. Tourism and education ventures can be improved through incorporating the knowledge and expertise held by Indigenous Australians, which in turn can provide new employment and income generating avenues and help in the conservation of turtles and their habitats[222].

## 6.5 Offsetting

Offsetting as a mechanism works as a trade-off between permanent immediate impacts on biodiversity and uncertain future biodiversity gains[15]. Consequently, offsetting is a last resort for biodiversity management, used only in an attempt to compensate for unavoidable damage to the species or its habitats. The best environmental option is to avoid impacting nesting beaches, internesting areas (during key periods) or affecting foraging habitats, particularly those described as habitat critical to the survival, without compelling reason.

With regard to marine turtles there is no way to fully offset an activity, as seagrass meadows are not easily restored, and due to the high site fidelity once a natal nesting area is lost, their area of occupancy and breeding success is usually permanently reduced. This is a concern with regard to the prediction in the future of higher temperatures and sea level rise, as it is not understood the extent to which marine turtles will adapt to a changing climate via behavioural or evolutionary means.

The outcomes of offsetting activities are generally highly uncertain, so any proposals for offsets for marine turtles should include commitments to;

- Manage terrestrial predation pressures (where applicable). This can include a range of management activities, including nest protection as well as predator reduction
- Collect marine debris from nesting beaches and in the marine environment (with consideration of its proximity to internesting, foraging and migratory pathways)
- Manage light around existing nesting beaches (may include retrofitting of existing light infrastructure on jetties, marinas or beaches) to reduce light impacts
- Rehabilitation of nesting beaches may be undertaken, but requires a complete understanding of why the impact occurred in the first place.

Guidance on the EPBC Act environmental offsets policy is available on the Department of the Environment and Energy website.

## 6.6 Reporting process

The Commonwealth Department of the Environment and Energy will review the plan at five years (mid-term) and at the completion of the plan in 2027.

The mid-term review will identify:

- Actions that have been completed
- Actions that are on-track for completion
- Actions that have not commenced.

In addition, at the five year review threats with an 'unknown' impact such as chronic noise will be re-assessed in light of new information.

At the expiry of the plan (2027) the plan will be evaluated using the performance measures identified in Table 2. Final reporting will include the progress of actions and detail any adaptive management required for the next plan. It will also report monitoring outcomes.



15 http://decision-point.com.au/?article=offset-policies-dont-work

## Monitoring the stocks

Monitoring of the stocks will occur through action areas B1 and B2. The aim of this monitoring is to determine the trajectory of each stock over time and assess whether there is evidence of species recovery. This will determine whether the long-term recovery objective of recovery, as defined in Section 1.2 of this plan, has been met.

# Appendix A – Key stakeholders

Key interested parties that were consulted during the development of the plan and may be involved with the implementation and review of the *Recovery Plan for Marine Turtles in Australia*.

***Australian Government***

Attorney-General's Department
Department of Agriculture and Water Resources
Department of Defence
Department of the Environment and Energy
Department of Foreign Affairs and Trade
Department of Industry, Innovation and Science
Department of Infrastructure and Regional Development
Department of the Prime Minister and Cabinet

***Agencies***

Australian Fisheries Management Authority
Australian Maritime Safety Authority
Great Barrier Reef Marine Park Authority
Indigenous Land Corporation
National Offshore Petroleum Safety and Environmental Management Authority
Torres Strait Regional Authority

***State/territory governments***

New South Wales Office of Environment and Heritage
Northern Territory Department of Environment and Natural Resources
Queensland Department of Environment and Heritage Protection
Western Australian Department of Parks and Wildlife
South Australian Department of Environment, Water and Natural Resources
Victorian Department of Environment, Land, Water and Planning
Tasmanian Department of Primary Industries, Parks, Water and Environment

***Academic institutions and expert consultants***

Blue Planet Marine
Charles Darwin University
Griffith University
James Cook University
Pendoley Environmental
WWF – Australia

*Indigenous groups*

Consultation occurred where possible across northern Australia. It was limited by budget and time. Consultation occurred via attending Prescribed Body Corporate (PBC) meetings, turtle workshops, and through workshops organised by the Department. At all of these meetings, rangers employed through the community and community representatives or elders were present.

