Marine Biodiversity Hub

National Environmental Science Programme

Project C5 -
Scoping of Potential Species for Ship Strike Risk Analysis

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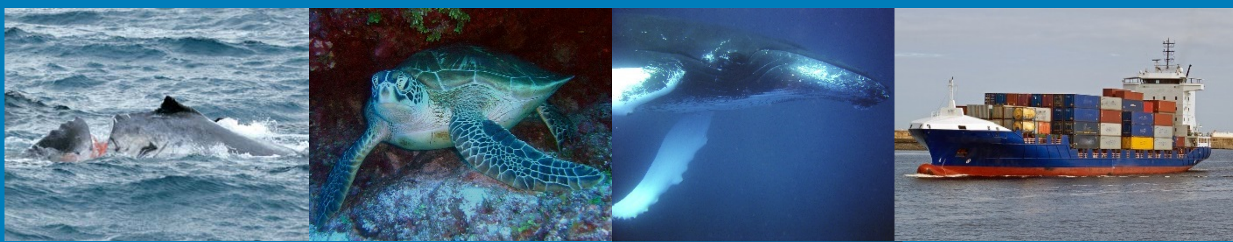
Pressures and impacts

5th May 2016



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Acknowledgement

This work was undertaken for the Marine Biodiversity Hub, a collaborative partnership supported through funding from the Australian Government's National Environmental Science Programme (NESP). NESP Marine Biodiversity Hub partners include the University of Tasmania; CSIRO, Geoscience Australia, Australian Institute of Marine Science, Museum Victoria, Charles Darwin University, the University of Western Australia, Integrated Marine Observing System, NSW Office of Environment and Heritage, NSW Department of Primary Industries.

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Important Disclaimer

Contents

List of Tables

EXECUTIVE SUMMARY

This report provides the results from the Phase 1 of the NESP project C5/A2 *Quantification of risk from shipping to large marine fauna*. The objective of the first phase of the project was to complete a review of large marine fauna species to identify a subset of species that a risk analysis could be undertaken on in Phase 2. A systematic approach was used to evaluate each species in terms of priority and feasibility, based on the following:

Priority - This assessment was to provide an evaluation of species for which the national modelling of risk would be both useful from a management context (e.g. a species has a high threat status) and that ship strike has been established as a known risk, and

Feasibility - This assessment was used to indicate how practical an analysis of the species would be within the project timeframe. The main aspect is availability of suitable data that could be used to model risk for that species at a national level.

To ensure that the research is most useful in management context, it is important to balance Priority and Feasibility to determine achievable projects. Once Priority and Feasibility had been assessed, then these were combined to determine overall **Suitability** for national modelling of the risk of vessel strike

Specifically, the selection of species was based on whether:

a) ship strike is likely to be having an appreciable impact;
b) there is existing substantial information on species distribution and abundance, and other behavioural aspects, such as migration patterns, breeding cycles, etc.; and,
c) the species is listed under the EPBC Act as vulnerable, endangered or critically endangered.

A further consideration in species selection was the size and types of vessels that are likely to be involved in ship strikes. Currently, AIS data is easily accessible for monitoring large vessel (>20m) movements, however a nationwide distribution of small vessels does not currently exist. This will require work to develop and hence any analysis of species at risk from small vessels cannot occur until that is done.

Based on the Suitability index, we concluded that humpback whales and Southern right whales should be analysed first, followed by dugongs, and finally green turtle, Australian snubfin dolphin and Australian humpback dolphin.

1. INTRODUCTION

Given the substantial increases in coastal/port development along the Australian coastline, and associated rise in recreational and commercial shipping (Bureau of Infrastructure, 2015), there is an increasing potential for adverse interactions with marine species. Two risks associated with these activities for large marine fauna are ship collisions and the impact of chronic ocean noise. Research is urgently needed to quantify these risks in both a spatial and temporal context to help better understand the magnitude of the problem and develop and implement appropriate management strategies.

This project aims to provide applied science by developing a spatial framework to model interactions between shipping and large marine fauna in Australian waters to inform decision-making by the Department of Environment in its application of the EPBC Act. This research will also be of utility to other Regulatory Agencies including, and not restricted to, the Australian Maritime Safety Authority (AMSA) and the Great Barrier Reef Authority (GBRMPA). Two different components of risk will be explored – ship strike and chronic shipping noise. From analysis of these risk profiles, areas for priority management action can be identified and potential strategies can be implemented to minimise the impact of vessel strike and noise on marine fauna.

Findings from this project will support implementation of multiple strategies in four Commonwealth Marine Bioregional Plans, including:

- provision of relevant, accessible and evidence-based information to support decision-making with respect to development proposals (strategy C);
- collaboration with industry, to improve understanding of the impacts of anthropogenic disturbance and address the cumulative effects on protected species (strategy D); and,
- developing targeted collaborative programs for species recovery (strategy E).

Furthermore, results of the project will provide guidance for the further development of the National Ship Strike Strategy, and for future revision of the North East Shipping Management Plan, which will outline how shipping traffic in the Great Barrier Reef is to be managed. Results from this project will also provide guidance for the development or revision of Recovery Plans and Threat Abatement Plans and management of Commonwealth Marine Reserves (e.g. strategies 1 and 2 in the South-east Commonwealth Marine Reserve Network Management Plan). This project will explore the risk of ship strike and shipping noise pollution on a number of large marine fauna species around the coastline of Australia, and within several Commonwealth Marine Reserves, Biologically Important Areas and Key Ecological Features. Therefore, results of this project could also potentially inform and/or refine delineation of these areas and features.

In the medium- to long-term (i.e., over the coming two years), this project will involve the use of existing shipping data (e.g., density, speed and noise levels), in parallel with distribution/habitat models for several of the most 'at-risk' marine species, to produce fine-scale relative spatial risk profiles that can be used to identify areas and times where there is co-occurrence of marine fauna and shipping.

2. PHASE 1 (2015) OBJECTIVE

The objective of the first phase of the project was to complete a review and consultation process to select a small subset of large marine fauna species (2-3 examples) for which

a) ship strike was likely to be having an appreciable impact;

b) there existed substantial information for species distribution and abundance, and other behavioural aspects, such as migration patterns, breeding cycles, etc.; and,
c) the species was listed under the EPBC Act as threatened to some degree.

Subsequent modelling of the risk of ship strike for this small group of species will allow for considerable development of methods and an opportunity for engagement and collaboration with key large marine fauna researchers. Other activities undertaken during the first phase included:

- an investigation of data sources detailing fatalities or injury (such as the various State stranding data bases);
- an investigation of the potential for identifying indications of injury from marine species photographic identification data bases; and,
- the acquisition and processing of fine-scale ‘raw’ shipping data for larger vessels operating in Australian waters from the Australian Maritime Safety Authority (AMSA). In addition to data concerning larger shipping, information concerning small vessel density and distribution was also explored, and the potential for subsequent analysis was reviewed.

3. PROJECT APPROACH AND OUTCOMES

3.1 Overarching assessment structure

The assessment and determination of species’ suitable for inclusion in nationwide modelling of vessel risk was undertaken as a two-step process involving two separate evaluative components to assess overall suitability. The components were:

1. **Priority** – This assessment was to provide an evaluation of species for which the national modelling of risk would be both useful from a management context (e.g. a species has a high threat status) and that ship strike has been established as a known risk. This included the assessment of two data elements namely (a) the available evidence for ship strike (both in Australia and internationally) summarised in Section 3.3 and (b) the status of the species under the EPBC Act and IUCN Red Listing detailed in Section 3.4. Priority was assessed as Low, Medium or High using the criteria given in Table 1.

Table 1 Criteria for priority based on ship strike evidence and species status

		Species status		
		Low	**Medium**	**High**
Ship strike evidence	**Strong**	Low	Medium	High
	Medium	Low	Low	Medium
	None	Low	Low	Low

2. **Feasibility** – This assessment was used to indicate how practical an analysis of the species would be within the project timeframe. The main aspect is availability of suitable data that could be used to model risk for that species at a national level. This step is critical in that it clearly identifies those species for which adequate data are available to populate a modelling framework. Feasibility was assessed (as per Table 2) using two elements:

a) ***Species distribution information*** – This was essentially an assessment of the amount and quality of spatial data available to describe a species' nationwide distribution. In assessing that data available for each species, we utilised a previously developed data classification tier system from the National Oceanic and Atmospheric Administration (NOAA) to map cetacean density and distribution within U.S. waters. We applied the same Tier system to maintain consistency in the assessment of data quality with existing and ongoing international research. In essence, the better the quality and availability of the data, the higher the Tier is it assigned with Tier 1 being the best and Tier 5 the worst. This assessment system including Tier definitions is further explained in Appendix D.

b) ***Vessel size data*** – Different species may be at higher risk from different sized vessels. Currently, large vessel (>20m in length) distribution data is easily obtained in the form of AIS data, whereas no spatial data is available nationwide for small vessel (<20m in length) distributions due to systems such as AIS not being compulsory for small vessels. Therefore we assessed each species against whether the likely risk was more likely to be from large vessels (i.e. AIS Class A ≥300 tonnes gross), smaller vessels (i.e. non-AIS equipped and AIS Class B) or both, as indicated from our review of vessel strike records and the process identified in Section 3.3.Consequently, species at risk from small vessels are given a lower feasibility score due to the need to first improve our understanding and mapping of small vessel distribution.

Table 2 Basis for calculation of species Feasibility level.

		Species Information Tier				
		1	**2**	**3**	**4**	**5**
Vessel size data	**Large**	1	2	3	4	5
	Small	3	3	3	4	5

To ensure that the research is most useful in a management context, it is important to balance Priority and Feasibility to determine achievable projects. Once Priority and Feasibility had been assessed, then these were combined to determine overall **Suitability** for national modelling of the risk of vessel strike. Suitability Levels were defined as a combination of Priority and Feasibility as given in Table 3.

Table 3 Basis for calculation of species Suitability level.

		Feasibility				
		5	**4**	**3**	**2**	**1**
Priority	**Low**	C	C	B	A	A
	Med	C	B	A	A+	A+
	High	C	B	A	A+	A++

Species with Suitability Levels A and B were then evaluated to determine those projects that were the best candidates for modelling both distribution and ship strike risk at the national level.

Given that it will not be possible to model all species ranked as Suitability A and B, it was important to select a sub-sample of these to take forward as part of the project. The selection of species for modelling was primarily based on its Suitability Level but other factors were also taken into account when determining which species to take forward. These other factors included:

- Suitability Level A species represent the best candidates for modelling and therefore are preferred over Level B species;
- Suitability Level B species, while all achieving the same Suitability designation, vary in their priority, species distribution information and vessel size data. Within Level B, preference, in priority order, was given to species that had:
    - the best species distribution data (i.e. Tier 3 rather than Tier 4) as having the best available data to ensure that the modelling is accurate and to provide a better estimate of risk; and
    - the highest priority ranking (i.e. High rather than Medium rather than Low) to focus research on species with the worst status and highest risk; and
    - achieving a balance of taxa (e.g. whales, dolphins, turtles, fish, etc.) and vessel size for exploratory modelling.

These preferred species were then allocated a **Project Order** to (a) determine which would be done and (b) in which order in the work plan. In determining project order, consideration was also given to balancing available workloads and also for some species that would become feasible once prior work had been completed on some of the higher ranked projects. This overall ranking therefore represents a balance between species status, species' distribution data quality and availability, vessel strike risk, and overall achievability.

3.2 Potential species

The first step of the project was to develop a list of every species in Australian waters that could potentially be involved in a vessel strike. An initial list was compiled from the IWC ship strike database, Department of Environment documents/reports (e.g. SPRAT website and Australian Progress Reports). This was followed by an extensive search of literature and media for indications of ship strike.

