Australian Government
Department of the Environment and Energy

National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna

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Introduction

Marine megafauna has a high public appeal in Australia, both for its ecological value as well as its economic, cultural and spiritual importance. Australian waters are home to 45 species of cetacean (whales, dolphins and porpoises), including permanent residents and occasional visitors. Dugongs, Whale sharks and six species of marine turtle are also found in Australian waters.

The risk of vessel collision is a known threat for Australia's marine megafauna, however, the scale of the problem is not clearly understood. Impacts to individual animals can be fatal or non-fatal, with non-fatal interactions potentially resulting in suffering and reduced fitness.

The *National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna* ('the strategy') is a guiding framework for identifying species most at risk of vessel collision; areas where these species are most at risk of vessel collision, and appropriate mitigation measures to reduce the risk of vessel collisions with marine megafauna. The strategy contributes to the implementation of the 2015 Long-Term Sustainability Plan for the Great Barrier Reef (https://www.environment.gov.au/marine/gbr/long-term-sustainability-plan).

The overarching goal of the strategy is to **provide guidance on understanding and reducing the risk of vessel collisions and the impacts they may have on marine megafauna**.

Vessel collisions are an international problem that require an improved understanding of the distribution, densities and behaviour of both marine fauna and vessels. Increasing our understanding of the numbers and location of collisions, and the circumstances surrounding them, is vital in understanding the scale of the problem in Australian waters and, where required, the appropriate implementation of mitigation measures.

The strategy addresses a range of marine megafauna including whales, dolphins, dugongs, turtles and Whale sharks. This list is not exhaustive, and the objectives and key actions can also apply to other marine fauna, as required.

While the focus of the strategy is to reduce the impacts of vessel collisions on the conservation status of marine species, it is recognised that doing this will also improve animal welfare and human safety, as well as reducing damage to vessels. In addition, vessel collision is only one of multiple anthropogenic threats that megafauna face, and any mitigation measures to reduce vessel collision are likely to complement measures that address other impacts such as noise and physical displacement.

For the purpose of the strategy a vessel includes any waterborne craft that could, if a collision with marine megafauna occurred, result in the injury or death of that animal. Examples can range from large, ocean-going commercial ships through to small recreational boats and jet skis.

The strategy proposes a strategic framework that identifies objectives and key actions that will help to understand and reduce the risk of vessel collision. The objectives will:

- address information and knowledge gaps through data acquisition
- determine the risk of vessel strike through data analysis
- reduce the likelihood and severity of megafauna vessel collision using appropriate mitigation measures
- undertake clear and effective communication through all stages of the strategy.

The target audiences of the strategy include government agencies responsible for the regulation of marine fauna or vessel activities, industry and those involved in policy development or managing activities in the marine environment.

The achievement of the strategy objectives and overarching goal will ultimately be determined by the level of resources that government authorities and other stakeholders commit to identifying and managing the problem. The quality of risk assessments will be determined by the availability and adequacy of the data collected and used.

Photo: Marine rescue vessels may need to travel at speed during emergency operations. This image shows the damage to a marine rescue vessel following the collision with a whale © Copyright Marine Rescue QLD and Keith Williams.

Strategic framework

Data acquisition

- New and existing information
- Spatial and temporal data
- Vessel density, movements, locations, and characteristics
- Species occurrence, habitat use and behaviour
- Data storage and management

Data analysis

- National risk analysis
- Identify areas of higher relative risk
- Determine absolute risk of collision

Mitigation

- Identification and development
- Research and innovation
- Implementation
- Education and enforcement
- Evaluation and review

Communication

- Identify and engage with key stakeholders
- Promote strategy

Measuring risk

The strategy will refer to two types of risk: **relative risk** and **absolute risk**.

Relative risk can predict where a collision is more likely to occur, but not how many collisions are likely to occur. As such, relative risk will not provide an indication of the magnitude of the risk, but rather a measure that compares risk between different areas. For example relative risk may indicate that the risk of collision is higher in area A than area B, or the risk of collision is 2.5 times higher in area A than area B.

Absolute risk quantifies the actual probability of a collision occurring in a defined geographical area. For example, area A has a 20 per cent chance of an individual and a vessel colliding in a given timeframe.

Simple measures of relative risk can be achieved by looking at animal and vessel density within a given area. An assessment of relative risk will identify areas of high co-occurrence and compare it to areas of low co-occurrence. A relative risk map can be useful in a number of ways. If we have evidence that indicates that animals are colliding with vessels, for example: where stranded animals have injuries consistent with a collision, than a relative risk map may show where these collisions are more likely to be occurring. On the other hand, if evidence of vessel collision is inconclusive, a relative risk map may be useful for indicating where a potential problem may emerge and where to focus monitoring.

Measuring absolute risk requires either comprehensive data indicative of all collisions (which in practice is difficult to obtain) or a much better understanding of the nature of the interaction between animals and vessels, such as the factors that will influence the probability of a vessel and an animal actually colliding. This includes vessel speed, beam and draft, probability of an animal being at the depth where collision could occur, and the probability of a particular species exhibiting avoidance or attraction behaviours. Absolute risk would provide the expected number of animals likely to be involved in collisions in a given timeframe, and hence, indicate how big a problem vessel strike is for a species.

Strategic framework for minimising the risk of vessel strike

Objectives and actions

Objective 1: Data acquisition – address information and knowledge gaps

One of the main difficulties in approaching the issue of vessel strike is that available data is often patchy and does not necessarily reflect the actual distribution or occurrence of vessel-strike incidents. The collection, collation and interpretation of data are the first critical steps in this process. This involves identifying species at risk; the spatial, temporal and biological characteristics that make these species susceptible to vessel strike; the vessel characteristics, including vessel type, patterns, densities and movements, and the impacts and injuries to megafauna that have been involved in a vessel collision.

At a minimum, information collected on vessels and marine megafauna needs to be adequate to determine the relative risk of megafauna vessel collision across Australia. This will enable the identification of areas where there is a higher likelihood of collision. To quantify relative risk, data on vessel and megafauna densities is required to identify where the co-occurrence of megafauna and vessels occur. Information can be collected from existing sources, modelling and projections. Where there is existing evidence of vessel collision, or where areas of higher-relative risk have been identified, the collection of further information on vessel movements, animal behaviour and environmental characteristics will improve our understanding of vessel strike and may allow for the determination of absolute risk.

Key actions

- Identify species suitable for a risk assessment based on known distribution, conservation status, known critical habitat, vulnerability to vessel strike and feasibility[1].
- For large vessels (those mandated to be fitted with Automatic Identification System (AIS) Class A), identify areas of high use in Commonwealth and state/territory waters. Examples may include international shipping lanes and ferry routes.
- For all other vessels not fitted with AIS Class A, such as recreational vessels and high-speed sports vessels, identify areas of high use, including near shore locations, confined bays and boat ramps.
- For areas identified as having high vessel use, define the distribution and abundance of suitable species.
- Collect information on vessel strike using all available records including historical records, government records (including state databases such as the New South Wales Elements Marine Fauna Database and Queensland's StrandNet) and the National Ship Strike Database https://data.marinemammals.gov.au/report/shipstrike.
- Undertake and document necropsies on stranded megafauna where evidence suggests vessel strike as the likely cause of death, and where modelling or hindcasting can reasonably determine the location of the collision.
- For areas predicted to have a higher, relative risk of vessel collision, collect additional information that will help to determine the absolute risk including:
  - species habitat use and critical habitats(s) such as those used for breeding, feeding, migrating and resting
  - species behaviour such as speed and manoeuvrability, time spent at the surface and habitat use
  - vessel characteristics including shape, speed, manoeuvrability, predictability and underwater noise characteristics
  - human behaviour and its influences on collision risk
  - level and effectiveness of enforcement by regulators
  - influences of season and time of day or night on collision risk
  - impact of noise and other environmental factors on ability of megafauna to hear or detect the direction of approaching vessels
  - water depths.
- Surveys of megafauna distribution patterns should aim to cover areas beyond known hot spots to enable routeing options to be evaluated.

Outcomes

- Maps and data of high-use areas for vessels including calibrated level of use, vessel type and speeds.
- Maps and data describing reported vessel strikes.
- List of species rated according to their suitability for analysis.
- For species identified as suitable for analysis, maps and data should be appropriate to measure the relative risk of vessel collision.
- For areas predicted to have a higher relative risk of collision between vessels and marine megafauna, maps and data should be appropriate to measure the absolute risk of vessel collision.
- Data and data layers should be open access and easily available on a publicly accessible website.

[1] NESP project C5 – *'Scoping of potential species for ship strike risk analysis'* identified species suitable for assessment based on two components: priority (ship-strike evidence and Environment Protection and Biodiversity Conservation 1999 Act status) and feasibility (species distribution and information, and vessel-size data). Feasibility referred to how practical a species analysis would be within a defined timeframe. The identification of suitable species will vary subject to the primary concerns of the organisation undertaking the assessment. Consideration could include high number of certain species reporting vessel collision, threatened status of species reporting vessel collision, or welfare reasons.

CASE STUDY – Data acquisition

Distribution patterns of Blue whale (Balaenoptera musculus) and shipping off southern Sri Lanka (Priyadarshana *et al.* 2015)

Visual and acoustic surveys were undertaken off the southern coast of Sri Lanka to better understand Blue whale distribution in relation to existing shipping lanes, with the data being used to model patterns of whale density. A high density of whales utilising this extremely busy shipping route suggests a severe risk of vessel collision.

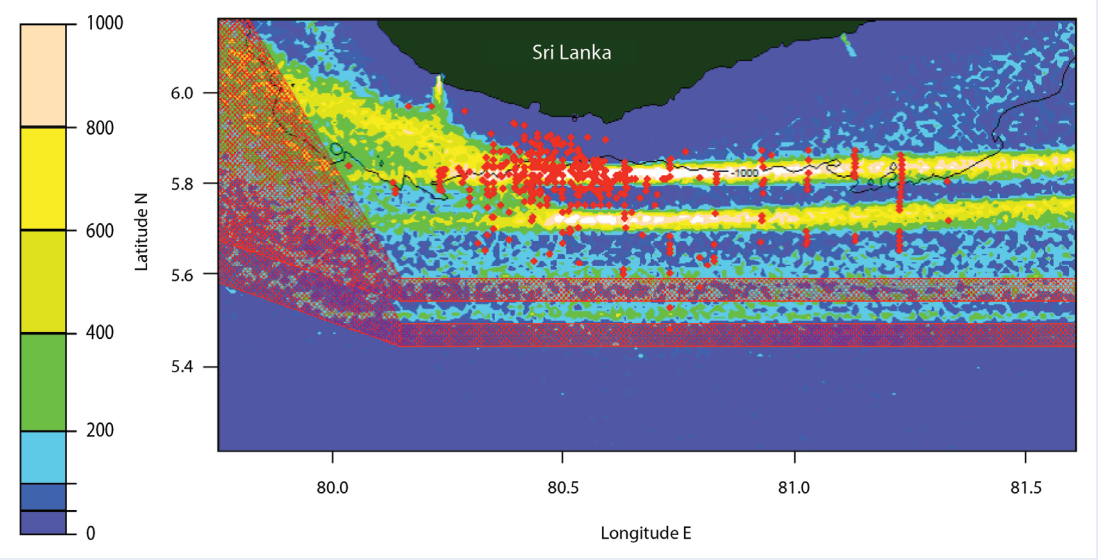

Figure 1: Shipping density according to scale measured as km-1 year-1. Red circles indicate all Blue whale sightings from surveys and whale watch observations by Raja and the whales. Red shaded area indicates possible alternative shipping route 15 nm to the south of the current Traffic Separation Scheme. ***Source: Priyadarshana et al. 2015.***

Objective 2: Data analysis - determine risk of vessel strike

The primary aim of this objective is to use existing and new information to first, determine the relative risk of megafauna vessel collision across Australia, and secondly, where locations of higher relative risk have been identified, consider more detailed information that can be analysed to better understand the nature of the interaction between animals and vessels. Ideally, the results of this analysis will not only identify where risk is higher and the magnitude of risk, but also assist in determining the appropriate mitigation measures suitable to species and locations, and the required level of resources needed to commit to reducing marine megafauna vessel interactions.