- 6 May 2015 – Broome, WA. Nyangumarta Traditional Owners PBC Directors' Meeting
- 7 May 2015 – Bidyadanga, WA. Workshop with representatives of the Karrajari Rangers.
- 27 May 2015 – Cairns, Qld. Workshop with ranger or elder representatives from eight communities including: Mapoon (Yupangathi); Lockhart River; Yuku Baja Miluku; Llama Llama; Wujul Wujul (Jajikalwarra); Thiidhaar; Apudthama (Gudang); and Kalan.
- 10-12 June 2015 – Cairns, Qld. Sea Turtle Foundation Workshop – representatives from: Dhimmiru (NT); Crocodile Islands Rangers (NT); Dawul Wuru Aboriginal Corporation (Qld); Djunbunji (Mandingalbay Yidinji); Girringun; Gudjuda Reference Group Aboriginal Corp.; Larrakia Rangers; Wunjunga Progress Association (NQ Dry Tropics); Yarrabah; Yintjingga/Lama Lama; and Yuku Baja Muliku Landowner and Reserves Ltd.
- 22-23 June 2015 – Milingimbi, Crocodile Island, NT. Workshop with ranger representatives from: Garig Gunak Barlu (Cobourg); Mardbalk (Goulburn Is); Garngi (Croker Is); Marthakal (Elcho Is); and Croc Is (Milingimbi).
- 24-25 June 2015 – Groote Eylandt. Workshop with representatives from: Yirralka Rangers – Yirrkala; Dhimurru Rangers – Nhulunbuy; Anindilyakwa Rangers (Groote Eylandt); and Li-anthawirriyarra Sea Rangers (Borroloola).
- 11 August 2015 – Broome, WA. Workshop with representatives from: Yawuru; Dambimangari; Wunambal Gaambera (Uunguu); Bardi Jawi; Nyul Nyul; and the Kimberley Land Council.
- Indigenous Reef Advisory Committee Meeting 30 September – 1 October 2015. Representatives were from: Nywaigi; Yirrganydji; Lama Lama; Woppaburra; Dharumbal; Wulgurukaba; and the Gidarjil Aboriginal Corporation.

# Appendix B – Individual stock risk matrices

The following risk matrices illustrate the outcome of the threat risk assessment process undertaken for each stock as described in Section 4.4.

Each threat was ascribed a likelihood of occurrence and the resulting consequence of the threat for the stock taking into account existing management. Where relevant, the most critical aspect of the threat is provided in brackets ( ) after the threat to provide clarity. Where multiple elements of the threatening process have been considered (i.e. different fisheries within fisheries bycatch) and different risk ratings have been found, the threat is presented multiple times on the risk matrices.

Green Turtle, Southern Great Barrier Reef (G-sGBR) Stock

| Likelihood of occurrence | Consequences | | | | |
|---|---|---|---|---|---|
| | No long term effect | Minor | Moderate | Major | Catastrophic |
| **Almost Certain** | | • Fisheries bycatch – international<br>• Habitat modification – dredging/trawling<br>• Habitat modification – infrastructure/coastal development<br>• Vessel disturbance<br>• International take – outside Australia's jurisdiction (meat)<br>• Light pollution | | | |
| **Likely** | • Recreational activities (tourism)<br>• Terrestrial predation (fox) | • Fisheries bycatch – domestic (pot, net and shark control programs)<br>• Indigenous take (meat) | • Chemical and terrestrial discharge – chronic<br>• Marine debris – ingestion<br>• Climate change and variability (flood pulse event) | | |
| **Possible** | • International take – within Australia's jurisdiction | • Fisheries bycatch – domestic (trawl and longline)<br>• Chemical and terrestrial discharge – acute<br>• Marine debris – entanglement | | | |
| **Unlikely** | • Noise interference – acute | | | | |
| **Unknown** | | | • Diseases and pathogens<br>• Noise interference – chronic | | |