A complete list of the species we identified as potentially being involved in a ship strike is given in Table 4. Most of the species we identified were already recognised as being at risk in Department of the Environment documentation. However, two exceptions were little penguins (*Eudyptula minor*) and Ocean sunfish (*Mola mola*).

For little penguins we found a number of recent media reports about the incidents of animals being killed by boat propeller injuries (ref). In the case of sunfish we found 22 reported incidents of sunfish being struck by mainly Sydney-Hobart racing yachts. Although some reports there was some uncertainty on whether the collision was with a sunfish or a whale.

We found one reference to salt water crocodiles being struck by vessels (Grant and Lewis, 2010). However, since the focus of the project is marine we did not include it in the list.

Table 4 List of species potentially at risk of vessel strike

	Species	Scientific name
Whales	Humpback whale	*Megoptera novaeangliae*
	Pygmy blue whale	*Balaenoptera musculus brevicauda*
	Antarctic blue whale	*Balaenoptera musculus intermedia*
	Southern right whale	*Eubalaena australis*
	Dwarf minke whale	*Balaenoptera acutorostrata subsp.*
	Antarctic minke whale	*Balaenoptera bonaerensis*
	Fin whale	*Balenoptera physalus*
	Sei whale	*Balaenoptera borealis*
	Bryde's whale	*Balaenoptera edeni*
	Pygmy right whale	*Caperea marginata*
	Sperm whale	*Physeter macrocephalus*
	Pygmy sperm whale	*Kogia breviceps*
	Dwarf sperm whale	*Kogia sima*
	Pilot whale (long & short fin)	*Globicephala sp.*
	Killer whale	*Orcinus orca*
	False killer whale	*Pseudorca crassidens*
	Pygmy killer whale	*Feresa attenuata*
	Omura's whale	*Balaenoptera omurai*
Dolphin	Australian snubfin dolphin	*Orcaella heinsohni + brevirostris*
	Australian humpback dolphin	*Sousa sahulensis*
	Common Bottlenose dolphin	*Tursiops truncatus*
	Indo-Pacific Bottlenose dolphin	*Tursiops aduncus*
	Risso's dolphin	*Grampus griseus*
	Short beaked common dolphin	*Delphinus delphis*
	Dugong	*Dugong dugon*
Seals	Australian sea lion	*Neophoca cinerea*
	New Zealand fur seal	*Arctocephalus forsteri*
	Australian fur seal	*Arctocephalus pusillus doriferus*
	Antarctic fur seal	*Arctocephalus gazella*
	Sub-Antarctic fur seal	*Arctocephalus tropicalis*
	Southern elephant seal	*Mirounga leonina*
Turtle	Green	*Chelonia mydas*
	Loggerhead	*Caretta caretta*
	Leatherback	*Dermochelys coriacea*
	Hawksbill	*Eretmochelus imbricata*
	Olive Ridley	*Lepidochelys olivacea*
	Flatback	*Natator depressus*
Misc	Whale shark	*Rhincodon typus*
	Great white sharks	*Carcharodon carcharias*
	Ocean sunfish	*Mola mola*
	Little penguin	*Eudyptula minor*

3.3 Evidence of vessel interactions occurring

The available data and information on ship strike make it hard to quantify the actual number of animals' killed or injured or to even determine trends in ship strike incidents. There are a number of reasons for this including:

1) Not all collisions are noticed, especially for modern, larger vessels (Silber et al 2012);
2) Depending on the species and geographical location, bodies may float out to sea or sink, and not be observed;
3) Reporting rates and collation of data may not be consistent;
4) There are issues with identification of species' involved in ship strikes, with many reports the whale species is unknown or possibly unreliable; and
5) It is often difficult to establish the cause of death and determine whether the animal was dead/sick before a ship strike.

Due to these difficulties, the aim of this scoping project was not necessarily to quantify and compare the amount of ship strike among species but rather to determine whether there is evidence that it does it happen. This involves looking at a number of different types of data for evidence:

- **Reports of strandings and ship strikes in databases**
  Each state collects and compiles information on incidents of ship strikes involving marine animals, which are provided annually to the Australian Marine Mammal Centre (AMMC) who submit the reports to a database and present Progress Reports to the International Whaling Commission (IWC). The IWC manages a database of compiled ship strike reports involving marine animals worldwide. As part of this project we have updated these data with historic and modern media reports of collisions dating back to 1872, see Appendix B. This data was examined for the presence of reports for each species.
- **Propeller marks observed on live animals**
  Not all animals struck by vessels die, some may be injured but survive. So an indication of vessel interaction is propeller damage and scaring observed in the wild. However, caution does need to be taken as in some cases what has been accepted as propeller scaring has turned out to be due to other non-anthropogenic causes, for example the case of seals off the coast of Scotland with injuries consistent with being injured by ducted propellers, which turned out to most likely be inflicted by adult grey seals (Hanson et al. 2015).
- **Other indications**
  For completeness, we checked if ship strike was listed as a threat in SPRAT information for the species or the NOAA endangered species listing. Finally, we plotted AIS overlapping Biologically Important Areas to get some indication if co-occurrence between ships and species of interest was possible, see Appendix C.

This information (detailed in Appendix A) is then assessed for Australia and overseas (see Apx Table 3) then consolidated (See Apx Table 2) to rate the overall evidence as: Strong, Medium, Weak or None, as summarised in Table 5.

Table 5 Summary of reported evidence for vessel interactions, see Appendix A for detailed information and references

	Species	Australian	Overseas	Comment/Evidence	Overall Evidence
Whales	Humpback whale	Strong	Y	Collision reports and strandings	Strong
	Pygmy blue whale	Strong	Y	Collision reports	Strong
	Antarctic blue whale	Strong		Collision reports and strandings	Strong
	Southern right whale	Strong	Y	Collision reports and strandings	Strong
	Dwarf minke whale	Strong	Y	Strandings	Strong
	Antarctic minke whale	Strong	Y	Collision report	Strong
	Fin whale	Strong	Y	Stranding	Strong
	Sei whale	Weak	Y	Listed as pressure in SPRAT	Medium
	Bryde's whale	Strong	Y	Collision report and overseas	Strong
	Pygmy right whale	Strong	N	Stranding	Medium
	Sperm whale	Strong	Y	Collision reports and strandings	Strong
	Pygmy sperm whale	Strong	Y	Collision reports	Strong
	Dwarf sperm whale	Weak	Y	SPRAT and overseas	Medium
	Pilot whale	Strong	Y	Collision report and overseas	Strong
	Killer whale	None	Y	Overseas evidence	Weak
	False killer whale	None	Y	Overseas evidence	Weak
	Pygmy killer whale	None	N	None	None
	Omura's whale	Strong	Y	Collision report and overseas	Strong
Dolphin	Australian snubfin/Irrawaddy	Strong	Y	Some reported collisions, strandings and propeller injury/scars seen in wild.	Strong
	Aus. humpback dolphin	Strong	Y		Strong
	Common bottlenose dolphin	Strong	Y		Strong
	Indo-Pacific bottlenose	Strong			Medium
	Risso's dolphin	Strong	Y		Strong
	Short beaked common	Weak			Weak
	Dugong	Strong	Y	Mainly Qld Stranding data	Strong
Seals	Australian sea lion	None	-	Seals are being injured by boat propellers, however indications are rather than 'boat strike' these can be attributed to be the seal interacting/playing with a boats. Pers. Comm.	None
	New Zealand fur seal	None	-		None
	Australian fur seal	None	-		None
	Antarctic fur seal	None	-		None
	Sub-Antarctic fur seal	None	-		None
	Southern elephant seal	None	Y		Weak
Turtle	Green	Strong	Y	Mainly Qld stranding data showing boat injury likely cause of death	Strong
	Loggerhead	Strong	Y		Strong
	Leatherback	Strong	Y		Strong
	Hawksbill	Strong	Y		Strong
	Olive Ridley	Strong	Y		Strong
	Flatback	Strong	-		Strong
Misc	Whale shark	Strong	Y	From scarring	Strong
	Great white sharks	None	N	None	None
	Ocean sunfish	Strong	Y	Reports from mainly racing yachts	Strong
	Little penguin	Strong	Y	Reports of propeller injury	Strong

3.4 Species status

The basis for assessing species status was the threat ranking for species under the Environment Protection and Biodiversity Conservation Act 1999 (the EPBC Act)[1] (Table 6). This is Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places — defined in the EPBC Act as matters of national environmental significance. The EPBC Act provides for the listing of nationally threatened native species and ecological communities, native migratory species and marine species. We chose to apply the EPBC Act threat rankings as it applies an Australian wide ranking for each species which is consistent with the National focus of this project. While the EPBC Acts National rankings for species, there are also separate State and Territory listings for species. We have not used these listings in our consideration of threat as they only refer to local and/or regional threats and populations, whereas our focus is an overall National one.

Under the EPBC Act, all cetaceans (whales, dolphins and porpoises) are protected in Australian waters. The Australian Whale Sanctuary includes all Commonwealth waters from the three nautical mile state waters limit out to the boundary of the Exclusive Economic Zone (i.e. out to 200 nautical miles and further in some places). It is an offence to injure, take, trade, keep, move, harass, chase, herd, tag, mark or brand a cetacean in the Australian Whale Sanctuary without a permit. For this reason, a species that may not have high status listing under the EPBC will still receive a high level of protection.

In addition to the EPBC Act Status, we also considered the International Union for the Conservation of Nature (IUCN) Red List of threatened Species[2] (Table 6). The IUCN Red List of Threatened Species is widely recognised as the most comprehensive, objective global approach for evaluating the conservation status of plant and animal species. We chose to include this in our assessment of status to provide an international overview of the species under consideration as some species have poorly defined distribution and status in Australia.

As a general rule, we followed the EPBC Act status but also considered the IUCN status listing (Table 6). The following ratings were applied:

- **High** – a status of *Endangered* under the EPBC or, if assigned a lower status than Endangered under the EPBC Act but *Endangered* or *Near threatened* under IUCN;
- **Medium** – A status of *Vulnerable* under the EPBC or *Vulnerable* under the IUCN; and
- **Low** – All other status categories under the EPBC (e.g. *Not listed*, *Migratory*, *Cetacean*) and under the IUCN (e.g. *Not threatened*, *Data deficient*, *Not listed*).