Key actions

- Develop methods to determine the relative risk of vessel strike for different species at an appropriate scale (local, regional or national).
- Undertake a national relative risk analysis for a range of marine taxa identified as suitable for analysis in the previous objective.
- Identify locations where there is a higher relative risk of megafauna vessel collisions, as indicated in the case study provided below.
- For areas identified as having a higher relative risk of megafauna vessel collision, undertake an assessment to determine the absolute risk of a collision occurring.
- Identify and map areas where the absolute risk of megafauna vessel collision is high.
- Analyse information and data on the interactions between megafauna and vessels that contribute to vessel strike.
- Consider what mitigation measures would be suitable relative to the level of risk, location, conservation status of species and the nature of the interactions between megafauna and vessels.
- Promote the use of risk assessments in planning facilities and activities in the marine environment to stakeholders, such as government agencies, tourism operators, mariners and port authorities.

Outcomes

- Maps and data of locations and species where there is a higher relative risk of megafauna vessel collisions.
- Maps and data of locations and species where the absolute risk of megafauna vessel collisions occurring is high.
- The nature of interactions, including the characteristics of vessels and megafauna that contribute to collisions is understood.
- Stakeholders are using appropriate risk assessments where a need is identified.
- Stakeholders understand the type of mitigations measures that are suitable to different situations.
- Outcomes and risk maps are open access and easily available on a publicly accessible website.

CASE STUDY- Data analysis

Quantitative assessment of the relative risk of ship strike to Humpback whales in the Great Barrier Reef (Peel et al. 2015) – On the east coast of Australia the main breeding ground for Humpback whales is within the Great Barrier Reef World Heritage Area (GBRWHA). Both the east and west coast of Australia have in the past decade experienced considerable coastal and port development and, as a consequence, an increase in shipping activity. Considering the rapid rate of increase of the east Australian population of Humpback whales there is potential for increased interaction between Humpback whales and shipping traffic and increased risk of ship strikes to the whales in their breeding ground.

To understand the risk of ship strike to Humpbacks in the GBRWHA, it is necessary to understand the distribution and densities for both whales and shipping. This study used current knowledge on the distribution of Humpback whales within the GBRWHA and contemporary shipping traffic data to provide estimates of relative risk of ship strike to Humpback whales within the GBR.

The analysis shows that the areas of highest relative risk coincide with offshore areas around the two major ports on the Queensland coast spanning the offshore area between the Whitsundays and Shoalwater Bay. One limitation of this risk assessment is that there are no results for the offshore areas to the south of Gladstone due to a lack of whale survey data in deeper waters. The full report can be found at the Australian Marine Mammal Centre website here:

https://data.marinemammals.gov.au/common/documents/grants/2013/AMMC-15-FINAL_REPORT-Quantitative_assessment_of_the_relative_risk_of_ship_strike_to_Humpback_whales_in_the%20GBR-v1.2.pdf

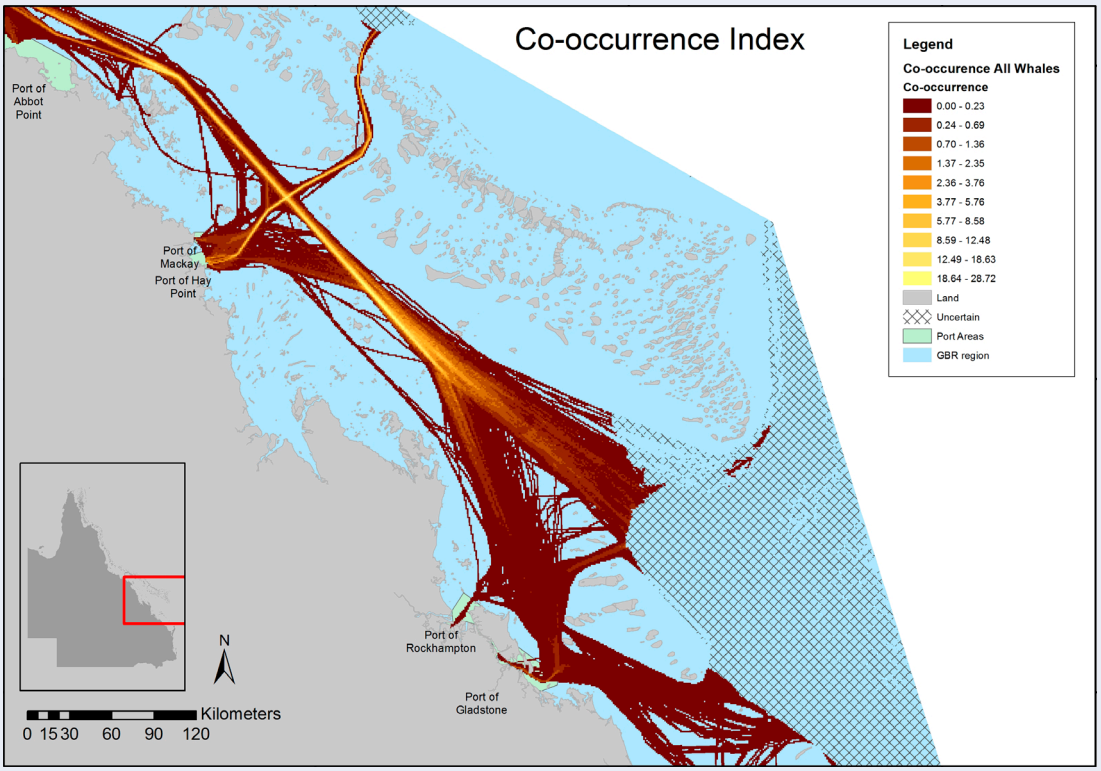

Figure 2 Co-occurrence risk for all whale groups and for all vessel type over the southern extent of the GBR. ***Source: Peel et al. 2015.***

Objective 3: Mitigation - reduce the likelihood and severity of megafauna vessel collision

When responding to an increased risk of vessel collision it is not always clear which mitigation measures are effective and where, how, and under what circumstances a measure for a particular location or species may be best employed. Consideration must be given to the time of year, species conservation status and behaviour, vessel characteristics and movement patterns, and the level of education and enforcement required to change human behaviour.

Mitigation measures should be based on sound science and appropriate risk assessment. However, if evidence emerges that vessel strike may be causing adverse impacts to a population of a species, a precautionary approach may be warranted. This means mitigation measures should be implemented to reduce the risk of collision-related mortality of a species, in the absence of full scientific certainty or data from long-term monitoring and research projects.

Mitigation measures may take the form of guidance, where particular measures are encouraged to reduce impacts, or regulation such as permanent routeing measures, speed restrictions and exclusion zones. The degree to which regulation is used will depend on the level of risk posed to a species and its conservation status. The use of regulation is most appropriate for threatened species that are at a higher risk of vessel collision.

In the case of large cetaceans, measures fall into three main categories - keeping vessels away from whales, slowing vessel speeds and avoidance manoeuvres. The Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO) has noted that 'minor routeing changes in high risk areas could lead to substantial reduction in strikes and was possibly the best measure of reducing ship strikes' (IMO 2016a).

Some vessels will choose to ignore measures such as speed restrictions and exclusion zones, and as such mitigation measures will only be effective if backed up by appropriate enforcement and penalties. It is also important to note that the implementation of mitigation measures must not compromise navigational safety at sea. In determining appropriate measures, early consultation should be undertaken with potentially affected stakeholders.

Key actions:

- Identify and adopt best-practice mitigation measures and emerging technologies, and encourage the development of new mitigation measures.
- Encourage innovation and collaboration between research organisations and industry.
- Develop a mitigation measures toolkit that provides guidance to stakeholders and managers on what measures are most suited to specific locations, species and vessel types.
- Develop and implement vessel strike management plans which identify appropriate mitigation measures in locations where the relative risk of vessel strike is higher, as determined by a risk assessment.
- Appropriate enforcement and penalties are applied to ensure compliance with regulation (if applicable).
- Adaptive management principles, including the use of regular reviews are used during the implementation of mitigation measures.

Outcomes

- A mitigation measures toolkit accompanied by a set of criteria that provides guidance on measures to be used is available to stakeholders.
- New and innovative measures have been developed and adopted.
- Where higher risk areas are identified, appropriate mitigation measures are considered and applied.
- The effectiveness of mitigation measures in reducing vessel collision is understood and reflected in the mitigation measures toolkit.
- The risk of vessel strike on marine megafauna in Australian waters is reduced.