Green Turtle, Coral Sea (G-CS) Stock

| Likelihood of occurrence | Consequences | | | | |
|---|---|---|---|---|---|
| | **No long term effect** | **Minor** | **Moderate** | **Major** | **Catastrophic** |
| **Almost Certain** | | • Marine debris – ingestion<br>• International take – outside Australia's jurisdiction | | | |
| **Likely** | | • Fisheries bycatch – international | | | |
| **Possible** | • Chemical and terrestrial discharge – acute and chronic<br>• International take – within Australia's jurisdiction | • Fisheries bycatch – domestic (trawl, longline, pot and net)<br>• Vessel disturbance<br>• Indigenous take (meat)<br>• Recreational activities | • Climate change and variability (extreme weather events) | | |
| **Unlikely** | • Habitat modification – dredging/ trawling<br>• Habitat modification – infrastructure/coastal development<br>• Terrestrial predation<br>• Light pollution<br>• Noise interference – acute and chronic | | | | |
| **Unknown** | • Diseases and pathogens | • Marine debris – entanglement | | | |

Green Turtle, Northern Great Barrier Reef (G-nGBR) Stock

| Likelihood of occurrence | Consequences: No long term effect | Minor | Moderate | Major | Catastrophic |
|---|---|---|---|---|---|
| **Almost Certain** | | • International take – outside Australia's jurisdiction<br>• Terrestrial predation (pig and goanna)<br>• Habitat modification – dredging/trawling<br>• Indigenous take (meat and eggs) | | | • Climate change and variability (increased extreme weather events and ocean acidification) |
| **Likely** | • Chemical and terrestrial discharge – acute | • Marine debris – ingestion<br>• International take – within Australia's jurisdiction | • Marine debris – entanglement<br>• Habitat modification – infrastructure/coastal development (historical mining) | | |
| **Possible** | • Fisheries bycatch – domestic and international<br>• Habitat modification – infrastructure/coastal development | • Chemical and terrestrial discharge – chronic<br>• Vessel disturbance | | | |
| **Unlikely** | • Recreational activities (off–road vehicles)<br>• Noise interference – acute and chronic | • Light pollution | | | |
| **Unknown** | | | • Diseases & pathogens | | |

Green Turtle, Gulf of Carpentaria (G-GoC) Stock

| Likelihood of occurrence | Consequences | | | | |
|---|---|---|---|---|---|
| | No long term effect | Minor | Moderate | Major | Catastrophic |
| **Almost Certain** | • Fisheries bycatch – domestic (trawl) | • Climate change and variability<br>• Fisheries bycatch – international<br>• Habitat modification – dredging/trawling<br>• Marine debris – ingestion<br>• Fisheries bycatch – domestic (net and pot) | • Marine debris – entanglement | | |
| **Likely** | | • Habitat modification – infrastructure/ coastal development<br>• Chemical and terrestrial discharge – chronic<br>• Terrestrial predation (goanna)<br>• International take – within Australia's jurisdiction | • Indigenous take (eggs) | | |
| **Possible** | • Recreational activities (tourism)<br>• Chemical and terrestrial discharge – acute | • Noise interference – acute (seismic)<br>• Vessel disturbance (boat strike)<br>• Terrestrial predation (fox and dog) | • International take – outside Australia's jurisdiction | | |
| **Unlikely** | | • Light pollution | | | |
| **Unknown** | • Diseases and pathogens | | • Noise interference – chronic | | |

Green Turtle, Cobourg (G-Cobourg) Stock

| Likelihood of occurrence | Consequences | | | | |
|---|---|---|---|---|---|
| | No long term effect | Minor | Moderate | Major | Catastrophic |
| **Almost Certain** | | • Fisheries bycatch – international<br>• International take – outside Australia's jurisdiction<br>• Marine debris – ingestion | • Marine debris – entanglement | | |
| **Likely** | | • Indigenous take (eggs) | • Climate change and variability | | |
| **Possible** | • Habitat modification – infrastructure/coastal development<br>• Noise interference – chronic | • Noise interference – acute (seismic)<br>• Habitat modification – dredging/ trawling<br>• Fisheries bycatch – domestic (trawl, net, longline and pot)<br>• International take – within Australia's jurisdiction<br>• Vessel disturbance (strike)<br>• Chemical and terrestrial discharge – chronic | • Chemical and terrestrial discharge – acute | | |
| **Unlikely** | | • Light pollution | | | |
| **Unknown** | • Diseases and pathogens | • Recreational activities (tourism) | • Indigenous take (meat)<br>• Terrestrial predation (goanna, pig and dog) | | |