[1] See https://www.environment.gov.au/epbc
[2] See http://www.iucnredlist.org/

Table 6 Species population status

	Species	EPBC	IUCN	Rating
Whales	Humpback whale	Vulnerable	Least concern	Medium
	Pygmy blue whale	Endangered	Endangered	High
	Antarctic blue whale	Endangered	Endangered	High
	Southern right whale	Endangered	Least concern	High
	Dwarf minke whale	Cetacean	Least concern	Low
	Antarctic minke whale	Cetacean	Data Deficient	Low
	Fin whale	Vulnerable	Endangered	High
	Sei whale	Vulnerable	Endangered	High
	Bryde's whale	Cetacean	Data Deficient	Low
	Pygmy right whale	Cetacean	Data Deficient	Low
	Sperm whale	Cetacean	Vulnerable	Medium
	Pygmy sperm whale	Cetacean	Data Deficient	Low
	Dwarf sperm whale	Cetacean	Data Deficient	Low
	Pilot whale (long & short finned)	Cetacean	Data Deficient	Low
	Killer whale	Cetacean	Data Deficient	Low
	False killer whale	Cetacean	Data Deficient	Low
	Pygmy killer whale	Cetacean	Data Deficient	Low
	Omura's whale	Cetacean	Data Deficient	Low
Dolphins	Australian snubfin dolphin	Cetacean	Near Threatened	High
	Aus. humpback dolphin	Cetacean	Near Threatened	High
	Common Bottlenose dolphin	Cetacean	Not Listed	Low
	Indo-Pacific Bottlenose dolphin	Cetacean	Least Concern	Low
	Risso's dolphin	Cetacean	Data Deficient	Low
	Short beaked common dolphin	Cetacean	Least Concern	Low
	Dugong	Marine	Vulnerable	Low
Seals	Australian sea lion	Vulnerable	Endangered	Medium
	New Zealand fur seal	Marine	Least concern	Low
	Australian fur seal	Marine	Least concern	Low
	Antarctic fur seal	Marine	Least concern	Medium
	Sub-Antarctic fur seal	Vulnerable	Least concern	Medium
	Southern elephant seal	Vulnerable	Least concern	Medium
Turtles	Green turtle	Vulnerable	Endangered	High
	Loggerhead turtle	Endangered	Vulnerable	High
	Leatherback turtle	Endangered	Critically endangered	High
	Hawksbill turtle	Vulnerable	Critically endangered	High
	Olive Ridley turtle	Endangered	Vulnerable	Medium
	Flatback turtle	Vulnerable	Data deficient	High
Misc	Whale shark	Not Listed	Lower risk	Low
	Great white sharks	Vulnerable	Vulnerable	Medium
	Ocean sunfish	Vulnerable	Vulnerable	Medium
	Little penguin	Marine	Least concern	Low

3.5 Assessing distribution data/information/knowledge

In developing robust models of species distribution, it is essential to have high quality data sets. A key step in the assessment process was reviewing all species of potential interest and assessing that available data that could be used to construct robust models of Australia wide distribution and densities. As noted previously in Section 3.1, we utilised a NOAA data classification tier system to categorise the available data. We applied the same Tier system for ease in comparability with existing and ongoing USA research and also as they provide a robust and consistent system for the assessment of data quality. In essence, the better the quality and availability of the data, the higher the Tier is it assigned with Tier 1 being the best and Tier 5 the worst. This assessment system including Tier definitions is further explained in Appendix D.

A key feature of the assessment was whether the data available was suitable for use in the development of an Australia-wide model. For some species, there are some fine-scale and highly detailed spatial models but for the most part these are only for small to medium scale areas (e.g. GBRMP) with very few approaching the national scale.

Species data were assigned a Tier value based on an evaluation of the available data (Table 7). We utilised a range of sources with the primary source being information provided in the Commonwealth's Species Profile and Threats[3] (SPRAT) database. Other sources include:

- Commonwealth Conservation Management Plans (both Approved and Draft)[4];
- Commonwealth Recovery Plans[5];
- Commonwealth Marine Bioregional Plans[6];
- Atlas of Living Australia[7];
- Scientific publications and reports; and
- Professional knowledge and experience of the project team and other researchers familiar with the individual species.

The information is summarised in Appendix E.

[3] Available at http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl
[4] Available at https://www.environment.gov.au/biodiversity/threatened/recovery-plans
[5] Available at https://www.environment.gov.au/biodiversity/threatened/recovery-plans
[6] Available at https://www.environment.gov.au/marine/marine-bioregional-plans
[7] Available at www.ala.org.au

Table 7 Summary of quality of distribution information at the Australia wide level

	Species	Tier[8]	Comment
Whales	Humpback whale	3	Tier 1 for the GBR
	Pygmy blue whale	4	Tier 3 for Bonney upwelling
	Antarctic blue whale	5	
	Southern right whale	4	Tier 3 for inshore waters
	Dwarf minke whale	4	
	Antarctic minke whale	5	
	Fin whale	5	
	Sei whale	5	
	Bryde's whale	5	
	Pygmy right whale	5	
	Sperm whale	4	Tier 3 from global modelling data
	Pygmy sperm whale	5	
	Dwarf sperm whale	5	
	Pilot whale (long & short fin)	5	
	Killer whale	4	
	False killer whale	5	
	Pygmy killer whale	5	
	Omura's whale	5	
Dolphin	Australian snubfin dolphin	4	
	Aus. humpback dolphin	4	
	Common Bottlenose dolphin	4	
	Indo-Pacific Bottlenose dolphin	4	
	Risso's dolphin	5	
	Short beaked common dolphin	5	
	Dugong	3	Tier 2 for GBR
Seals	Australian sea lion	4	
	New Zealand fur seal	5	
	Australian fur seal	5	
	Antarctic fur seal	5	
	Sub-Antarctic fur seal	5	
	Southern elephant seal	4	
Turtle	Green	4	
	Loggerhead	5	
	Leatherback	4	
	Hawksbill	5	
	Olive Ridley	5	
	Flatback	5	
Misc	Whale shark	4	
	Great white sharks	5	
	Ocean sunfish	5	
	Little penguin	4	

[8] Tier based on NOAA information hierarchy e.g. Tier 1 good, Tier 5 poor (see Appendix D)

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Species analysis priority

As outlined in section 3.1, an overall **Suitability** score was assigned for each species that incorporated components of **Priority** and **Feasibility** to determine an achievable project and ensure the research is useful in a management context. The Suitability score was used as a guide to determine the species' to be included for national modelling of the risk of vessel strike (Table 8).

Based on the Suitability index, we concluded that humpback whales and Southern right whales should be analysed first, followed by dugongs, and finally green turtle, Australian snubfin dolphin and Australian humpback dolphin.

In some instances other aspects beyond the suitability score were considered. For example, Pygmy blue whales received a higher suitability index than humpback whales, however the project team has recently finished modelling Great Barrier Reef humpback whales, so it makes sense to continue that momentum and start humpback whale immediately. Both Green turtle and leatherback turtle received the same suitability rating, however given much higher number of boat strikes happening to green turtles, there may be enough data to better quantify risk from stranding data. Therefore, green turtles were chosen for analysis.

The main recommendations resulting from the first stage of the project are as follows:

1) Seek wider consultation and feedback on the species selected for initial analysis

2) Assimilate our new ship strike data into the AMMC's National Marine Mammal Database and IWC worldwide data bases.

3) Complete and document an analysis of the new ship strike data

4) In coordination with other NESP projects work toward a modelled distribution map of small vessels.

5) Based on the data coverage outlined in this document, identify knowledge gaps for each species in the context of ship strike analysis. For example, identify areas and species which could benefit from surveys.

Table 8 Summary of species' priority, feasibility and subsequent suitability for analysis

	Species	Priority			Feasibility				
		Ship strike Evidence	EPBC/IUCN Status	Priority	Species Distribution Information	Vessel size data needed	Feasibility	Suitability	Project Order
Cetaceans	Humpback whale	Strong	M	Med	3	Large	3	A	Phase 1
	Pygmy blue whale	Strong	H	High	4	Large	4	B	
	Antarctic blue whale	Strong	H	High	5	Large	5	C	
	Southern right whale	Strong	H	High	3	Large	3	A	Phase 1
	Dwarf minke whale	Strong	L	Low	4	Large	4	C	
	Antarctic minke whale	Strong	L	Low	5	Large	5	C	
	Fin whale	Strong	H	High	5	Large	5	C	
	Sei whale	Strong	H	High	5	Large	5	C	
	Bryde's whale	Strong	L	Low	5	Large	5	C	
	Pygmy right whale	Strong	L	Low	5	Large	5	C	
	Sperm whale	Strong	M	Med	4	Large	4	B	
	Pygmy sperm whale	Strong	L	Low	5	Large	5	C	
	Dwarf sperm whale	Strong	L	Low	5	Large	5	C	
	Pilot whale (long & short finned)	Strong	L	Low	5	Large	5	C	
	Killer whale	Medium	L	Low	4	Large	4	C	
	False killer whale	Medium	L	Low	5	Large	5	C	
	Pygmy killer whale	None	L	Low	5	Large	5	C	
	Omura's whale	Strong	L	Low	5	Large	5	C	
Dolphins	Australian snubfin dolphin	Strong	H	High	4	Small	4	B	Phase 3
	Aus. humpback dolphin	Strong	H	High	4	Small	4	B	Phase 3
	Common Bottlenose dolphin	Strong	L	Low	4	Small	4	C	
	Indo-Pacific Bottlenose dolphin	Strong	L	Low	4	Small	4	C	
	Risso's dolphin	Strong	L	Low	5	Small	5	C	
	Short beaked common dolphin	None	L	Low	5	Small	5	C	
	Dugong	Strong	L	Low	3	Small	3	B	Phase 2
Seals	Australian sea lion	None	M	Med	4	Small	4	C	
	New Zealand fur seal	None	L	Low	5	Small	5	C	
	Australian fur seal	None	L	Low	5	Small	5	C	
	Antarctic fur seal	None	M	Low	5	Small	5	C	
	Sub-Antarctic fur seal	None	M	Low	5	Small	5	C	
	Southern elephant seal	Medium	M	Low	4	Small	4	C	
Turtles	Green turtle	Strong	H	High	4	Small	4	B	Phase 3
	Loggerhead turtle	Strong	H	High	5	Small	5	C	
	Leatherback turtle	Strong	H	High	4	Small	4	B	
	Hawksbill turtle	Strong	H	High	5	Small	5	C	
	Olive Ridley turtle	Strong	M	Med	5	Small	5	C	
	Flatback turtle	Strong	H	High	5	Small	5	C	
	Whale shark	Strong	L	Low	4	?	4	C	
	Great white sharks	None	M	Low	5	?	5	C	
	Ocean sunfish	Strong	M	Med	5	Yacht	5	C	
	Little penguin	Strong	L	Low	4	Small	4	C	

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APPENDIX A – SHIP STRIKE EVIDENCE

Apx Table 1 Description and glossary of entries in Apx Table 3

Column		Description	Sources	Values
Australia	Incidents	*Number of reported collisions in Australia since 2000*.*	cetaceans – IWC Newspapers	Total number of records
Australia	Bodies	*Number of bodies attributed to ship strike not reported as collisions e.g. floating at sea, washed up on beach*	cetaceans – IWC/Newspapers Turtles – Stranding databases	Total number of records
Australia	Rate	*Since the incident data is some-times over different time frames we also provide annual rate*	Above columns	Records per year
Australia	Marks	*Are there reports of visual vessel damage to animals in the wild? e.g. propeller marks*	Internet searches of photos Published Papers	Y/N
Australia	SPRAT	*Is ship strike mentioned as a threat in the species SPRAT entry*	SPRAT	Y/N
Australia	Evidence	*Based on the above information do we think there is evidence that ship strike does occur*	Above columns	S –strong W-weak N-None
World	Report Incident	*Have there been collisions reported*	cetaceans – IWC Other - Various literature	Y/N
World	Bodies	*Are bodies found attributed to ship strike not reported as collisions e.g. floating at sea, washed up on beach*	cetaceans – IWC Other - Various literature	Y/N
World	Marks	*Are there reports of visual vessel damage to animals in the wild? e.g. propeller marks*	Internet searches of photos Published Papers	Y/N
World	NOAA	*Is ship strike mentioned as a threat in NOAA Threatened species entry*	NOAA	Y/N/-
World	Evidence	*Based on the above information do we think there is evidence that ship strike does occur*	Above columns	Y/N

* Our reported whale ship strike records go back to 1872 however species were seldom identified until recent record keeping, see Appendix C so we only used modern records >2000. Also this data is still being validated and cleaned so numbers are subject to change

Apx Table 2 Categorisation of ship strike evidence based on Australian and worldwide evidence

		Australian Evidence		
		None	**Weak**	**Strong**
Worldwide	**Yes**	Weak	Medium	Strong
Worldwide	**No**	None	Weak	Medium

Apx Table 3 Summary of reported evidence for vessel interactions, see footnotes for details, examples and references.