CASE STUDY – mitigation

Offshore example: The case of the endangered North Atlantic Right whale - This species migrates along the east coast of the US and has been reduced to less than 500 individuals in the world. Collision with vessels is the leading human-caused source of mortality for the endangered North Atlantic Right whale. To reduce ship strike the US government introduced seasonal speed restrictions (10 knots or less), areas to be avoided and recommended shipping routes and traffic separation schemes for certain areas of the US east coast. Further information can be found at the US Government's National Oceanic and Atmospheric Administration website here: www.nmfs.noaa.gov/pr/shipstrike/

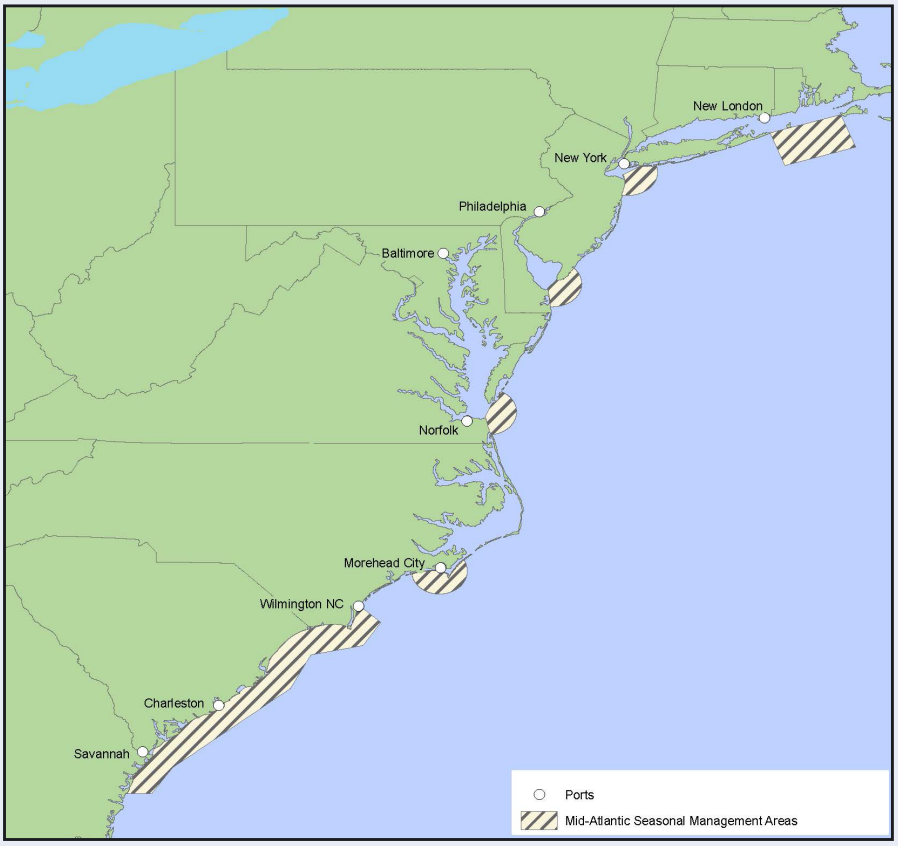

Figure 3 Mid-Atlantic Seasonal Management Area for North Atlantic Right Whale (NOAA NMFS 2013).

Near shore example: Moreton Bay in Queensland – Moreton Bay is home to dugongs, six species of marine turtle, and dolphins, as well as providing seasonal habitat for migrating whales. To protect dugong and turtles from boat strike the Queensland government has implemented go slow areas for certain areas of Moreton Bay (Queensland Government 2015). This includes:

- Go slow areas for turtles and dugong:
  - All vessels must travel off-plane or in displacement mode, and in a way that minimises the chance of a turtle or dugong being struck.
  - Motorised water sports are prohibited.
- Go slow areas for turtles and dugong (vessels >eight m):
  - Vessels >eight m are restricted to 10 knots or less.

High-speed vessel events in marine parks (Queensland): This operational policy outlines the circumstances under which high-speed vessel events may be permitted to occur within state marine parks (Queensland Government 2013). More information can be found at: www.npsr.qld.gov.au/policies/pdf/op-pk-mp-high-speed-vessel-events.pdf

Objective 4: Communication - undertake clear and effective communication through all stages of the strategy.

Communication is a vital component of any strategy and is important for all stages, from collecting information on species and vessels, through to the development, implementation and evaluation of mitigation measures to reduce vessel strike. Communication should occur between all stakeholders, including government agencies, scientists, industry, non-government organisations (NGOs), mariners, vessel owners and operators, and members of the general public. Where mitigation measures are likely to impact on marine users, early engagement is particularly important.

Key actions:

- Develop a communication plan.
- Identify key stakeholders and other groups with an interest in the strategy including government, researchers, NGOs, industry and the public.
- Seek input and cooperation from key stakeholders to collect data, undertake analysis and develop and implement mitigation measures, including:
  - Liaising with individuals and agencies that hold relevant data and information that can be used in undertaking risk assessments.
  - Communicating results of national risk assessment to key stakeholders.
  - Implementing mitigation measures.
- Include vessel collision as a standing item in existing fora where relevant.
- Promote the strategy, including:
  - Use of the database data.marinemammals.gov.au/report/shipstrike
  - The use of risk assessment methodology where more detailed local research is required.
  - The application of mitigation measures where risk assessment indicates a need, including the use of monitoring.
  - Education and outreach programs.

Outcomes:

- Increased reporting of vessel collision.
- Stakeholders and the general public understand risks and how to reduce them.
- Mitigation measures are implemented and enforced.
- Stakeholders have had the opportunity to provide input.
- Stakeholders are aware of relevant vessel strike mitigation resources and are using them in decision making processes.

Marine Notice 15/2016: Minimising the risk of collisions with cetaceans:

Marine notices are published by the Australian Maritime Safety Authority and provide information to the shipping and broader maritime community on a range of issues.

The purpose of this Marine Notice is to provide guidance to shipowners and operators in reducing the risk of collision with cetaceans. It also provides information on the location and migration periods of threatened whale species that occur in Australian waters (AMSA 2016).

More information can be found at: apps.amsa.gov.au/MOReview/MarineNoticeExternal.html

Duration, cost and evaluation

Ongoing and effective monitoring and evaluation of the strategy is critical to ensure that it continues to support best practice and that the actions are helping to achieve the strategy goal of reducing vessel strike risk. The strategy should be reviewed at intervals of no longer than five years.

Investment in many of the actions listed in the strategy will be determined by the level of resources that government and stakeholders commit to manage the problem. As knowledge regarding the full extent of the problem in Australian waters is not known, the total cost of implementation cannot be quantified.

Projects currently funded or underway

- Quantification of risk from shipping to large marine fauna across Australia. Project summary - tools and research are needed to spatially quantify the risk of ship strike to help develop management strategies. This work will use shipping density and speed data from the recent past, in parallel with species distribution and habitat models, to produce relative risk maps that can be used to identify areas and times where there is co-occurrence of at-risk marine fauna and shipping.
  http://www.nespmarine.edu.au/project/project-c5-quantification-national-ship-strike-risk
- Ship strike database – the Australian Government has developed a national ship strike database and associated web-based questionnaire. The data collected will inform other actions under this strategy and is compatible with the International Whaling Commission (IWC) ship strike database.
  https://data.marinemammals.gov.au/report/shipstrike

Strategy evaluation should identify knowledge gaps; evaluate the success of methods used to collect information and determining risk, the success of mitigation measures and the effectiveness of communication.

Background information relevant to the development of the strategy

Data and trends

International

IWC data indicate that there has been an increase in reported cetacean vessel collisions over the last 50 years (IWC 2010) (Figure 4). This increase is likely to be a combined result of several factors including better reporting, increased conservation interest, increased vessel activity and increasing population size for some species.

Although the number of reported incidents globally per year remains relatively low, there continues to be a significant number of incidents that are not reported to the IWC. This lack of reporting is likely a result of ship personnel being inexperienced with reporting procedures, fear of penalties if incidents are reported and species interactions going undetected due to large vessel size or vessel speed (Laist et al. 2001). In the case of stranded fauna, vessel collision may not always be recognised as the cause of death due to absent or inconclusive post mortems. Early data is based on historic accounts rather than direct reports.

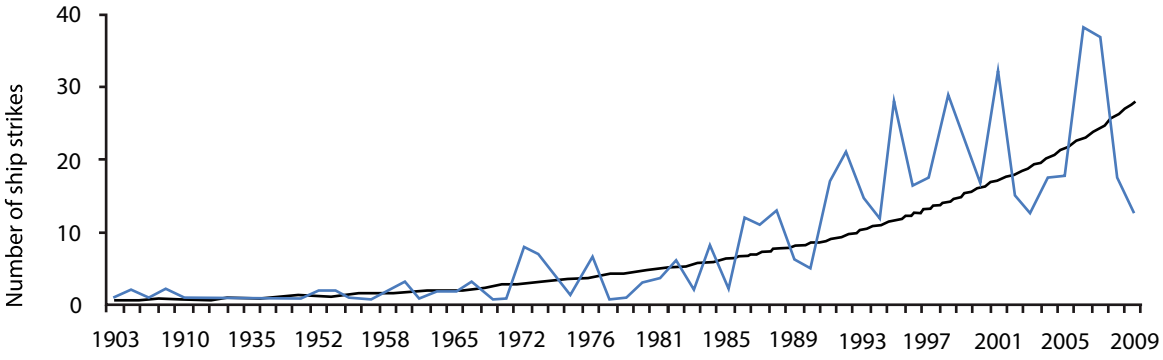

Figure 4 Number of vessel-strike incidents reported for the years 1903 to 2009 from the IWC global database *(Data source: IWC 2010).*

International data on ship strikes collated in the IWC global ship strike database shows the vessel type in the vast majority of strikes has not been recorded or is listed as 'unknown' (Figure 5). From the records with listed vessels, whale-watching boats, naval ships and container ships were recorded in the higher number of collisions. Laist *et al.* (2001) notes that it is likely that greater passenger and crew awareness is reflected in the higher numbers of whale watching and naval vessels involved in collisions.

Australian waters

A recent paper by Peel *et al.* (2016) provides the most up to date analysis of whale vessel collisions in Australian waters. Following a detailed search of online archives the study found reports dating back to 1840, including 74 additional records not in the IWC database, bringing the number of reported vessel collisions in Australian waters to 109. While this increases Australia's contribution to worldwide reports, the paper also notes that international vessel-strike data will be influenced by reporting bias and unknown coverage, and as such Australian vessel strike numbers may not reflect Australia's actual international contribution.

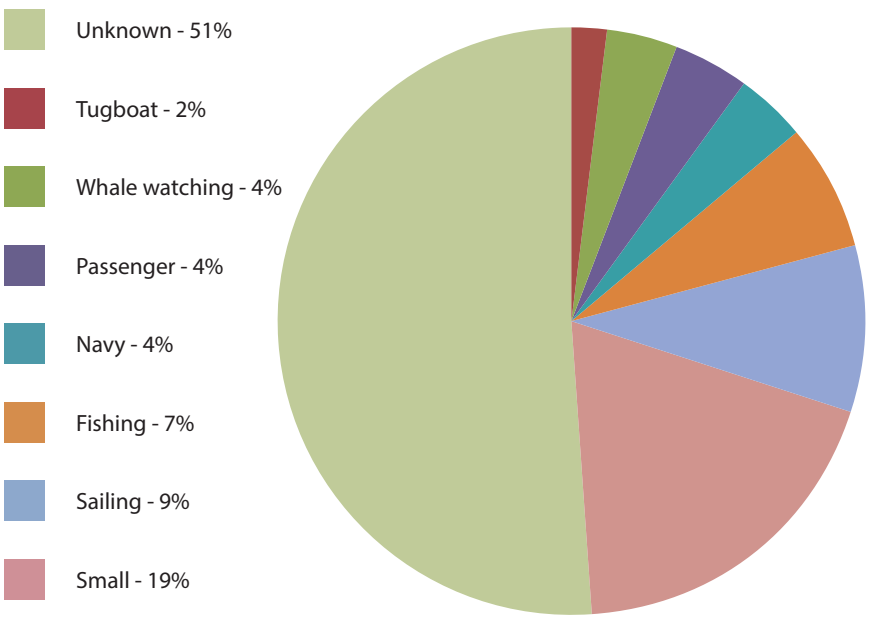

Figure 5 Proportion of vessel types involved in collisions with cetaceans in Australian waters *(Data source: IWC 2010, Peel at al 2016).*

International approaches to the management of vessel collision

The IMO is the United Nations' specialised agency that has responsibility for establishing standards for the safety, security and environmental performance of international shipping (IMO 2016a). The IMO has taken action to reduce the threat of ship strikes to large whales since first considering this issue in 1997. In 2008, Australia co-sponsored a proposal to the IMO's Marine Environment Protection Committee (MEPC) to develop an IMO guidance document to address the issue of ship strikes with cetaceans. In 2009, the MEPC approved the *Guidance Document for Minimizing the Risk of Ship Strikes with Cetaceans* and issued this as an MEPC circular (MEPC 2009) for the attention of interested parties and shipping companies. While emphasising that maritime safety is paramount, this document outlines important general principles and actions that may be taken to reduce the risk of ship strikes. These principles include the scientific assessment of shipping activity and co-occurring cetacean populations, evidence-based risk mitigation, monitoring the effectiveness of any mitigation measure, and seafarer education and outreach programs (MEPC 2009). Australian policy and principles have been informed by the IMO guidance document.