Appendix B

## Green Turtle, North-west Shelf (G-NWS) Stock

| Likelihood of occurrence | Consequences | | | | |
|---|---|---|---|---|---|
| | No long term effect | Minor | Moderate | Major | Catastrophic |
| **Almost Certain** | | • Marine debris – entanglement<br>• Habitat modification – dredging/trawling<br>• Habitat modification – infrastructure/coastal development<br>• Indigenous take (eggs)<br>• Recreational activities (off–road vehicles) | | | |
| **Likely** | | • Terrestrial predation (fox and goanna)<br>• Climate change and variability (temperature)<br>• Vessel disturbance (strike) | | | |
| **Possible** | | • Fisheries bycatch – domestic (trawling)<br>• Chemical and terrestrial discharge – chronic<br>• Fisheries bycatch – international<br>• Indigenous take (meat) | • Light pollution<br>• Chemical and terrestrial discharge – acute | | |
| **Unlikely** | | • Diseases and pathogens (Fibropapilloma) | | | |
| **Unknown** | | • Marine debris – ingestion | • Noise interference – acute and chronic<br>• International take – outside and within Australia's jurisdiction (meat) | | |

### Green Turtle, Ashmore Reef (G-AR) Stock

| Likelihood of occurrence | Consequences | | | | |
|---|---|---|---|---|---|
| | No long term effect | Minor | Moderate | Major | Catastrophic |
| **Almost Certain** | | • Light pollution<br>• International take – outside and within Australia's jurisdiction<br>• Indigenous take (meat) | • Marine debris – entanglement # | | |
| **Likely** | | • Marine debris – ingestion<br>• Vessel disturbance | | | |
| **Possible** | | • Fisheries bycatch – domestic (trawl, longline and net)<br>• Fisheries bycatch – international | • Chemical and terrestrial discharge – acute and chronic | • Climate change and variability | |
| **Unlikely** | • Habitat modification – infrastructure/coastal development<br>• Habitat modification – dredging/trawling<br>• Noise interference – acute and chronic<br>• Recreational activities | • Fisheries bycatch – domestic (pot) | | | |
| **Unknown** | | • Diseases and pathogens | | • Terrestrial predation (tropical fire ant) | |

# Given this stock is likely to forage in known ghost net hot spots, a precautionary approach is taken regarding assignation of possible consequences.

Appendix B

## Green Turtle, Scott-Browse (G-ScBr) Stock

| Likelihood of occurrence | Consequences | | | | |
|---|---|---|---|---|---|
| | No long term effect | Minor | Moderate | Major | Catastrophic |
| **Almost Certain** | | • Light pollution | | | |
| **Likely** | | • Marine debris – ingestion<br>• Vessel disturbance<br>• Noise interference – acute | | | |
| **Possible** | • Fisheries bycatch – domestic (trawl)<br>• Habitat modification – dredging/trawling | • Fisheries bycatch – domestic (net)<br>• Fisheries bycatch – international<br>• Indigenous take (meat) | • Climate change and variability #<br>• Chemical and terrestrial discharge – acute and chronic<br>• Habitat modification – infrastructure/coastal development | | |
| **Unlikely** | • Recreational activities | • Fisheries bycatch – domestic (pot and trap) | | | |
| **Unknown** | | • Diseases and pathogens | • International take – outside and within Australia's jurisdiction<br>• Noise interference – chronic<br>• Marine debris – entanglement<br>• Terrestrial predation (tropical fire ant) | | |

# Given the localised breeding of this stock, a precautionary approach is taken regarding assignation of possible consequences.