	Species	Australian						Worldwide				
		Incidents (2000-15)	Bodies (2000-15)	Rate[£]	Marks	SPRAT	Evidence	Incidents	Bodies	NOAA	Marks	Evidence
Whales	Humpback whale	29*	10*	2.6	[1]	Y	S	Y[#]	Y[#]	Y	[12]	Y
	Pygmy blue whale	2*	0*	0.1		Y	S	Y[#$]	Y[#$]	Y[$]	[12] [13]	Y[$]
	Antarctic blue whale	2*	2*	0.3		Y	S					
	Southern right whale	5*	4*	0.6		Y	S	Y[#]	Y[#]	Y	[12] [14]	Y
	Dwarf minke whale	0*	2*	0.1		N	S	N[#]	N[#]	Y[!]		Y
	Antarctic minke whale	1*	0*	0		Y	S	N[#]	N[#]	Y		Y
	Fin whale	0*	1*	0.1		Y	S	Y[#]	Y[#]	Y	[15]	Y
	Sei whale	0*	0*	0		Y	W	Y[#]	Y[#]	Y	[16]	Y
	Bryde's whale	1*[@]	0*	<0.1		Y	S	Y[#]	Y[#]	Y	[17]	Y
	Pygmy right whale	0*	1*	0.1		N	S	N[#]	N[#]	-		N
	Sperm whale	3*	3*	0.4		Y	S	Y[#]	Y[#]	Y	[18]	Y
	Pygmy sperm whale	2*	0*	0		Y	S	Y[#]	Y[#]	Y	Y	Y
	Dwarf sperm whale	0*	0*	0		Y	W	N[#]	N[#]	Y	Y	Y
	Pilot whale	1*	0*	0.1		N	S	Y[#]	N[#]	-	[19]	Y
	Killer whale	0*	0*	0.0		N	N	Y[#]	N[#]	Y	[20]	Y
	False killer whale	0*	0*	0		N	N	N[#]	N[#]	N	[21]	Y
	Pygmy killer whale	0*	0*	0		N	N	N[#]	N[#]	N		N
	Omura's whale	0*	0*[&]	0		-	S	Y[#]	Y[#]	-		Y
Dolphin	Australian snubfin /Irrawaddy	0	0	0	[2]	N	S	-	Y[k,m]	-	-	Y
	Aus. Humpback dolphin	1*	1*	0.2		N	S		Y[l,m]	-	[12]	Y
	Common Bottlenose dolphin	1*	5*	0.8	[3]	N	S		Y[m]	N	[21]	Y
	Indo-Pacific Bottlenose	0	3	0.5	[4]	N	S			-		
	Risso's dolphin	1	0	<0.1		N	S			N	[22]	Y
	Short beaked common	0	0	0		N	W			N		
	Dugong	0	40[a]	2.4		Y	S		Y	-	[23]	Y
Seals	Australian sea lion	0[%]	8[b]			N	N	-	-	-	-	-
	New Zealand fur seal	0[%]				N	N	-	-	-	-	-
	Australian fur seal	0[%]				N	N	-	-	-	-	-
	Antarctic fur seal	0[%]				N	N	-	-	-	-	-
	Sub-Antarctic fur seal	0[%]				N	N	-	-	-	-	-
	Southern elephant seal	0[%]				N	N			Y[+]		Y[+]
Turtle	Green	0	360[c]	72	[5]	Y	S		Y[n]	N		Y
	Loggerhead	0	39[d]	7.8	[6]	Y	S		Y[o]	-		Y
	Leatherback	0	1[e]	0.2	[7]	Y	S		Y[p]	N		Y
	Hawksbill	0	5[f]	1	[8]	Y	S		Y[q]	N		Y
	Olive Ridley	0	7[g]	1.4		Y	S		Y	N		Y
	Flatback	0	1[h]	0.2	[9]	Y	S	-	-	-	-	-
Misc	Whale shark	0			[10]	Y	S			-	[6]	Y
	Great white sharks	0				N	N			-		N
	Ocean sunfish	15*	1	1.0		-	S	Y[j]		-		Y
	Little penguin	0			[11]	N	S		Y[r]	-		Y

Notes

*	IWC + this project's ship strike data base see Appendix B
#	IWC ship strike database 2010
-	Species not present outside Australian waters
@	In the SPRAT listing for Bryde's whales there is mention of a collision off Tasmania. This was not found in the IWC data base
%	There are incident of seals being injured by boat propellers, however indications are rather than 'boat strike' these can be attributed to be the seal interacting/playing with a boats. Pers. Comm. with a number of experts indicated the incident of boat strike for seals is very low.
&	In 1992 a dead Omura whale was found draped over a ship's bulbous bow, necropsy indicated whale alive when hit (IWC Data 2010)
^	So few of this species are seen in the wild, the lack of reports of animals with vessel related injuries is to be expected. Given the small numbers in Australian waters the single record from 1990 gave us reason to say there was evidence
$	Records for "Blue whale"
!	NOAA groups dwarf minke whales with general minke whales
+	Information is for the Northern Elephant seal
£	For better comparison between species it would make sense to standardise the rate relative to abundance. However, given the uncertainty on these incident rates and the differing quality of abundance estimates it was decided sufficient for the question of evidence just to look at annual rate of incidents,

Reference for incidences/strandings information

a. Queensland between 1996-2012 STRANDNET report 2012

b. Western Australia between 1980 and 1996, see Mawson, P. R., & Coughran, D. K. (1999). Records of sick, injured and dead pinnipeds in Western Australia 1980–1996. Journal of the Royal Society of Western Australia, 82, 121-128.

c. 360 between 1999 and 2004, DoE Key Threatening Process Nomination Form
52 deaths+47 fractures, Queensland in 2011, from 641 strandings with known causes+670 unknown,– STRANDNET report 2012

d. 39 between 1999 and 2004, DoE Key Threatening Process Nomination Form
SPRAT reports 8 per year.
3 deaths + 2 fractures, Queensland in 2011 – from 24 strandings with known causes + 15 unknown - STRANDNET report 2012

e. 1 between 1999 and 2004, DoE Key Threatening Process Nomination Form
SPRAT report 0.7 per year

f. 5 between 1999 and 2004, DoE Key Threatening Process Nomination Form
1 death + 4 fractures, Queensland in 2011 – from 46 strandings with known causes + 61 unknown - STRANDNET report 2012

g. 1 between 1999-2004 Queensland Greenland et al. (2006),
0 records, Queensland in 2011 – 0 from 5 strandings with known causes + 4 unknown - STRANDNET report 2012

h. Queensland between 2000-2011 –1 from 6 strandings with known causes + 15 unknown – STRANDNET report 2012

i. Rodger, K., Smith, A., Newsome, D., Patterson, P. & Davis, C. (2010) A framework to guide the sustainability of wildlife tourism operations: examples of marine wildlife tourism in Western Australia. Cooperative Research Centre for Sustainable Tourism. pp. 23-25.

j. Mola mola - http://www.vancouversun.com/technology/sunfish+collisions+point+oceanic+warming+coast+beyond/11290983/story.html?__lsa=21af-c0eb

k. Irrawaddy dolphins http://www.irrawaddy.com/burma/irrawaddy-dolphin-survey-shows-continued-population-decline.html

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+ Denkinger, J., Parra, M., Muñoz, J. P., Carrasco, C., Murillo, J. C., Espinosa, E., ... & Koch, V. (2013). Are boat strikes a threat to sea turtles in the Galapagos Marine Reserve?. *Ocean & coastal management*, *80*, 29-35.

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p. Deem, S. L., Dierenfeld, E. S., Sounguet, G. P., Alleman, A. R., Cray, C., Poppenga, R. H., ... & Karesh, W. B. (2006). Blood values in free-ranging nesting leatherback sea turtles (Dermochelys coriacea) on the coast of the Republic of Gabon. *Journal of Zoo and Wildlife Medicine*, *37*(4), 464-471.

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r. Blue Penguin - New Zealand page 4: http://www.doc.govt.nz/nature/native-animals/birds/birds-a-z/penguins/little-penguin-korora/

References or examples of injury/scars in the wild

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+ http://www.tasmanventure.com.au/2012-october-whale-watching-blog-post

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+ Parra Vergara, G. J., & Corkeron, P. J. (2001). Feasibility of using photo-identification techniques to study the Irrawaddy dolphin, Orcaella brevirostris (Owen in Gray 1866). Aquatic Mammals, 27, 45-49.

[3] See "The Action Plan for Australian Mammals" 2012 page 853 Wells and Scott 2009
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+ http://arwh.taronga.net.au/sites/default/files/files-uploads/2013%20Interesting%20Case%20Summary%20January%20to%20March%202013.pdf
+ http://www.smh.com.au/photogallery/2006/08/24/1156012655548.html?page=2
+ http://www.redmap.org.au/sightings/908/

[6] http://www.nprsr.qld.gov.au/marine-parks/boat-strike-turtle-dugong-mbmp.html

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[13] Sri Lanka image of propeller notched whale https://www.facebook.com/jetwingnaturalists/posts/463681103833222

[14] New Zealand survey Southern right whale http://phys.org/news/2012-08-wealth-whales-sea-lions-birds.html

[15] http://www.tethys.org/tethys/fin-whale-with-propeller-marks/

[16] http://whalesightings.blogspot.com.au/2011/08/august-13-prince-of-whales.html

[17] http://www.desertinho.com/brydes-whale-ship-propeller/

[18] http://www.cetaceanalliance.org/cetaceans/Pm_hellenictrench.htm
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[20] Visser, I. N. (1999). Propeller scars on and known home range of two orca (Orcinus orca) in New Zealand waters.

[21] Luksenburg, J. A. (2014). Prevalence of external injuries in small cetaceans in Aruban waters, Southern Caribbean. *PloS one*, *9*(2), e88988.

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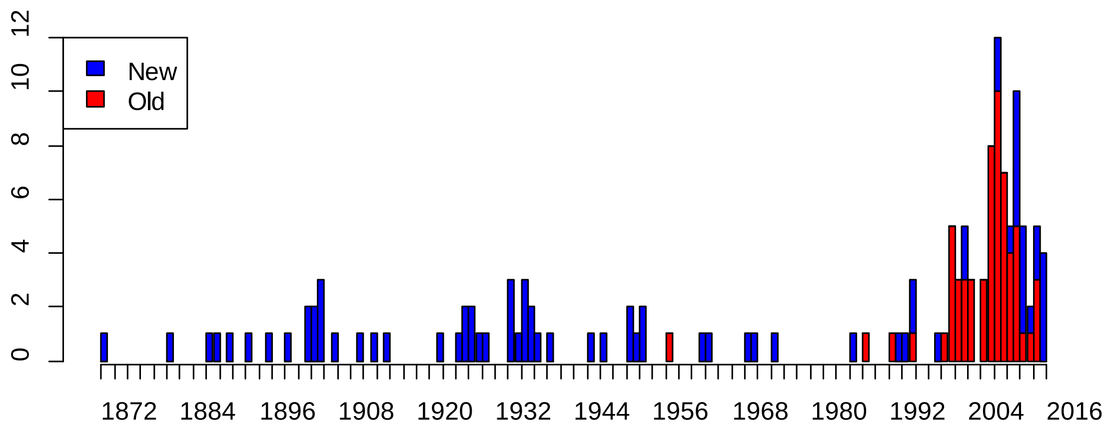
[23] For Florida Manatees: Calleson, C. S., & Frohlich, R. K. (2007). Slower boat speeds reduce risks to manatees. *Endangered Species Research*, *3*(3), 295-304.

APPENDIX B - WHALE SHIP STRIKE DATA BASE

The IWC has collated a database of worldwide reported ship strikes for whales and small cetaceans. Australia is currently finalising a National Marine Mammal Database that feeds into the IWC data base.

During the course of this project we searched historical (National library TROVE covering newspapers up to the mid-1950s) and modern newspapers (online searches) for reports of ship and fauna collisions and found many whale incidents that did not appear to be in the IWC database (based on the older 2010 data base) (see Apx Figure 1). This project data is currently being cleaned and will be added to National Marine Mammal Database. The main issue with the data is still reporting bias, and any changes may reflect changes in what was reported and recorded rather than changes in the underlying ship strikes.