Based on submissions to the IMO, a range of IMO-adopted measures have been implemented by various countries where there are known ship-strike impacts due to the overlap of high shipping traffic and whale occurrence. Measures can include ship reporting systems and other alerting tools, voluntary or mandatory ship routeing systems, including traffic separation schemes and areas to be avoided, to reduce ship/whale interactions (AMSA 2017).

The IWC has been a key player in investigating the issue of ship strike through its conservation and scientific committees. To gain further insight into this global problem and potential measures of mitigation a 'Ship Strike Working Group' (SSWG) was established in 2005, of which Australia is an active member. Focus was directed at improving ways to estimate the number of whales involved in vessel strike. In 2016, the IWC submitted a paper summarising their work on ship strikes to the MEPC of the IMO (IWC 2016a), and in 2017 finalised the *Strategic Plan to Mitigate the Impacts of Ship Strike on Cetacean Populations: 2017-2020* that aims to develop approaches and solutions to achieve a permanent reduction in ship strikes (IWC 2017).

A global ship strike database incorporating information about cetaceans and vessels involved in collisions provides estimates of the incidence of ship strike, identifies trends and allows better understanding of risk factors. Currently over 1 000 international records of vessel collisions are held in the database, covering both recent and historical incidents (IWC 2016b).

The Secretariat of the Pacific Regional Environment Programme (SPREP) is an intergovernmental agency represented predominantly by Pacific Island countries including Australia. The SPREP Marine Species Programme is a regional strategy for the conservation and management of dugongs, marine turtles, whales and dolphins (SPREP 2012). Vessel interaction is identified as a threat for all species in the program and specific actions to reduce vessel interaction are included in the *Whale and Dolphin Action Plan 2013-2017* (CMS 2012).

Legal framework

National legislation

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Australian Government's key piece of environmental legislation. Under the EPBC Act, approval is required for any proposed action, including projects, developments, or activities, likely to have a significant impact on any of the identified matters of national environmental significance (MNES). Both threatened species and migratory species are MNES under the EPBC Act. In the Commonwealth marine areas it is also an offence to kill or injure a cetacean or a species listed as threatened, migratory or marine.

Under the EPBC Act, listed threatened species are required to have a Conservation Advice or a Recovery Plan. There are currently Conservation Management Plans (which fulfil the requirements of recovery plans under the EPBC Act) for the Southern Right whale (DSEWPC 2012) and Blue whale (DoEE 2015a). Both of these plans identify 'minimising vessel collision' as being high priority actions. Minimising vessel collision is also identified as a high priority action in the Conservation Advice for Fin, Sei and Humpback whales.

The *Great Barrier Reef Marine Park Regulation 1993* provides protection for cetaceans through provisions that require certain vessels to adhere to distances and speeds when operating near cetaceans within the Great Barrier Reef Marine Park.

In addition to the cetaceans mentioned above, the *Recovery Plan for Marine Turtles in Australia 2017-2027* identifies vessel disturbance including boat strike as being a threat to marine turtles (DEE 2017).

State and territory legislation

Coastal waters (up to three nautical miles offshore) lie under state and territory jurisdiction. Marine species present in this area are protected under legislation relevant to the adjacent state or territory. State and territory legislation relevant to the protection of marine fauna includes:

- *Biodiversity Conservation Act 2016* (New South Wales).
- *Biodiversity Conservation Act 2016* (Western Australia).
- *Nature Conservation (Wildlife Management) Regulation 2006* (Queensland).
- *National Parks and Wildlife Act 1972* (South Australia).
- *Threatened Species Protection Act 1995* (Tasmania).
- *Whales Protection Act 1988* (Tasmania).
- *Nature Conservation Act 2002* (Tasmania).
- *Wildlife Act 1975* (Victoria).
- *Flora and Fauna Guarantee Act 1988* (Victoria).
- *Territory Parks and Wildlife Act 2000* (Northern Territory).

What makes a species vulnerable to vessel collision?

Cetaceans

While factors such as vessel speed are known to affect the incidence and severity of a collision, there is less knowledge on whale behaviour in the presence of vessels (McKenna et al. 2015). Behavioural traits of certain species can make them more vulnerable to vessel strike such as slow swimming speed, and the habituation and general lack of awareness of vessel noise and danger posed by vessels.

Some species spend more time at the surface when resting, foraging or mating making them more vulnerable to vessel strike. Species such as Southern Right Whale are particularly vulnerable due to their colour, profile and lack of dorsal fin (M Watson, pers. comm., 10 May 2017). Species that are known to spend more time at the surface include Sperm whale, which have been observed sleeping at or just below the surface (Miller et al. 2008). Juvenile and unwell individuals may also spend more time at the surface (Koschinski 2003).

Laist *et al.* (2001) noted that individuals engaged in behaviours such as feeding, mating or nursing may be more vulnerable to vessel collision, when distracted by these activities. A study by McKenna *et al.* (2015) showed that Blue whales demonstrated limited behavioural response when being approached by ships. While some animals responded by undertaking shallow dives at a slow descent, none showed signs of horizontal movement away from the approaching ship.

Dugong

Studies in Queensland showed that dugongs spend around 47 per cent of their time within 1.5 m of the surface including 3.5 per cent resting at the surface (Hodgson 2004). This study also showed that calves spent 13 per cent of their time travelling or resting on their mother's back.

There is evidence that dugongs fail to flee or evade the approach of fast approaching vessels until an impact is unavoidable (Groom *et al.* 2004). Hodgson (2004) believes that vessel speed is the primary factor affecting collision risk due to 'the time available to flee being equal to the time the boat takes to travel the distance from the flee threshold to the dugong'.

In shallow water with large intertidal areas, vessels and dugongs can be constrained to channels during low tide periods, increasing the probability of vessel interaction. Groom *et al.* (2004) also recorded dugongs responding to an approaching vessel by moving towards deeper water, which again may result in dugongs interacting with vessels in channels.

Photo: Recreational boat passing dugong mother and calf in Moreton Bay © Copyright Rachel Groom.

Marine turtle

The effect of vessel speed and turtle flee response can be significant. A study by Hazel *et al.* (2007) recorded 60 per cent of Green turtles (benthic and non-benthic) fleeing from vessels travelling at four km/h, while only four per cent fled from vessels travelling at 19 km/h. When fleeing 75 per cent of turtles moved away from the vessel's track, eight per cent swam along the vessel track and 18 per cent crossed in front of the vessel. The study concluded that most turtles would be unlikely to avoid vessels travelling at speeds greater than four km/h.

The propagation characteristics of sound in the marine environment make it difficult for marine turtles to identify the direction of the source of vessel noise, and areas of high vessel use (and other anthropogenic noise) may mask individual noise (Hazel 2009). This is likely to limit the ability of marine turtles to use sound to avoid approaching vessels.

The relatively small size of turtles and the significant time spent below the surface makes their observation by vessel operators extremely difficult or impossible. Green turtles observed by Hazel (2009) generally only exposed the dorsal-anterior part of the head above the surface of the water and never for longer than two seconds.

Whale shark

Whale sharks are known to spend considerable time close to the surface increasing their vulnerability to vessel strike. Whale sharks tagged off Western Australia (Wilson et al. 2006, Gleiss *et al.* 2013) spent approximately 25 per cent of their time less than two metres from the surface and greater than 40 per cent of their time in the upper 15 m of the water columns.

Whale sharks migrate large distances and can be found in coastal offshore waters. Spending such considerable time within the 15 m of the surface leaves them vulnerable to collision with smaller vessels as well as larger commercial vessels that have drafts that extend greater than 20 m below the surface.

Impacts of vessel strikes

The consequence for a marine animal involved in a collision with a vessel can range from minor to extreme. An individual may show no sign of injury, have a survivable non-debilitating injury or sustain debilitating or even fatal injuries. Vessel strike may include collisions with the bow or hull which can cause major cranial fractures, haemorrhaging, tissue and organ damage, bow draping (often only of large cetaceans) whereby a large animal becomes draped over the bow and dragged along at the front of the vessel over substantial distances, or being struck by the propellers, potentially causing loss of fins or flukes and severe lacerations to the body (van Waerebeek *et al.* 2006).

Mother and calf dugongs killed by boat strike in Moreton Bay © Copyright Rachel Groom.

Injuries sustained from vessel collisions are not always lethal. Jensen and Silber (2003) reported that of 292 incidents of vessel strike with large cetaceans, only seven appeared to have no signs of injury, while Jefferson (2000) identified several dolphins with evidence of severe propeller injuries on the back of the animal and the dorsal fin. In these cases, the loss of blood, possibility of infection and reduced swimming efficiency would lead to an overall reduction in fitness of the individuals (van Waerebeek *et al*. 2006).

For species considered threatened, vessel collision may also have population level impacts. In the case of a species that is recovering well, such as the east and west coast populations of Humpback whales, the loss of one individual would be unlikely to impact at the population level. However, in the case of the south-eastern Australian population of the Southern Right whale which is showing little evidence of recovery, the loss of an individual would be considered significant (DSEWPC 2012).

The influence of vessel speed on the incidence and severity of collision

Speed is a concern when considering collision risk and the outcome. Vanderlaan and Taggart (2007) observed that an escalation in speed of the vessel caused an increase in the severity of injury to large cetaceans. Slower moving vessels provide greater opportunity for both fauna and vessel to avoid collision. Species detection depends on their profile on the surface and slower moving vessels would be afforded greater time to manoeuvre and predict their movements. Vessel speed may also result in animals, including large whales, being drawn laterally towards the hull of the vessel (Silber *et al*. 2010).

Collisions with large cetaceans involve a variety of vessel types including large ships such as tankers, cargo or cruise ships, but also navy ships, whale-watching vessels, yachts or hydrofoils (Laist et al., 2001; Jensen and Silber 2003; van Waerebeek *et al.* 2007; Carrillo and Ritter 2010). Large, high-speed vessels, in particular, have become a major concern as they are capable of travelling at speeds of up to 35 to 40 knots, which correlates to an increase in collisions (Weinrich 2004; Ritter 2010). Many of these vessels also incorporate modern hull shapes which may be particularly hazardous to cetaceans (Carrillo and Ritter 2010). According to Laist *et al*. (2001), 89 per cent of incidences where the whale was severely hurt or killed occurred at vessel travelling speeds greater than 14 knots and were most serious in large vessels (> 80 m). Furthermore, the chance of an injury being lethal increases significantly as vessel speed increases up to 13-15 knots (Vanderlaan and Taggart 2007).