Green Turtle, Cocos–Keeling (G-CK) Stock

| Likelihood of occurrence | Consequences | | | | |
|---|---|---|---|---|---|
| | No long term effect | Minor | Moderate | Major | Catastrophic |
| **Almost Certain** | | • Marine debris – ingestion and entanglement<br>• Vessel disturbance (strike and noise) | | | |
| **Likely** | • Indigenous take (meat and eggs) | • Habitat modification – infrastructure/coastal development (removal of vegetation at high tide mark) | • Habitat modification – dredging/trawling | • Climate change and variability (erosion and temperature) | |
| **Possible** | • Recreational activities (tourism and off–road vehicles)<br>• Chemical and terrestrial discharge – acute and chronic | • International take – outside Australia's jurisdiction (meat)<br>• Fisheries bycatch – international<br>• Fisheries bycatch – domestic (net, longline and pot) | | | |
| **Unlikely** | • Noise interference – acute and chronic<br>• Light pollution | • Diseases and pathogens<br>• International take – within Australia's jurisdiction<br>• Terrestrial predation (bird, crab and tropical fire ant) | | | |
| **Unknown** | | | | | |

## Loggerhead Turtle, South-west Pacific (LH-swPac) Stock

| Likelihood of occurrence | Consequences | | | | |
|---|---|---|---|---|---|
| | **No long term effect** | **Minor** | **Moderate** | **Major** | **Catastrophic** |
| **Almost Certain** | • Recreational activities<br>• Chemical and terrestrial discharge – chronic<br>• Diseases and pathogens | • Vessel disturbance<br>• Habitat modification – infrastructure/coastal development<br>• Habitat modification – dredging/trawling<br>• Fisheries bycatch – domestic (nets and shark control programs) | | • Fisheries bycatch – international (longline) | |
| **Likely** | | • International take – outside Australia's jurisdiction | • Marine debris – entanglement and ingestion<br>• Light pollution<br>• Climate change and variability (extreme weather) | | |
| **Possible** | • Fisheries bycatch – domestic (trawl and longline)<br>• Indigenous take<br>• International take – within Australia's jurisdiction | • Terrestrial predation<br>• Chemical and terrestrial discharge – acute | | | |
| **Unlikely** | • Noise interference – acute | | | | |
| **Unknown** | | | • Noise interference – chronic | | |

Loggerhead Turtle, Western Australia (LH-WA) Stock

| Likelihood of occurrence | Consequences | | | | |
|---|---|---|---|---|---|
| | No long term effect | Minor | Moderate | Major | Catastrophic |
| **Almost Certain** | | • Terrestrial predation (fox)<br>• Light pollution<br>• Habitat modification – dredging/trawling<br>• Vessel disturbance (strike)<br>• Fisheries bycatch – domestic (pot and trawl)<br>• Habitat modification - infrastructure/coastal development | | | |
| **Likely** | • Recreational activities (tourism)<br>• Chemical and terrestrial discharge – chronic | • Indigenous take (eggs)<br>• International take – outside Australia's jurisdiction<br>• Noise interference – acute<br>• Fisheries bycatch – international | | | |
| **Possible** | • International take – within Australia's jurisdiction<br>• Indigenous take (meat) | | • Chemical and terrestrial discharge – acute<br>• Climate change and variability (temperature)<br>• Fisheries bycatch – domestic (longline) | | |
| **Unlikely** | | | | | |
| **Unknown** | | • Diseases and pathogens | • Noise interference – chronic<br>• Marine debris – entanglement and ingestion | | |