Apx Figure 1 Plot through time of the new data.

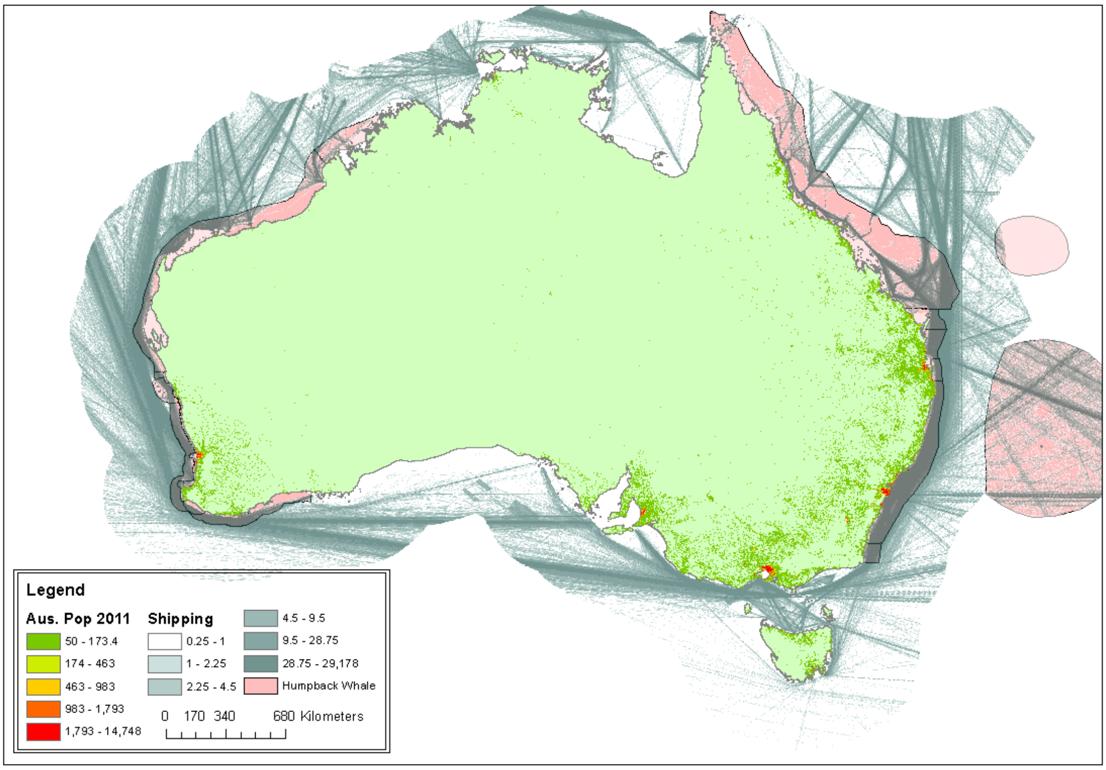
APPENDIX C - BIOLOGICALLY IMPORTANT AREAS

To get some indication if there was potential co-occurrence of shipping and areas of importance for species we overlayed AIS data and population centres (as a proxy for small boating) on the Department of Environments identified biologically important areas (BIA)[9].

The BIAs will not necessarily correspond to species distribution but "are spatially defined areas where aggregations of individuals of a species are known to display biologically important behaviour such as breeding, foraging, resting or migration"[9]. For turtles in particular the BIAs may not be appropriate for our ship strike context, since the turtle BIAs generally reflect important nesting habitat, which while important for broader management, may not be as relevant to potential boat strike risk.

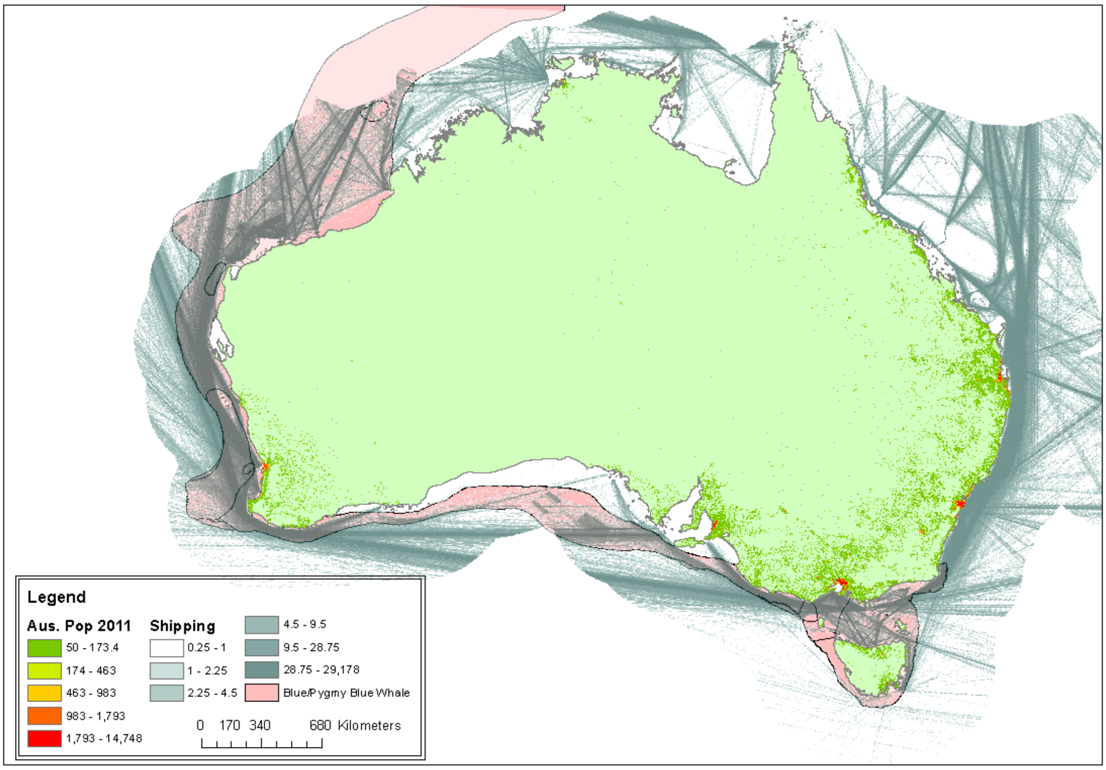
The AIS data is for 2014 only, restricted to vessels >22m and does not include port/harbour data (see Apx Figure 2 to Apx Figure 19). These maps will be updated for our full AIS data, and small vessel information later in the project, initial maps are included here just to give general indications of potential co-occurrence.

Most of the species for which we had biologically important areas showed some potential co-occurrence. This idea of using general important areas and overlaying boating data may be useful for species where distribution densities are unknown to establish where there is potential for risk and direct further data collection and/or modelling.

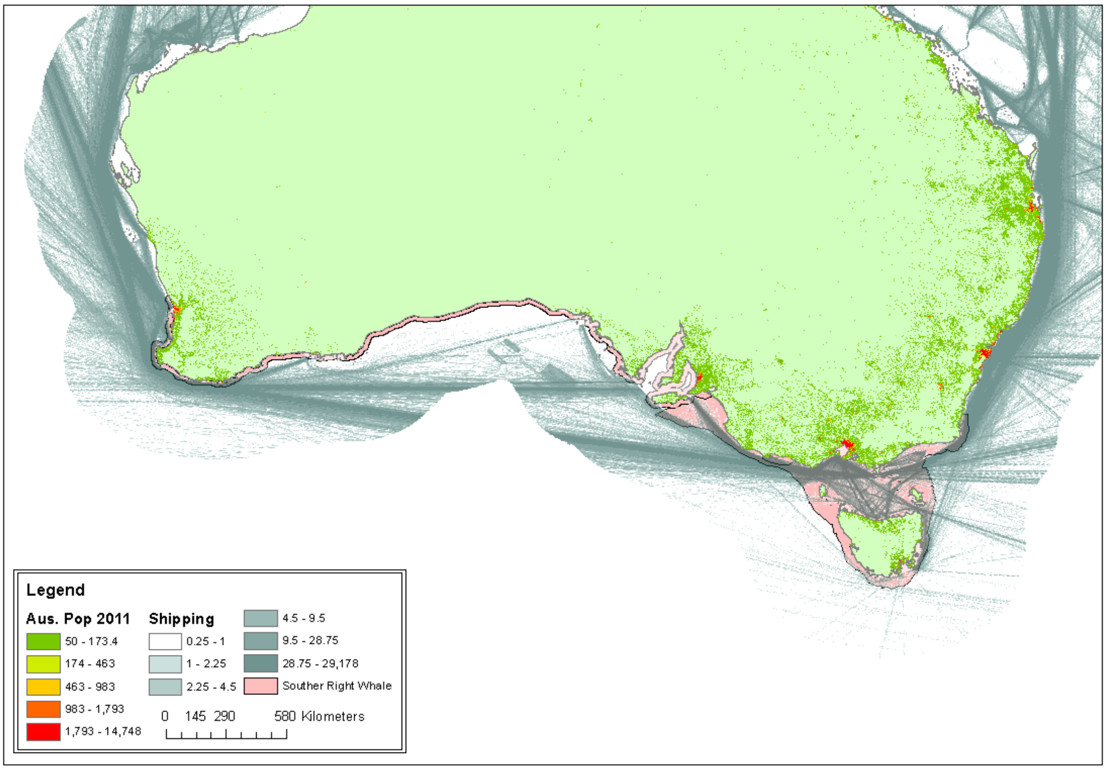


Apx Figure 2 Humpback whale biologically important area with general shipping density (all vessels >22m)

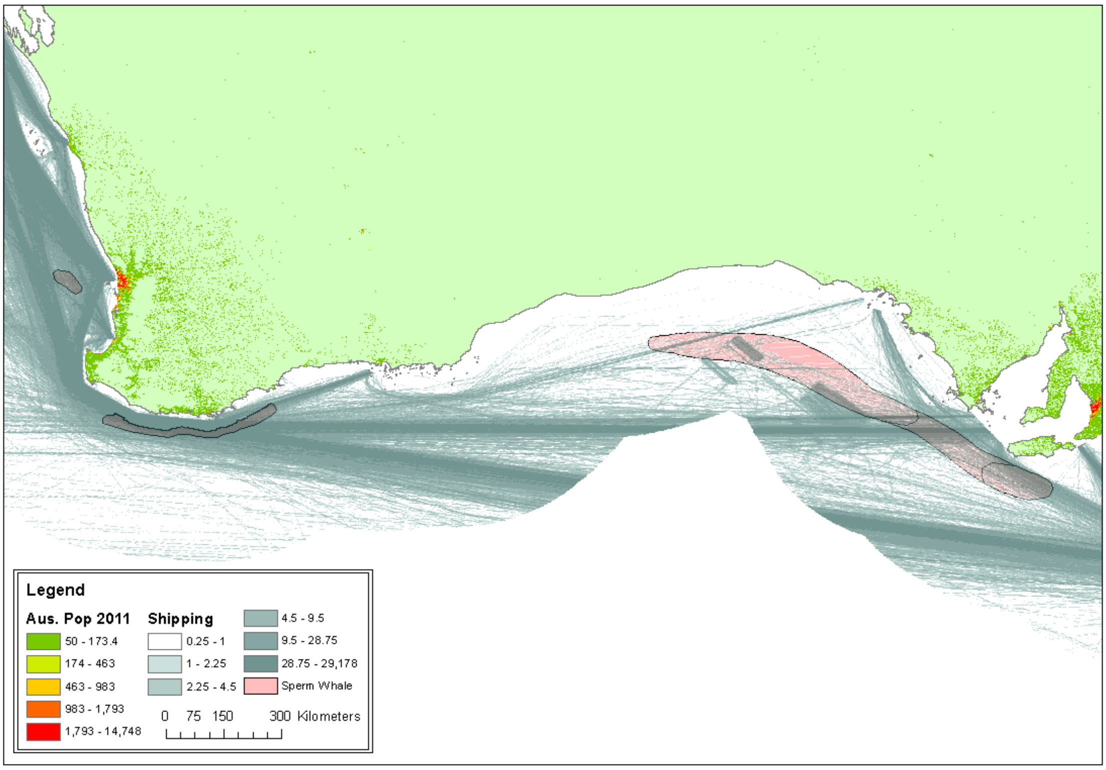
[9] http://www.environment.gov.au/marine/marine-species/bias