Similarly, Hazel *et al*. (2007) and Hodgson (2004) found speed to be a critical factor in determining a flee response in marine turtles and dugongs being approached by vessels. The proportion of flee responses decreased significantly with increasing speed, particularly with close encounters. While speed is a particularly important factor, so too is the movement patterns of the vessel for example, whether a vessel is transiting a dedicated route or is a recreational boat that is moving erratically.

Vessel movements and densities in Australian waters

Commercial vessels

Australia is geographically remote from major world suppliers and markets and therefore relies heavily on sea-borne trade. Over 98 per cent of Australia's trade by weight is carried by sea (BITRE 2014). Figure 6 shows the location of major Australian ports and the level of shipping activity associated with each of these ports.

Over 30,000 commercial vessels visited Australian ports for the year ending 2014. This included 11,000 dry bulk vessels, 5308 container vessels, 3225 bulk liquid vessels and 737 cruise vessels (Ports Australia 2014, Port of Melbourne 2016).

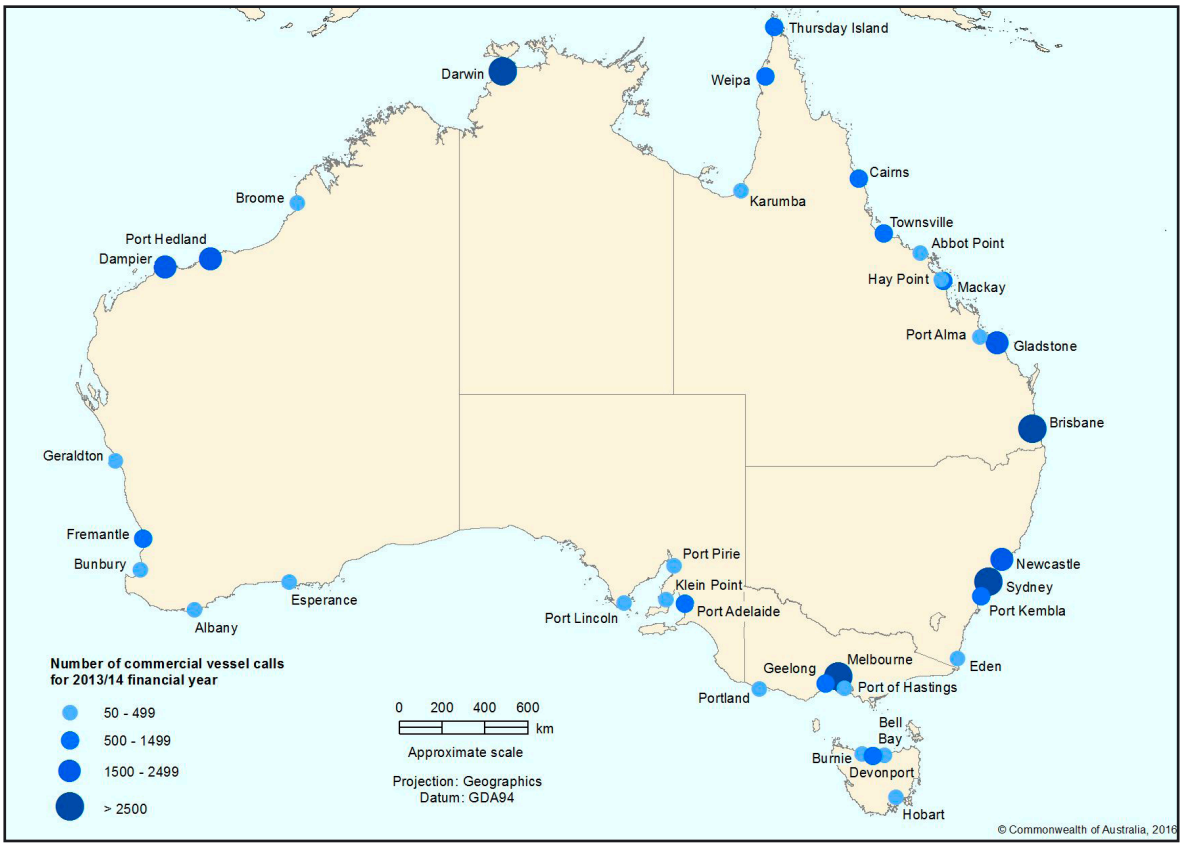

Figure 6 National ports showing total number of commercial vessel calls for 2013/2014 (Note: Sydney includes Sydney Harbour and Port Botany) ***(Data source Ports Australia 2014).***

A report by the Bureau of Infrastructure, Transport and Regional Economics (BITRE 2014) forecasts containerised trade (20 foot equivalent units (TEU)) across Australian ports will increase by 5.1 per cent per year until 2032, while non-containerised trade (tonnes) is forecast to increase by 3.9 per cent per year. The report also forecasts sea passengers (inbound and outbound) to increase by 1.8 per cent per year over the same period. While factors such as increased vessel sizes may influence forecast vessel numbers, this level of increase in tonnage, units and passengers is likely to result in a significant increase in shipping activity in Australian waters in the future.

Recreational vessels

Prideaux (2012) undertook a review of relevant literature and found that there was about 832, 065 recreational boats registered in Australia. Table 1 provides the approximate number of registered recreational boats for each state and territory. The review indicates that Queensland has the highest ownership of registered recreational vessels in Australia.

Table 1 Number of registered recreational boats in Australia ***(Data source: Prideaux 2012)***

	Approximate number of registered recreational boats (< 24 m)	Approximate number of recreational ships (> 24 m)	Approximate total
Queensland	233,600	1727	235,327
New South Wales	228,643	1862	230,505
Victoria	172,847	707	173,554
Western Australia	93,244	642	93,886
South Australia	51,844	284	52,128
Tasmania	29,370	287	29,657
Northern Territory	11,717	296	12,013
Australian Capital Territory	10,800	N/A	10,800
Australia wide	832,065	5805	837,870

N.B. Actual number of boats may be higher as this statistic does not include non-powered boats. Findings should be interpreted with caution as not all boats require registration and therefore, the total number of boats may be much higher.

Recreational vessel trends in Queensland

In January 2016 there were approximately 256,000 registered recreational vessels in Queensland. The highest number of registrations were in the Brisbane maritime region with 143,000 vessels and the Gladstone maritime region (which includes the coastal area from the Capricorn Coast to Hervey Bay) with 48,000 vessels. Over the last eight years the number of registered recreational vessels in Queensland has increased by approximately 16 per cent. Over this period the Gladstone maritime region had the highest percentage increase of approximately 23 per cent (Maritime Safety Queensland 2016).

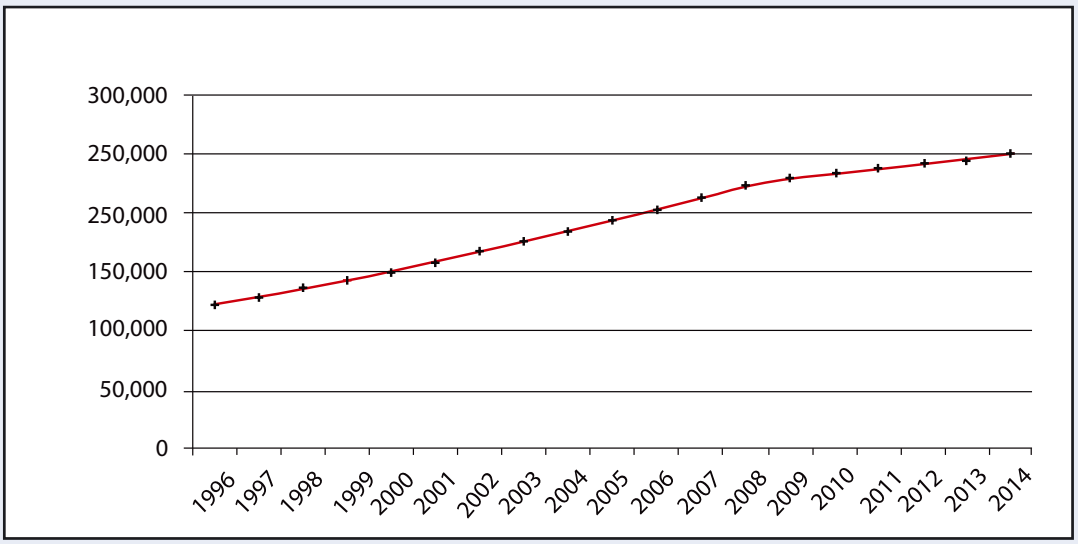

Figure 7 Growth of registered recreational vessels in Queensland between 1996 and 2014. ***Data source: Queensland Government 2016.***

A report by NSW Maritime (2010) states that boat ownership in New South Wales has generally mirrored population growth and that there has been little evidence of the effects of economic crisis on Australian boat ownership. Australia's population has grown by approximately 1.3 per cent per year between 1992 and 2012 and is forecast to grow at approximately 1.5 per cent per year until 2032. This is considered high by OECD average growth rates that have ranged from 0.5 per cent and 0.7 per cent per year over the same period (DIRD 2015). While there are likely to be other factors that influence vessel numbers, considering Australia's high population growth it is considered likely that there will also be significant growth in the number of recreational vessels in Australia.

Passenger ferry services

Passenger ferry services within or close to large population areas can contribute to high vessel traffic. Significant ferry traffic occurs in Sydney Harbour in addition to the commercial and recreational vessels, water taxis, naval vessels and sea-going ships. Regular passenger and car ferries travel between mainland Australia and offshore islands such as Rottnest Island in Western Australia, Kangaroo Island in South Australia and Stradbroke Island in Queensland. Stradbroke Island ferries alone make up to 25,000 crossings of Moreton Bay each year (http://www.stradbrokeferries.com.au/about/). A study in the Canary Islands in Spain (Ritter 2010) noted that collisions with whales increased over the period in which slow moving ferries were replaced with high-speed vessels.

Species of concern in Australian waters

Whales

Data on vessel strikes of large cetaceans in Australian waters to date is limited. What is known has been compiled from reports given to the IWC global database (IWC 2010) and a more recent report by Peel *et al.* (2016).

In Australian waters, records of vessel strike from 1997 to 2015 show that Humpback whales, in particular, occur with the highest frequency (47 per cent) followed by Southern Right whales with 12 per cent. Twenty five per cent of the records were recorded as unidentified large whale (Peel *et al.* 2016). Figure 8 shows the approximate locations of reported vessel collisions for whales in Australian waters between 1990 and 2015, and the locations of whales that were found at sea or washed up, where the cause of death was attributed to vessel strike. Figure 9 provides a breakdown of large cetaceans involved in vessel strikes in Australian waters in modern times.

Impacts of vessel collision on whale, Scott Filmer © Copyright NPWS and Scott Filmer.