Flatback Turtle, Eastern Queensland (F-eQld) Stock

| Likelihood of occurrence | Consequences | | | | |
|---|---|---|---|---|---|
| | No long term effect | Minor | Moderate | Major | Catastrophic |
| **Almost Certain** | | • Habitat modification – infrastructure/coastal development<br>• Habitat modification – dredging/trawling | | | |
| **Likely** | | • Marine debris – ingestion | | | |
| **Possible** | • Recreational activities (tourism)<br>• Fisheries bycatch – domestic (trawl and net) | • Marine debris – entanglement<br>• Chemical and terrestrial discharge – acute and chronic<br>• Terrestrial predation (pig and fox) | • Light pollution | • Climate change and variability (temperature) | |
| **Unlikely** | • International take – outside and within Australia's jurisdiction | • Fisheries bycatch – domestic (pot)<br>• Vessel disturbance<br>• Indigenous take (eggs) | | | |
| **Unknown** | | • Fisheries bycatch – international<br>• Noise interference – acute | • Diseases and pathogens<br>• Noise interference – chronic | | |

Flatback Turtle, Arafura Sea (F-ArS) Stock

| Likelihood of occurrence | Consequences: No long term effect | Minor | Moderate | Major | Catastrophic |
|---|---|---|---|---|---|
| **Almost Certain** | • International take – outside and within Australia's jurisdiction (meat) | | • Marine debris – entanglement | | |
| **Likely** | | | • Climate change and variability (limited range)<br>• Indigenous take (eggs)<br>• Terrestrial predation (pig, dog and goanna) | | |
| **Possible** | • Recreational activities (off road vehicles and tourism)<br>• Habitat modification – infrastructure/coastal development<br>• Habitat modification – dredging/trawling | • Chemical and terrestrial discharge – acute and chronic<br>• Vessel disturbance<br>• Indigenous take (meat)<br>• Light pollution<br>• Noise interference – acute<br>• Fisheries bycatch – domestic (net, trawl and pot) | | | |
| **Unlikely** | | • Noise interference – chronic | | | |
| **Unknown** | | • Diseases and pathogens<br>• Fisheries bycatch – international (longline and gillnet) | • Marine debris – ingestion | | |

## Flatback Turtle, Cape Domett (F-CD) Stock

| Likelihood of occurrence | Consequences | | | | |
|---|---|---|---|---|---|
| | No long term effect | Minor | Moderate | Major | Catastrophic |
| **Almost Certain** | | • Marine debris – entanglement<br>• Indigenous take (eggs) | | | |
| **Likely** | | • Light pollution<br>• Marine debris – ingestion<br>• Habitat modification – infrastructure/coastal development<br>• Habitat modification – dredging/trawling<br>• Noise interference – acute | • Climate change and variability (temperature and sea level rises) | | |
| **Possible** | • Recreational activities (tourism)<br>• Fisheries bycatch – international | • Terrestrial predation (dingo/wild dog and night heron)<br>• Fisheries bycatch – domestic (trawl, net and longline)<br>• Vessel disturbance<br>• Chemical and terrestrial discharge – chronic | • Chemical and terrestrial discharge – acute | | |
| **Unlikely** | • International take – outside and within Australia's jurisdiction | • Fisheries bycatch – domestic (pot)<br>• Recreational activities (off road vehicles) | | | |
| **Unknown** | • Diseases and pathogens | | • Noise interference – chronic | | |

Flatback Turtle, South-west Kimberley (F-swKim) Stock

| Likelihood of occurrence | Consequences | | | | |
|---|---|---|---|---|---|
| | No long term effect | Minor | Moderate | Major | Catastrophic |
| **Almost Certain** | | • Light pollution<br>• Recreational activities (off–road vehicles)<br>• Habitat modification – infrastructure/coastal development<br>• Habitat modification – dredging/trawling<br>• Vessel disturbance (strike)<br>• Indigenous take (eggs) | | | |
| **Likely** | | • Noise interference – acute (seismic)<br>• Marine debris – entanglement<br>• Terrestrial predation (fox)<br>• Climate change and variability (temperature) | | | |
| **Possible** | • Fisheries bycatch – international<br>• Marine debris – ingestion | • Fisheries bycatch – domestic (trawl, net, pot and longline)<br>• Chemical and terrestrial discharge – chronic | • Chemical and terrestrial discharge – acute | | |
| **Unlikely** | • International take – outside and within Australia's jurisdiction | | | | |
| **Unknown** | | • Diseases and pathogens | • Noise interference – chronic | | |