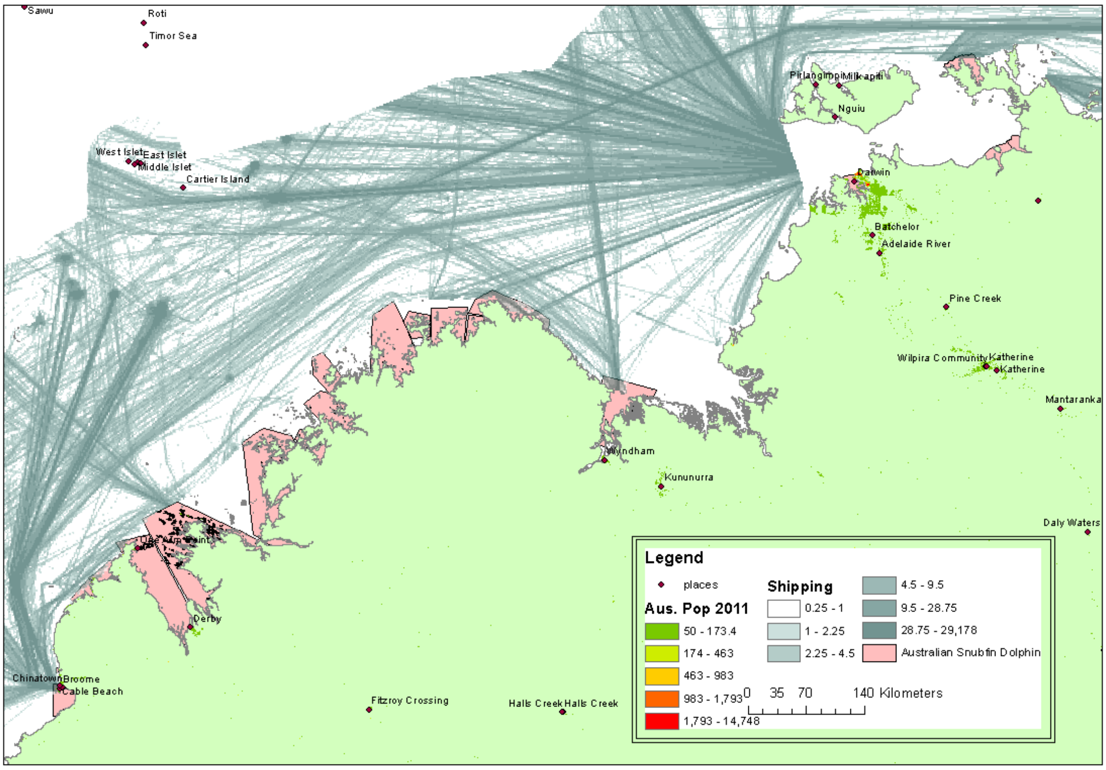
Apx Figure 3 Blue whale and Pygmy blue whale biologically significant area with general shipping density (all vessels >22m) and human population density.



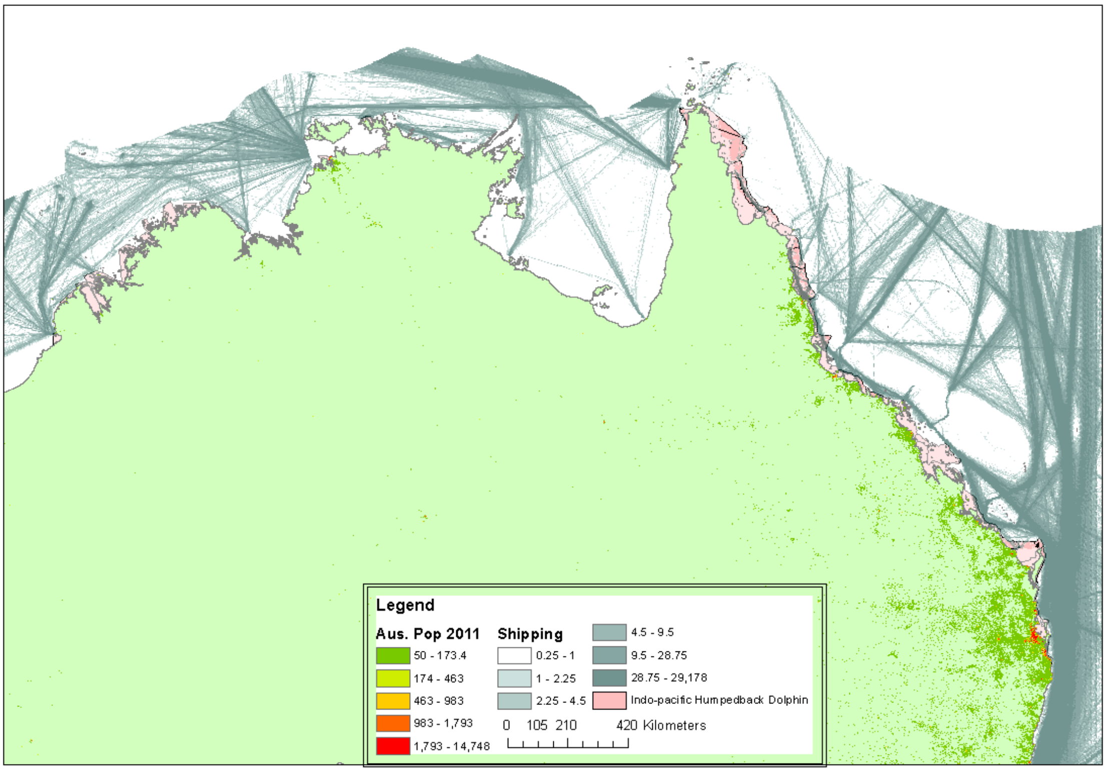
Apx Figure 4 Southern right whale biologically important area with general shipping density (all vessels >22m)



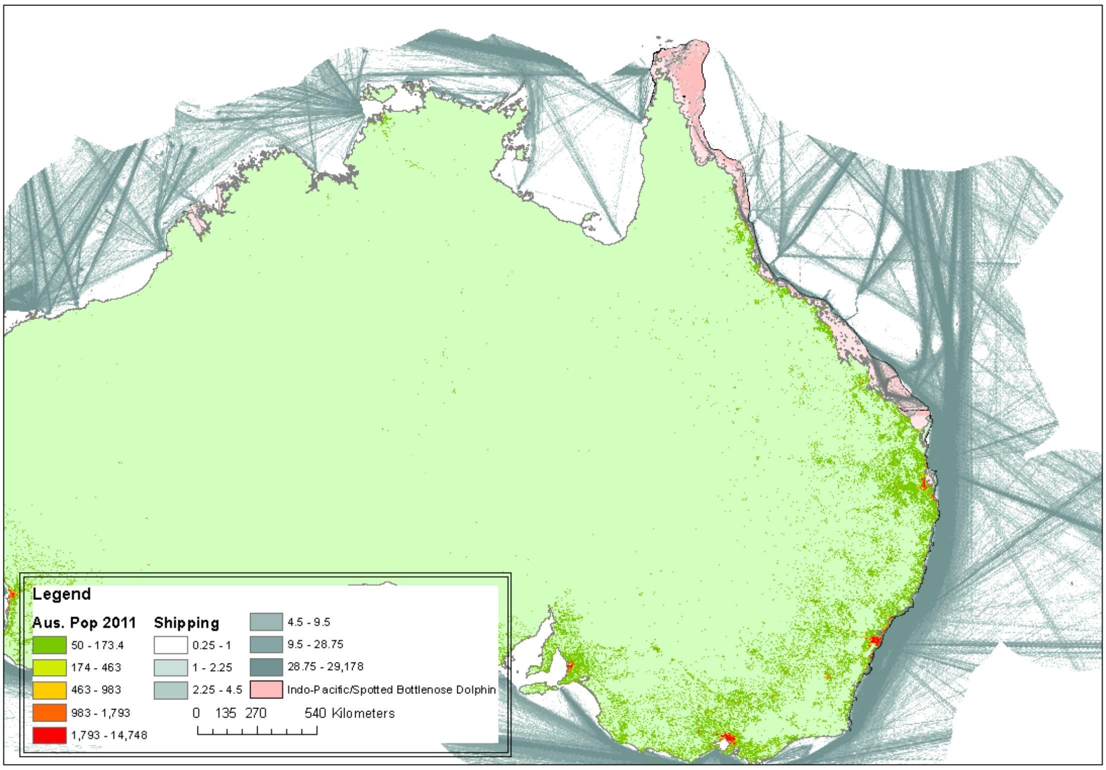
Apx Figure 5 Sperm whale biologically significant area with general shipping density (all vessels >22m) and human population density



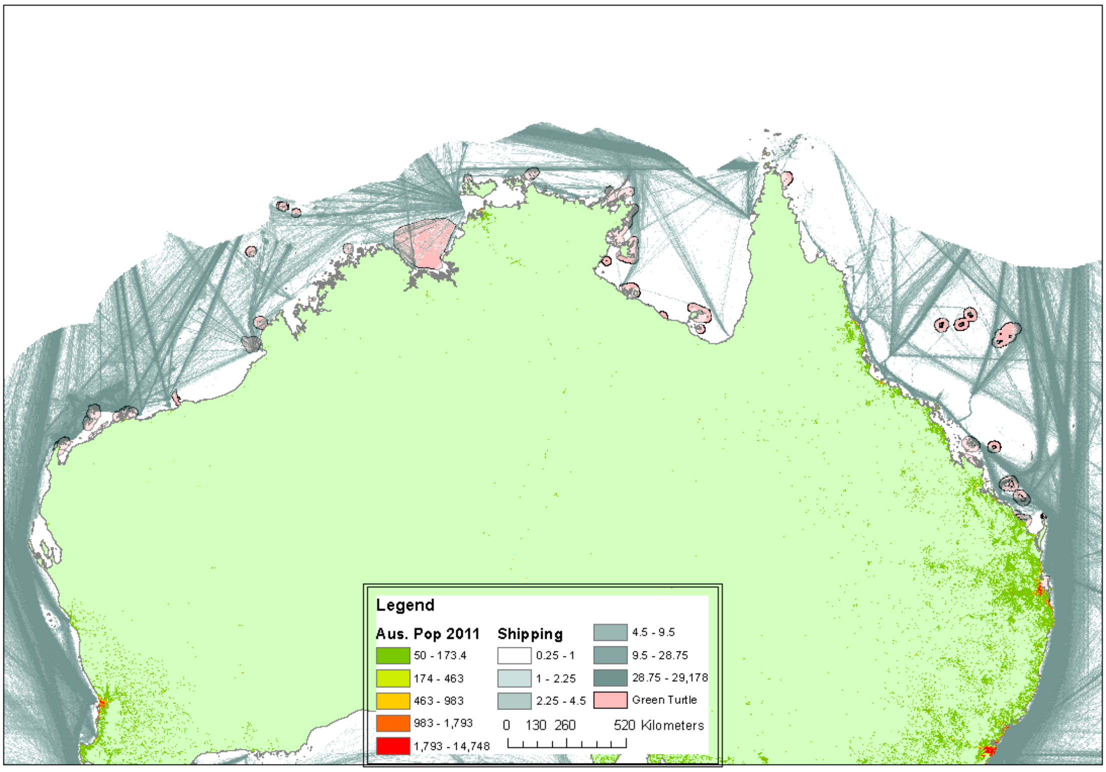
Apx Figure 6 Snubfin Dolphin biologically significant area with general shipping density (all vessels >22m) and human population density.