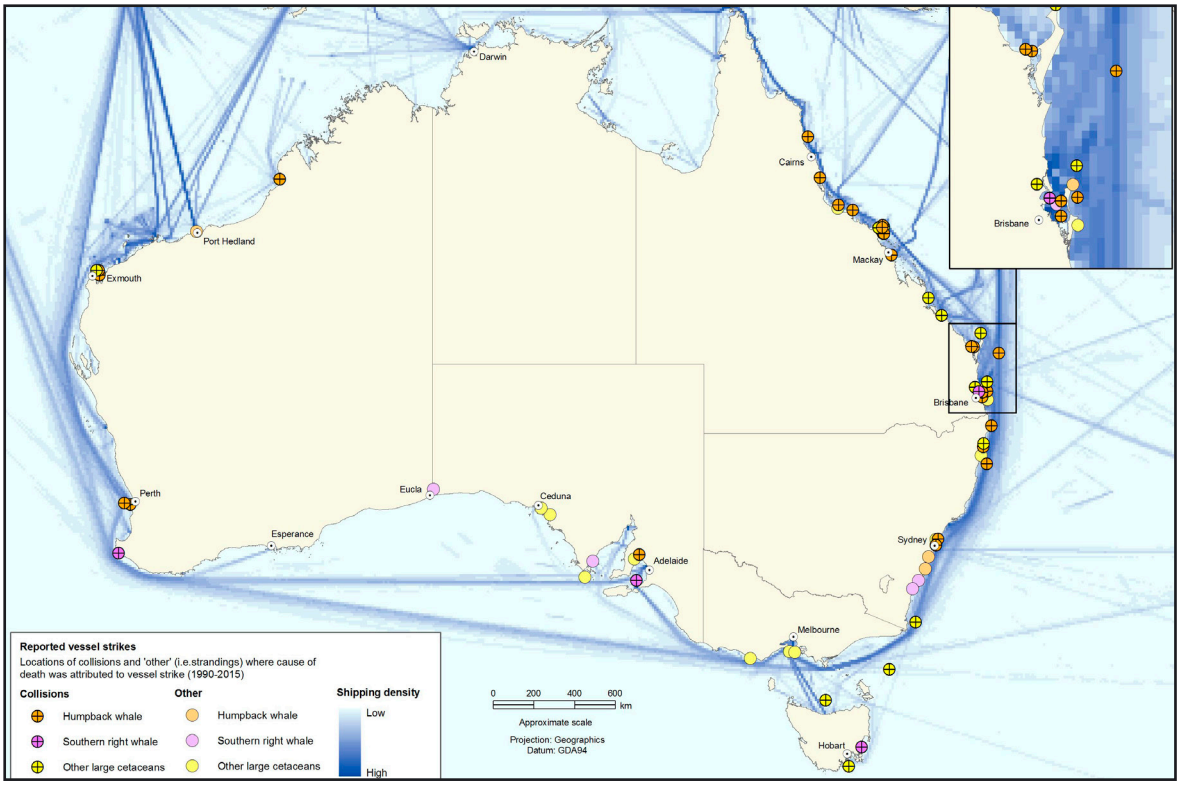

Figure 8 Location of reported vessel collisions with whales, or other incidents such as strandings where cause of death is attributed to vessel collision. ***(Data source: Peel et al. 2016, Commonwealth of Australia (2014) ESRI Australia Pty Ltd (1992): ARCWORLD World Dataset 1:3 million, Geoscience Australia (2004): GEODATA TOPO 100K – Coastline, Geoscience Australia (2006): GEODATA TOPO 250K).***

Documented vessel strikes in Australian waters listed in the global IWC database date back to 1988, but are sparse until after the year 2000. Peel *et al.* (2016) undertook a preliminary examination of vessel collision reports between 1840 and 2015. While the 2010 IWC ship strike database contained 35 records in Australian waters, the paper found additional records that increased the total to 109 records. It was also noted that further validation is needed for the additional reports.

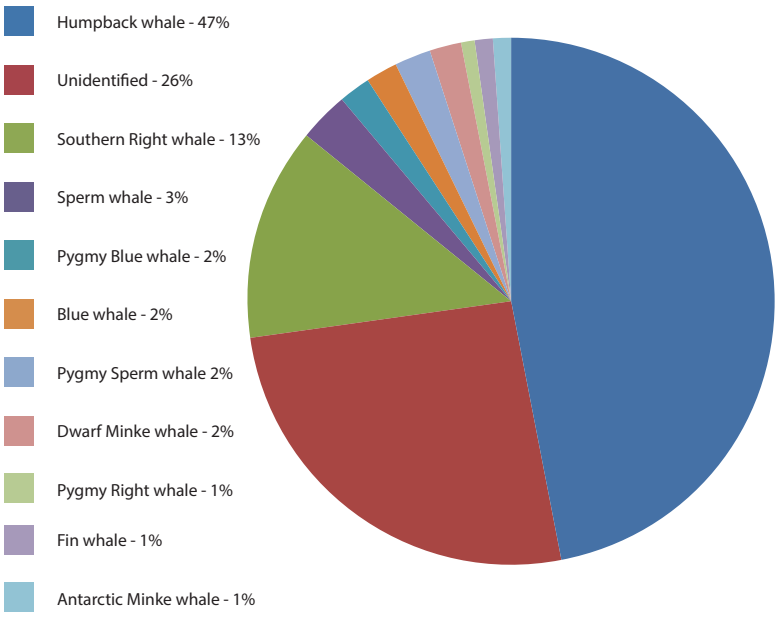

Figure 9 Break down of large cetaceans involved in vessel strike in Australian waters from 1997 to 2015 ***(Data source: Peel et al. 2016).***

Southern Right whale (*Eubalaena australis*)

The Southern Right whale is currently listed as endangered under the EPBC Act. In Australian waters there is a south-west population and a south-east population. Southern Right whales generally migrate as far north as Sydney on the east coast and occasionally as far north as Hervey Bay. In coastal waters southern right whales generally occur within two kilometres off shore.

Southern Right whales from the south-west population appear to be increasing at the maximum biological rate but there is limited evidence of increase in south-eastern waters. The most recent population estimates for the south-east population range from 224 – 257 (AMMC 2015).

Southern Right whales are considered vulnerable to vessel strike due to their presence in near shore waters during critical life phases such as breeding, as well as their profile, lack of dorsal fin, slow swimming behaviour and time spent at the surface.

Due to their extremely low population estimates, the loss of an individual from the south-east population is likely to result in significant, potentially population-scale impacts (DSEWPC 2012). Small populations are also more vulnerable to inbreeding and the impacts of stochastic events.

In recent times there have been at least three fatal vessel collisions and two non-fatal vessel collisions in Australian waters involving Southern Right whales. In 2001 a ferry traveling between the mainland and Kangaroo Island struck and killed an adult Southern Right whale (Kemper *et al.* 2008). In 2009, a Southern Right whale calf was struck and killed by a vessel off Ulladulla, New South Wales (Gedamke *et al.* 2010). In 2014, a female Southern Right whale was hit and killed by a ferry operating in Moreton Bay, Queensland (Peel *et al.* 2016; ABC 2014).

The major problem with records of collisions to date is the vast knowledge gaps, especially concerning true numbers of vessel interactions with different species. Even though there is the obligation to report any vessel collision that may result in a cetacean being injured or killed (Section 232, EPBC Act), it is likely that some vessel collisions go undetected and/or are not being reported (Laist *et al.* 2001).

The steady increase over the last decade in shipping activity in Australia and the predicted escalation in the future (Laist et al., 2001, BITRE 2014), coinciding with the growth in population size of both Southern Right whale (south west population) and Humpback whale populations, suggests the probability of vessel interactions involving these species will also increase.

Dolphins, dugong, Whale shark and turtle

As smaller taxa and vessels are often confined to significant intertidal areas or constrained to narrow channels during low tidal phases, there is a considerable increase in the risk of vessel strike. In coastal areas of Australia, inshore populations of dolphins, marine turtles and dugongs inhabit or migrate through some of the nation's busiest waterways. The resulting interaction between inshore species and bathymetry is likely to be a major factor in the higher probability of vessel strikes in such areas. Small motorised, fast-moving vessels have increased as a source of anthropogenic disturbance, be it noise or collision, in coastal waters due to their rise in popularity.

Whale sharks routinely feed at the surface making them vulnerable to vessel strike. This species is found in coastal and oceanic environments making them vulnerable to both collisions with smaller recreational vessels and large ships.

The IWC ship strike database has limited records of vessel strike with dolphins in Australian waters. Between 1988 and 2000 there were only three documented incidents involving small marine mammals, including a single Indo-Pacific Humpback dolphin, a Common Bottlenose dolphin and an unidentified dolphin.

In New South Wales, the National Parks and Wildlife Service (NPWS) maintain the Elements Marine Fauna Database (NPWS 2017) which records all marine fauna strandings. Within this database, there have been nine recorded incidents of vessel strike involving Bottlenose, Common, and Striped dolphin species to date. Three of these incidents involved a Common dolphin and occurred in Sydney Harbour, six resulted in fatalities. 54 vessel strike incidents have been reported for marine turtles resulting in 21 confirmed deaths.

In Tasmania, the Marine Conservation Program within the Department of Primary Industries, Parks, Water and Environment (DPIPWE) maintains a database of cetacean sightings, strandings, entanglements and/or other injuries. Since 1999, 10 incidents of vessel-strike have been reported and recorded, involving six species. Six events resulted in confirmed fatalities.

The Queensland Department of Environment and Heritage Protection (EHP) maintain a database of marine wildlife strandings and deaths (referred to as StrandNet). In 2011, StrandNet recorded 126 incidents involving marine turtle interactions with vessels, including propeller cuts and impact injuries from colliding with the hull. Of these occurrences, 116 were fatalities, making this interaction the greatest cause of anthropogenic mortality to marine turtles in this year. The vast majority of these records involved Green turtles, with Flatback, Loggerhead and Hawksbill species also involved in incidents of vessel strike. Of these records, it is also notable that an overwhelming number occurred in Moreton Bay, Gladstone and Townsville areas with 51, 36 and 13 respective records. Collectively, between 1996 and 2011, there were 48 recorded stranding events of dugongs, with evidence of boat strike in Queensland (QLD Government 2011).

Potential areas of concern for large cetaceans

Given the migratory nature of many large cetaceans, defined 'areas of concern' may only be relevant on a temporal or seasonal basis when whale movement through a region is high. Areas surrounding major Australian ports, primarily along the east and west coasts where shipping activity is highest may be cause for concern. Melbourne, Brisbane, Newcastle, Dampier, Sydney, Port Hedland, Fremantle, Darwin and Gladstone harbours or ports had the highest number of ship calls (during the 2013/14 period) and all, with the exception of Darwin, lie on migratory routes or close to areas that whales aggregate.

Figure 12 illustrates the migratory routes and aggregation areas for Humpback whales along the west and eastern seaboard and the relevant shipping density data. It is evident that there is an overlap between Humpback whale migratory paths and shipping activity, in particular the high number of port calls in known regions of cetacean distribution (e.g. Brisbane Harbour and Dampier Port). Figures 13 and 14 overlay Blue whale and Southern Right whale core habitat and aggregation areas with AIS shipping point density data and provides a basic representation of where ships are likely to co-occur with these species.