## Flatback Turtle, Pilbara (F-Pil) Stock

| Likelihood of occurrence | Consequences | | | | |
|---|---|---|---|---|---|
| | No long term effect | Minor | Moderate | Major | Catastrophic |
| **Almost Certain** | | • Habitat modification – dredging/trawling<br>• Vessel disturbance (strike) | | | |
| **Likely** | • Recreational activities (off road vehicles) | • Noise interference – acute<br>• Marine debris – entanglement<br>• Indigenous take (eggs)<br>• Terrestrial predation (fox and goanna)<br>• Chemical and terrestrial discharge – chronic | • Climate change and variability (temperature)<br>• Habitat modification – infrastructure/coastal development | | |
| **Possible** | • Fisheries bycatch – international<br>• Marine debris – ingestion | • Fisheries bycatch – domestic (trawl, net, pot and longline) | • Light pollution<br>• Chemical and terrestrial discharge – acute | | |
| **Unlikely** | • International take – outside and within Australia's jurisdiction | | | | |
| **Unknown** | | • Diseases and pathogens | • Noise interference – chronic | | |

Hawksbill Turtle, North Queensland (H-nQld) Stock

| Likelihood of occurrence | Consequences | | | | |
|---|---|---|---|---|---|
| | No long term effect | Minor | Moderate | Major | Catastrophic |
| **Almost Certain** | | | | • Marine debris – entanglement<br>• International take – outside Australia's jurisdiction (shell) | |
| **Likely** | | • Indigenous take (eggs)<br>• International take – within Australia's jurisdiction (shell) | • Climate change and variability<br>• Terrestrial predation (pig, dog and goanna) | | |
| **Possible** | | • Marine debris – ingestion<br>• Chemical and terrestrial discharge – chronic<br>• Fisheries bycatch – domestic (pot, trawl, longline and net)<br>• Fisheries bycatch – international (longline, net and trawl) | | | |
| **Unlikely** | • Light pollution<br>• Recreational activities | • Vessel disturbance<br>• Habitat modification – dredging/trawling<br>• Habitat modification – infrastructure/coastal development<br>• Chemical and terrestrial discharge – acute | | | |
| **Unknown** | | • Diseases and pathogens<br>• Noise interference – acute and chronic | | | |

Appendix B

Hawksbill Turtle, North-east Arnhem Land (H-neArn) Stock

| Likelihood of occurrence | Consequences | | | | |
|---|---|---|---|---|---|
| | No long term effect | Minor | Moderate | Major | Catastrophic |
| **Almost Certain** | | | | • Marine debris – entanglement | |
| **Likely** | | • International take – within Australia's jurisdiction (shell) | • Climate change and variability<br>• Indigenous take (eggs) | • International take – outside Australia's jurisdiction (shell) | |
| **Possible** | • Recreational activities (tourism)<br>• Habitat modification – dredging/trawling<br>• Habitat modification – infrastructure/ coastal development<br>• Chemical and terrestrial discharge – acute | • Fisheries bycatch – domestic (trawl, longline, pot and net)<br>• Noise interference – acute<br>• Marine debris – ingestion<br>• Chemical and terrestrial discharge – chronic<br>• Vessel disturbance<br>• Fisheries bycatch – international (longline, net and trawl) | • Terrestrial predation (goanna and dog) | | |
| **Unlikely** | | • Light pollution | | | |
| **Unknown** | | • Diseases and pathogens<br>• Noise interference – chronic | | | |