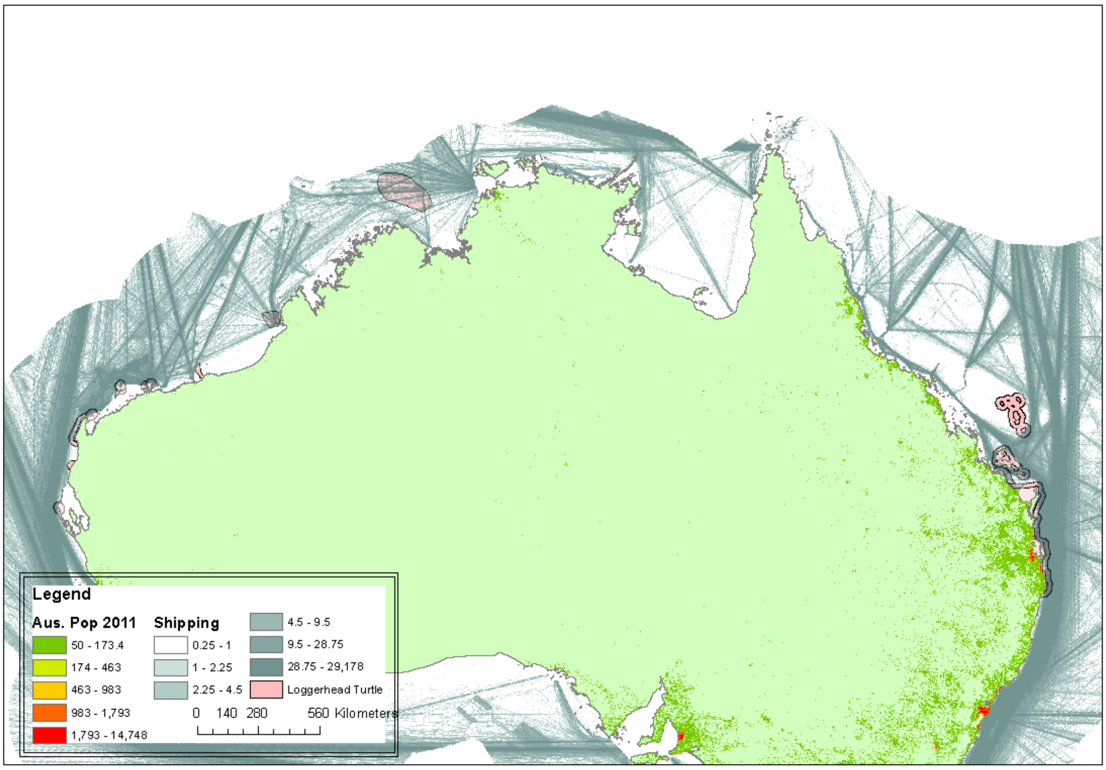
Apx Figure 7 Info-Pacific Humpbacked Dolphin biologically significant area with general shipping density (all vessels >22m) and human population density.



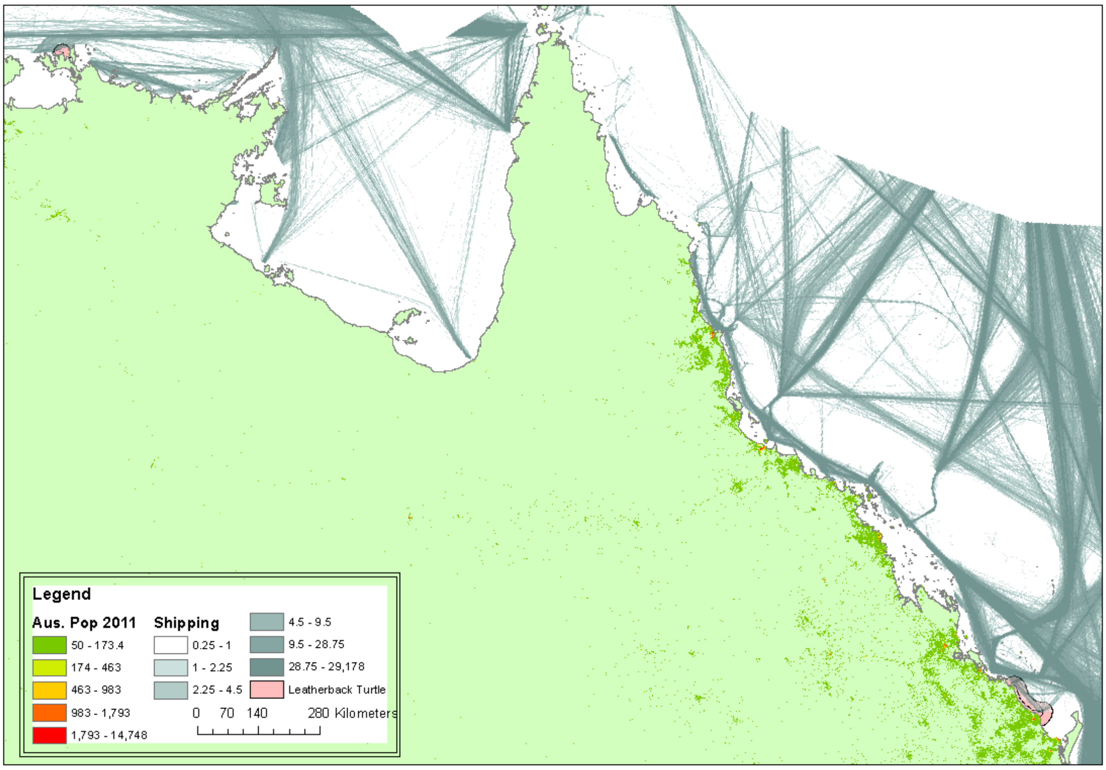
Apx Figure 8 Indo-pacific – spotted dolphin biologically significant area with general shipping density (all vessels >22m) and human population density.



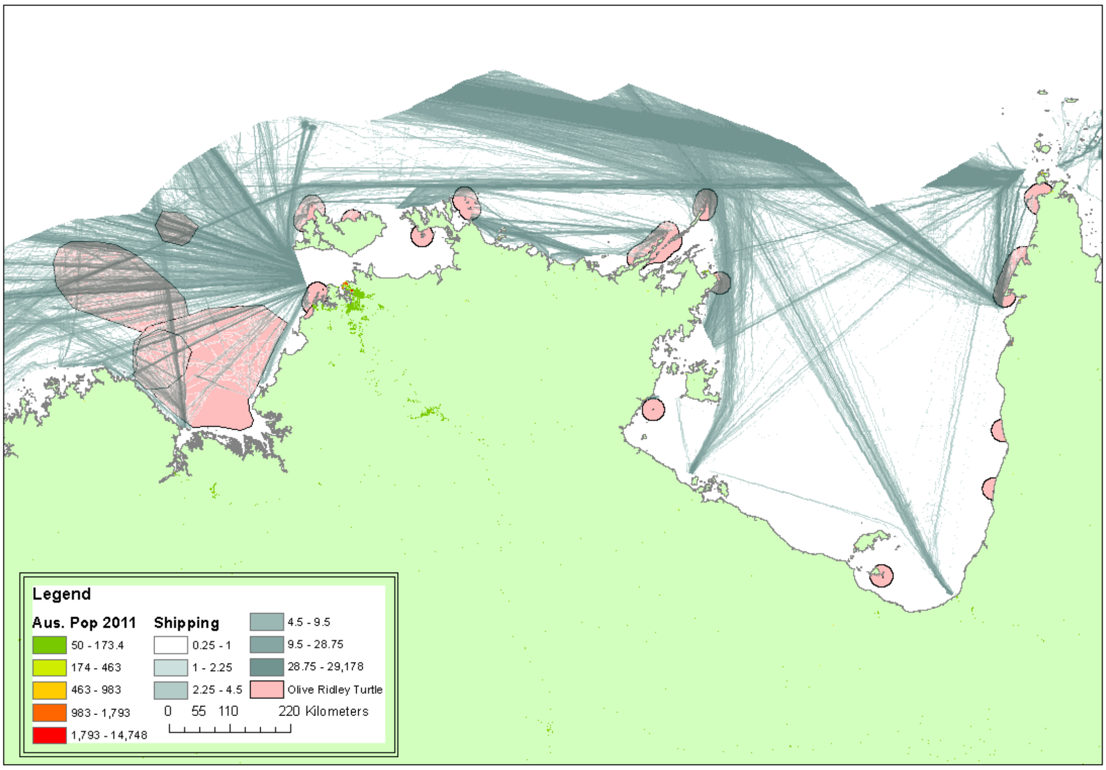
Apx Figure 9 Green turtle biologically significant area with general shipping density (all vessels >22m) and human population density.



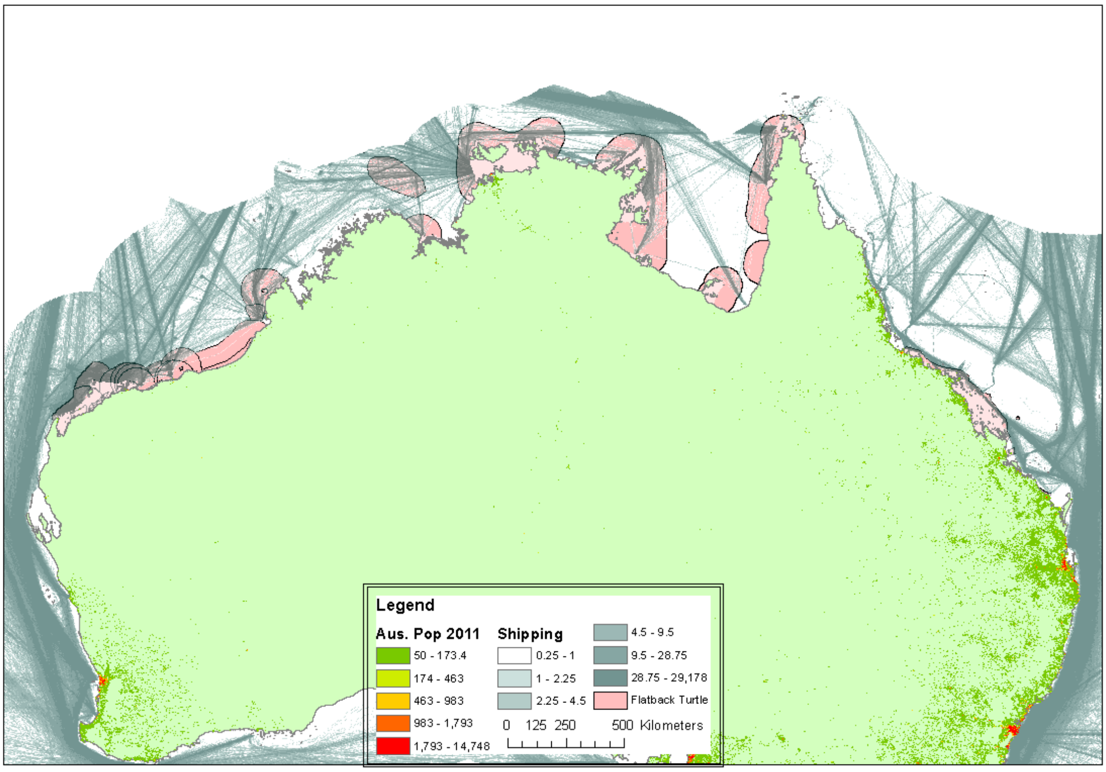
Apx Figure 10 Loggerhead turtle biologically significant area with general shipping density (all vessels >22m) and human population density.