Peel *et al.* (2016) looked at the spatial and temporal distribution of vessel collision reports in modern times and showed that the majority of records were from Queensland (Figure 11). The seasonal distribution of vessel strikes in all Australian waters showed that the majority of vessel collisions for Humpback whales and Southern Right whales occurred in the month of August (Figure 10).

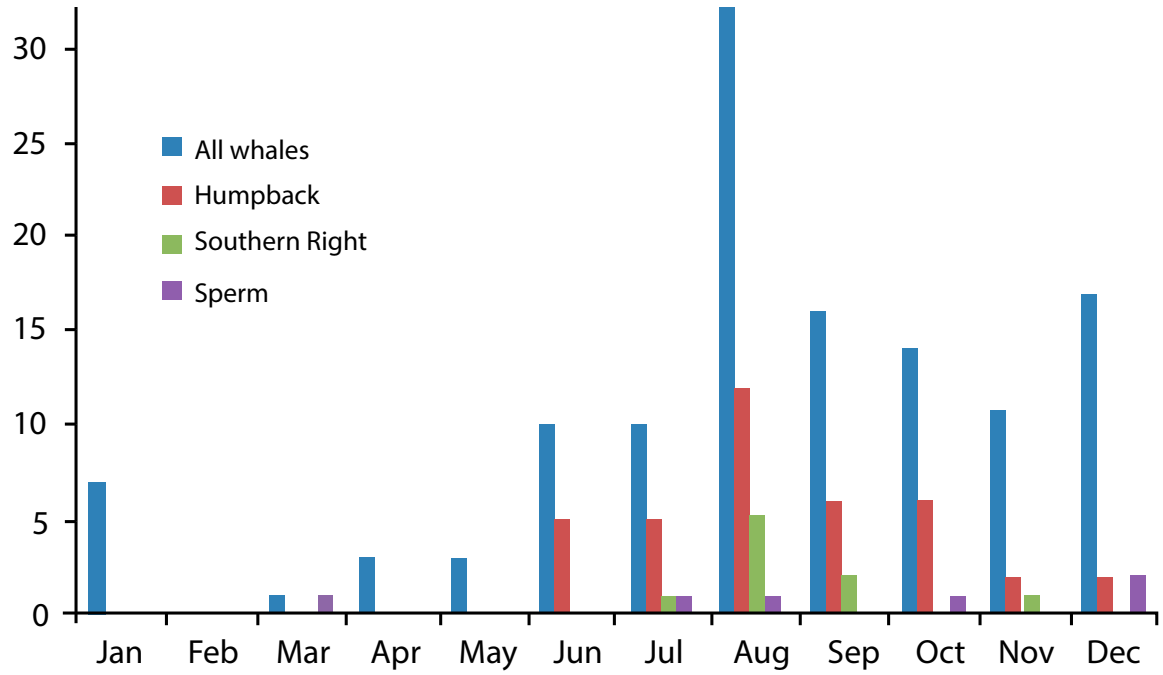

Figure 10 Seasonal distribution of reported vessel collision for Humpback whales, Southern Right whale, Sperm whale and all whales in Australian waters ***(Data source: Peel et al. 2016).***

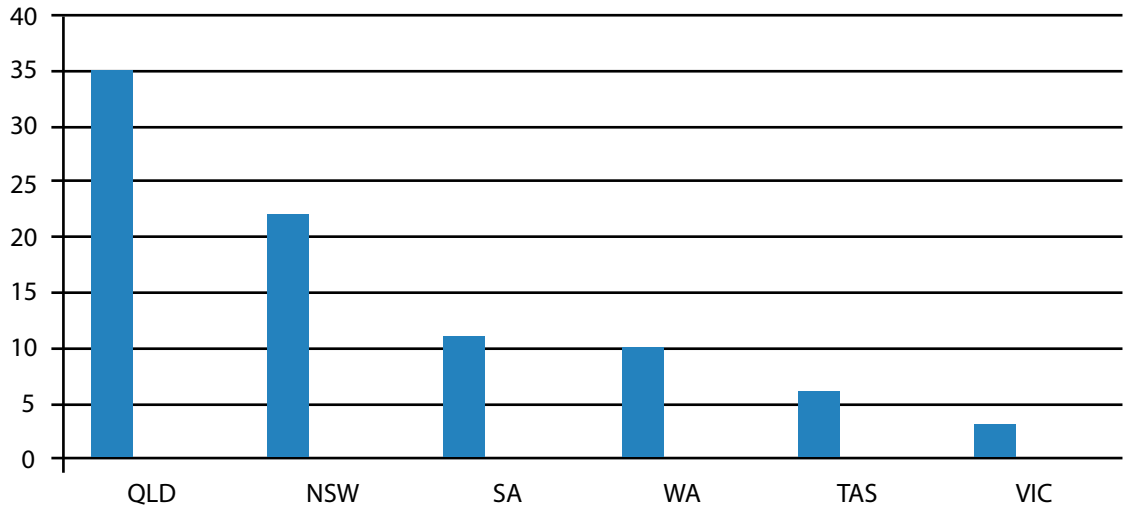

Figure 11 Reported whale vessel collisions for each state of Australia between 1995 and 2015 ***(Data source: Peel et al. 2016).***

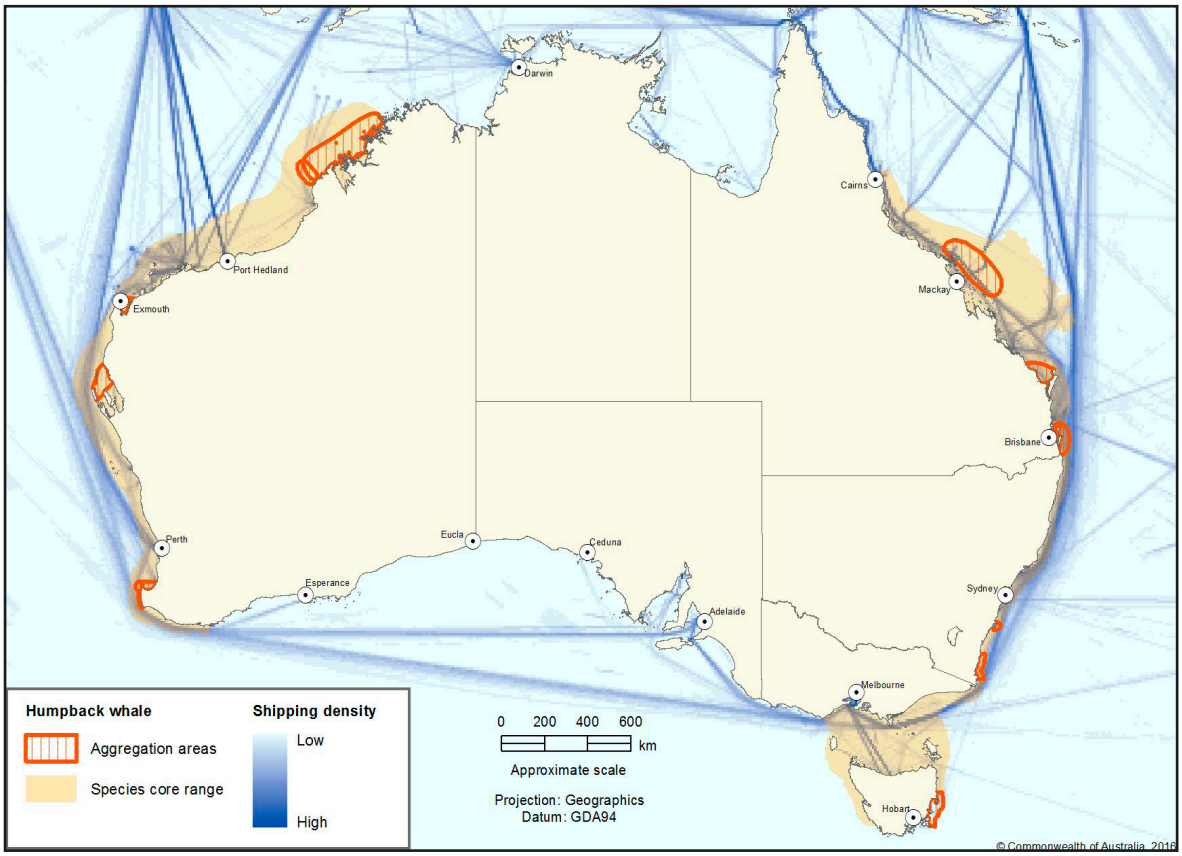

Figure 12 Humpback whale core range and aggregation areas with shipborne Automatic Identification System point density. ***Data source: DoEE (2015) Commonwealth of Australia (2014) ESRI Australia Pty Ltd (1992): ARCWORLD World Dataset 1:3 million, Geoscience Australia (2004): GEODATA TOPO 100K – Coastline, Geoscience Australia (2006): GEODATA TOPO 250K.***

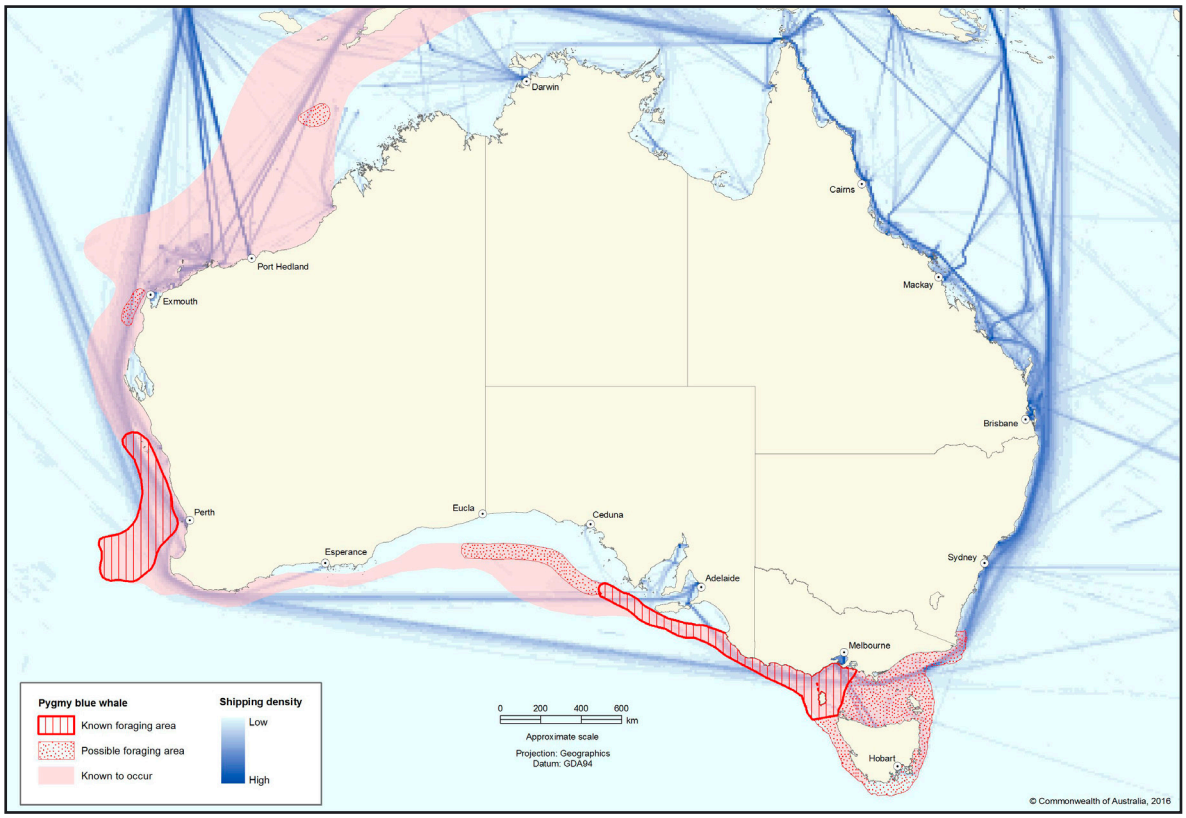

Figure 13 Pygmy Blue whale areas of occurrence and known and potential foraging areas with shipborne Automatic Identification System point density. ***Data source: DoEE (2015a) Commonwealth of Australia (2014) ESRI Australia Pty Ltd (1992): ARCWORLD World Dataset 1:3 million, Geoscience Australia (2004): GEODATA TOPO 100K – Coastline, Geoscience Australia (2006): GEODATA TOPO 250K.***