Hawksbill Turtle, Western Australia (H-WA) Stock

| Likelihood of occurrence | Consequences | | | | |
| --- | --- | --- | --- | --- | --- |
| | No long term effect | Minor | Moderate | Major | Catastrophic |
| **Almost Certain** | | • Vessel disturbance<br>• Fisheries bycatch – international (longline, gillnet and purse seine) | | | |
| **Likely** | | • Marine debris – entanglement<br>• Terrestrial predation (silver gull)<br>• International take – within Australia's jurisdiction (shell)<br>• Habitat modification – infrastructure/coastal development | • Climate change and variability (temperature)<br>• Light pollution | | |
| **Possible** | • Recreational activities (tourism) | • Habitat modification – dredging/ trawling<br>• Chemical and terrestrial discharge – acute and chronic<br>• Indigenous take (eggs)<br>• Fisheries bycatch – domestic<br>• Noise interference – acute | | • International take – outside Australia's jurisdiction (shell) | |
| **Unlikely** | | | | | |
| **Unknown** | | • Diseases and pathogens<br>• Marine debris – ingestion | • Noise interference – chronic | | |

Olive Ridley Turtle, North-Western Cape York (O-nwCY) Stock

| Likelihood of occurrence | Consequences | | | | |
|---|---|---|---|---|---|
| | **No long term effect** | **Minor** | **Moderate** | **Major** | **Catastrophic** |
| **Almost Certain** | | | | • Marine debris – entanglement | • Terrestrial predation (pig, dog and goanna) |
| **Likely** | | • Indigenous take (eggs)<br>• Fisheries bycatch – international | | | |
| **Possible** | • Fisheries bycatch – domestic (longline and pot)<br>• Habitat modification – dredging/trawling<br>• Habitat modification – infrastructure/coastal development<br>• International take – outside and within Australia's jurisdiction | • Light pollution<br>• Vessel disturbance<br>• Chemical and terrestrial discharge – acute and chronic | • Fisheries bycatch – domestic (trawl and net) | • Climate change and variability (temperature, limited range and small population) | |
| **Unlikely** | • Recreational activities (tourism and off–road vehicles)<br>• Noise interference – acute | | | | |
| **Unknown** | | • Diseases and pathogens<br>• Marine debris – ingestion<br>• Noise interference – chronic | | | |

Olive Ridley Turtle, Northern Territory (O-NT) Stock

| Likelihood of occurrence | Consequences | | | | |
|---|---|---|---|---|---|
| | No long term effect | Minor | Moderate | Major | Catastrophic |
| **Almost Certain** | | | • Marine debris – entanglement | | |
| **Likely** | | • Indigenous take (eggs)<br>• International take – outside and within Australia's jurisdiction (meat)<br>• Fisheries bycatch – international | • | | |
| **Possible** | • Recreational activities (tourism and off–road vehicles)<br>• Fisheries bycatch – domestic (pot)<br>• Habitat modification – infrastructure/coastal development<br>• Habitat modification – dredging/trawling | • Vessel disturbance<br>• Chemical and terrestrial discharge – chronic<br>• Light pollution | • Fisheries bycatch – domestic (trawl, longline and net) | • Climate change and variability | |
| **Unlikely** | • Noise interference – acute | | | • Chemical and terrestrial discharge – acute | |
| **Unknown** | | • Diseases and pathogens<br>• Noise interference – chronic | • Terrestrial predation<br>• Marine debris – ingestion | | |

Appendix B

Leatherback Turtle, Nesting in Australia (LB)

| Likelihood of occurrence | Consequences | | | | |
|---|---|---|---|---|---|
| | No long term effect | Minor | Moderate | Major | Catastrophic |
| **Almost Certain** | | | | | |
| **Likely** | | • Fisheries bycatch – domestic (pot) | • Fisheries bycatch – international (longline, net, and purse seine)<br>• Fisheries bycatch – domestic (longline)<br>• International take – outside Australia's jurisdiction (eggs and meat)<br>• Marine debris – ingestion | | |
| **Possible** | • Indigenous take<br>• Light pollution | • Vessel disturbance (strike)<br>• Habitat modification – infrastructure/coastal development<br>• Marine debris – entanglement | • Climate change and variability (extreme weather) | | |
| **Unlikely** | • International take – within Australia's jurisdiction<br>• Habitat modification – dredging/trawling<br>• Recreational activities | • Chemical and terrestrial discharge – acute | | | |
| **Unknown** | | • Diseases and pathogens<br>• Chemical and terrestrial discharge – chronic<br>• Noise interference – acute and chronic | • Terrestrial predation | | |

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