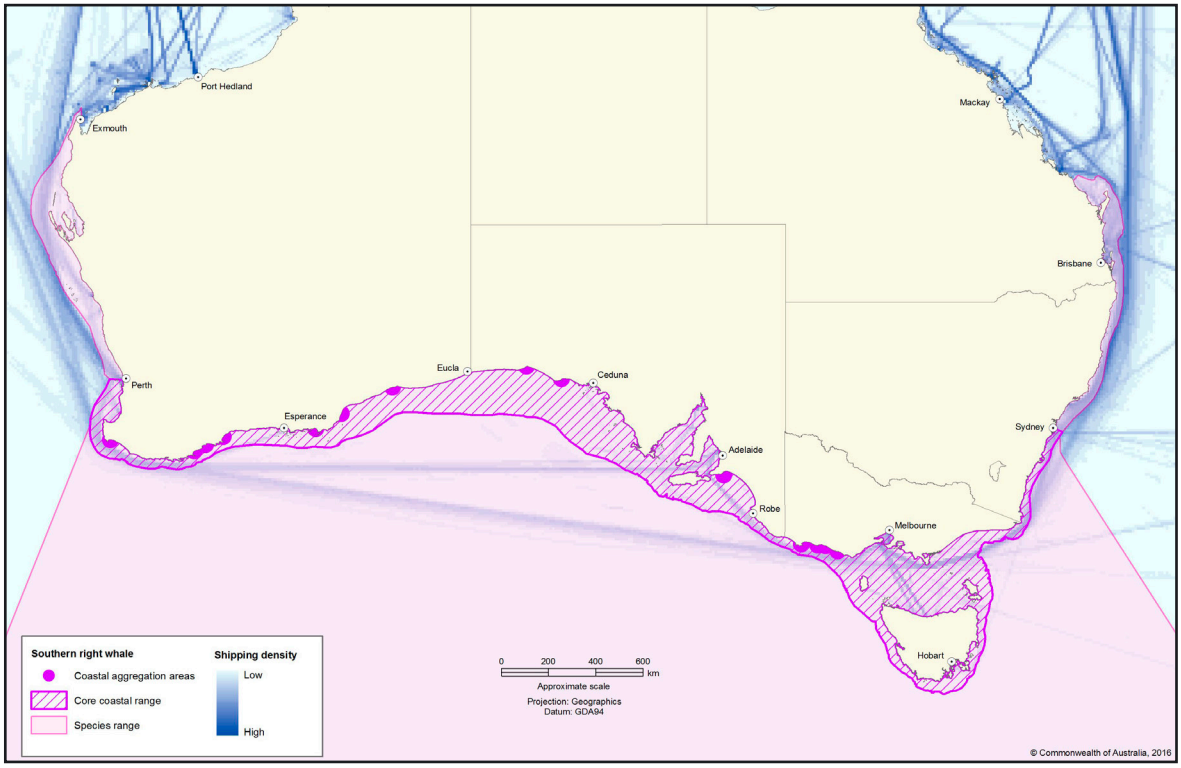

Figure 14 Southern Right whale species range and aggregation areas with shipborne Automatic Identification System point density. ***Data source: DSEWPC (2012) Commonwealth of Australia (2014) ESRI Australia Pty Ltd (1992): ARCWORLD World Dataset 1:3 million, Geoscience Australia (2004): GEODATA TOPO 100K – Coastline, Geoscience Australia (2006): GEODATA TOPO 250K.***

Potential areas of concern for dolphin, dugong and turtle

There are several areas that may be classified as potential 'areas of concern' for vessel strike with small marine fauna. With the exception of New South Wales and Queensland, however, there is a general lack of data on the incidents of vessel strike and where they occur. This preliminary assessment shows that many small fauna inhabit some of Australia's busiest waterways with resident groups or local breeding populations often coinciding with a high density of boating activity. It is also evident that records in many of these areas are limited. To date, records from NPWS and Queensland StrandNet suggest Port Stephens in New South Wales and Gladstone and Moreton Bay in Queensland are potential 'areas of concern' for vessel strike.

NPWS records involving small marine taxa in New South Wales showed 22 per cent of incidents occurred in Port Stephens. The steadily increasing tourism industry which is strongly based on dolphin watching, as well as consistently growing densities of recreational boat users contributes to a higher risk profile for this area. Turtles have been involved in recorded incidents of vessel strike. Whilst there are no reports of collisions with dolphins in this area, the increasing density of recreational boats may become a greater threat to the small isolated population of Indo-Pacific Bottlenose dolphins inhabiting this waterway.

In Moreton Bay in south eastern Queensland, there has been an 'area of concern' identified for dugongs killed by vessel strikes (Yeats and Limpus 2003). Prior to 2004, nine dugong deaths were attributed to boat strike within a few kilometres of a focal area within Moreton Bay. Figure 15 provides dugong density levels for the east coast of Queensland as well as the approximate number of registered recreational vessels for different maritime regions in Queensland. Moreton Bay has also been acknowledged as a potential 'area of concern' for marine turtles with relatively consistent records of vessel strike incidents since 2000. In 2011, almost half the number of mortalities attributed to vessel strike occurred in Moreton Bay. These incidents involve Hawksbill, Loggerhead, Flatback and Olive Ridley turtles; however, the vast majority involved Green turtles.

Gladstone is another potential 'area of concern' of vessel strike on small marine fauna. In 2011, there was a significant spike in the mortality of marine turtles attributed to vessel strike, with nearly 30 per cent of all injuries related to vessel strike in Queensland occurring in this region (Queensland Government 2011).

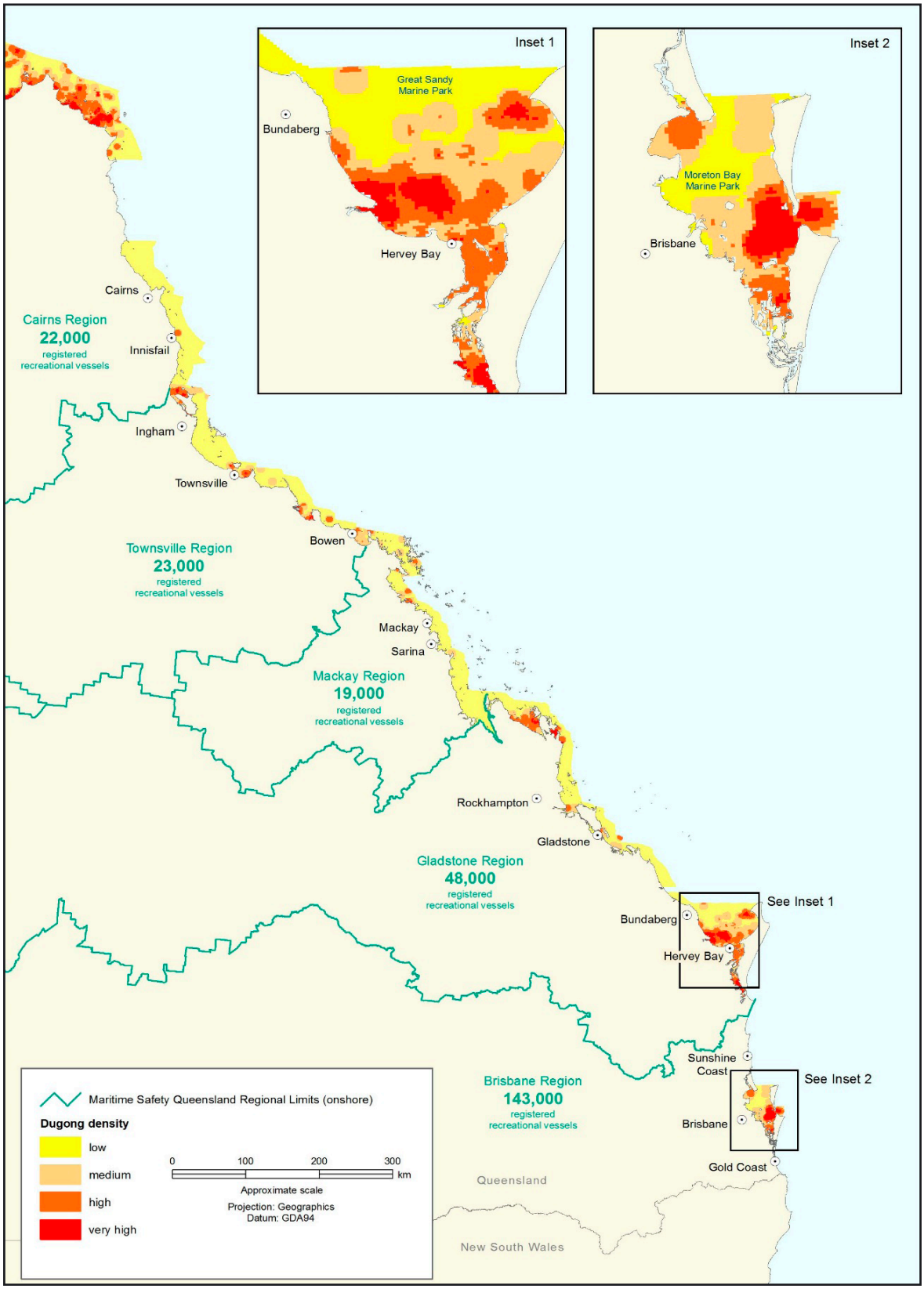

Figure 15 Dugong density for the Queensland coast and approximate registered recreational vessel numbers for each Maritime Safety Queensland region. ***Data source: Sobtzick et al. 2015, Queensland Government 2016.***

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