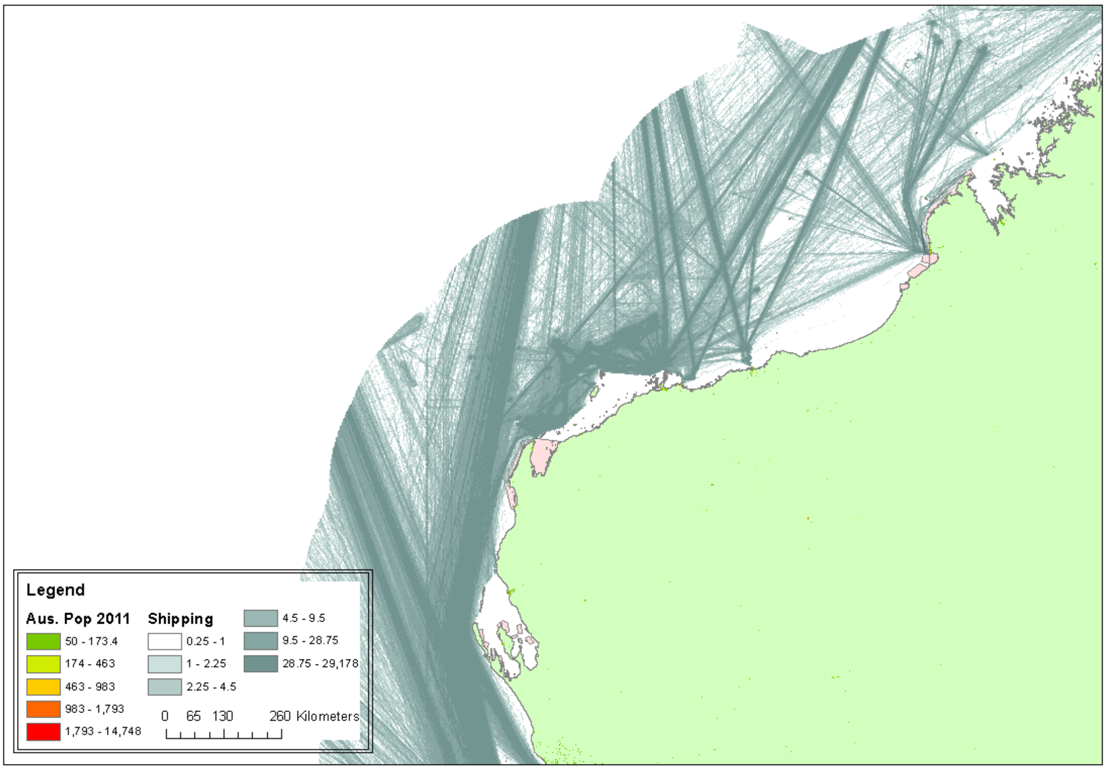
Apx Figure 11 Leatherback turtle biologically significant area with general shipping density (all vessels >22m) and human population density.



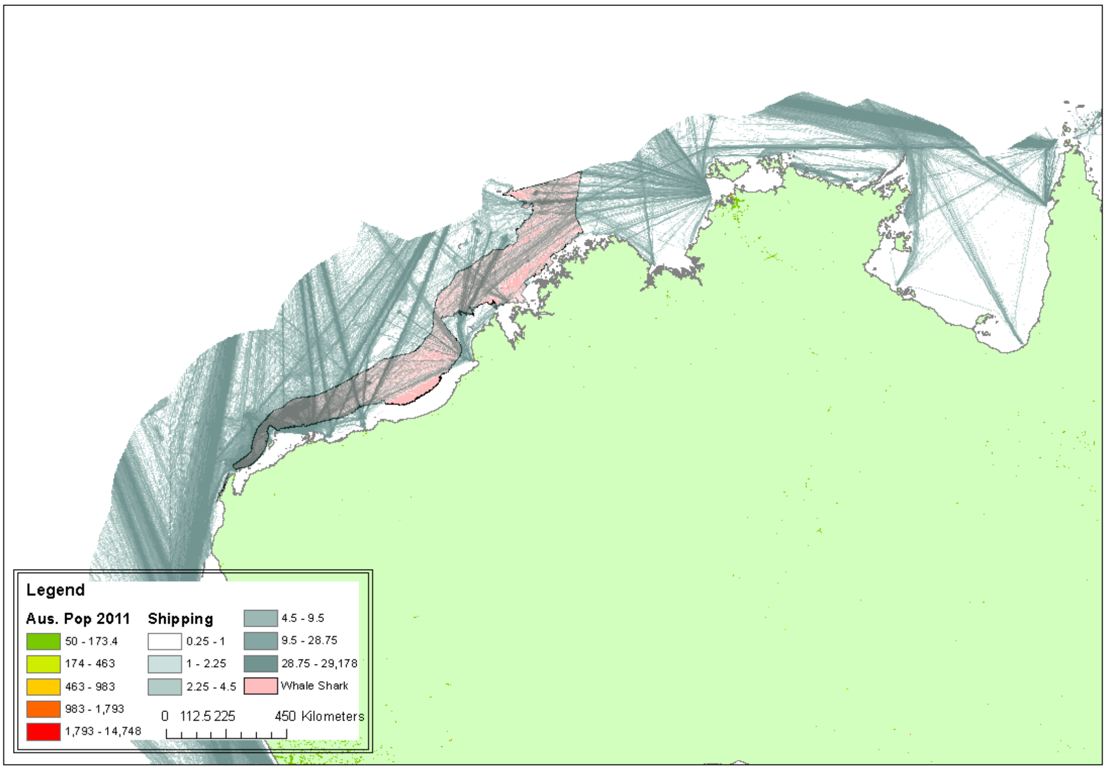
Apx Figure 12 Olive Ridley Turtle biologically significant area with general shipping density (all vessels >22m) and human population density.



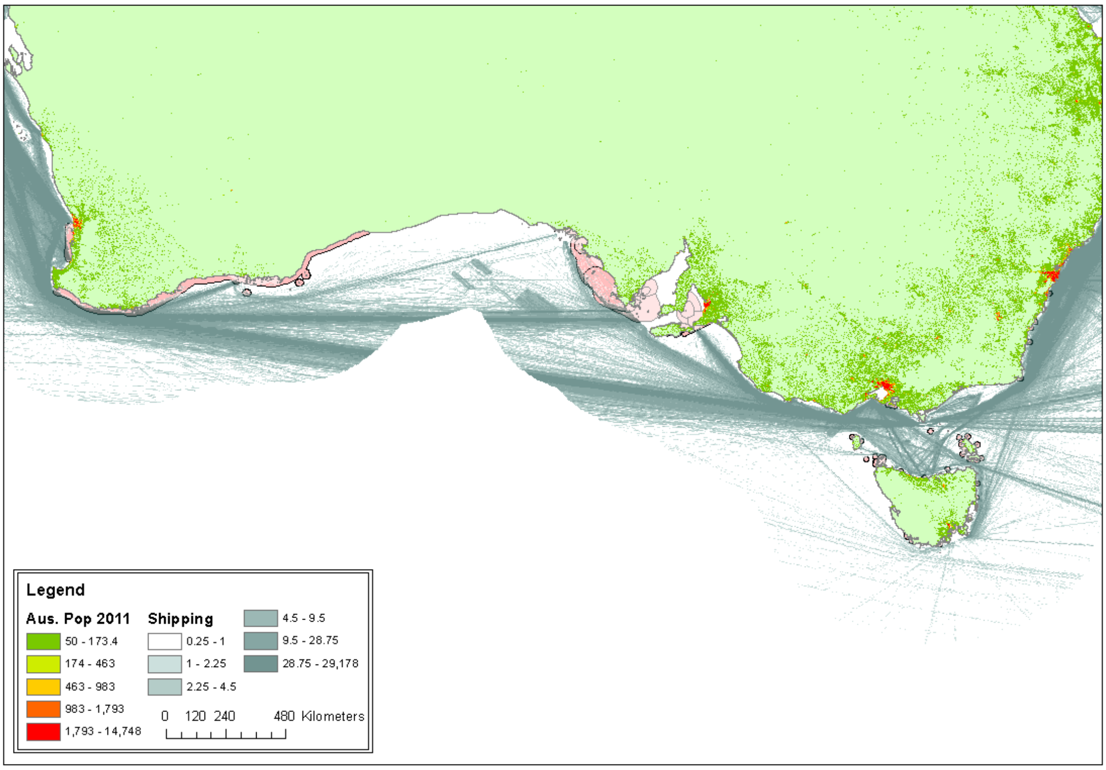
Apx Figure 13 Flatback turtle biologically significant area with general shipping density (all vessels >22m) and human population density.



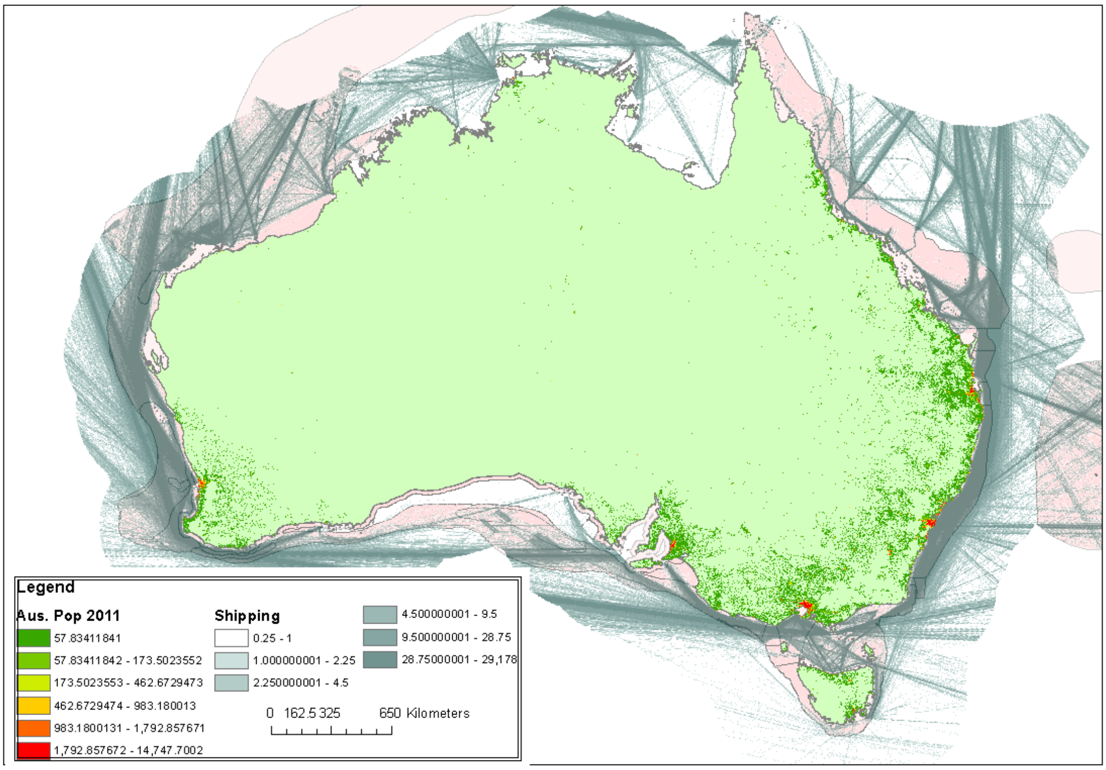
Apx Figure 14 Dugong biologically significant area with general shipping density (all vessels >22m) and human population density.



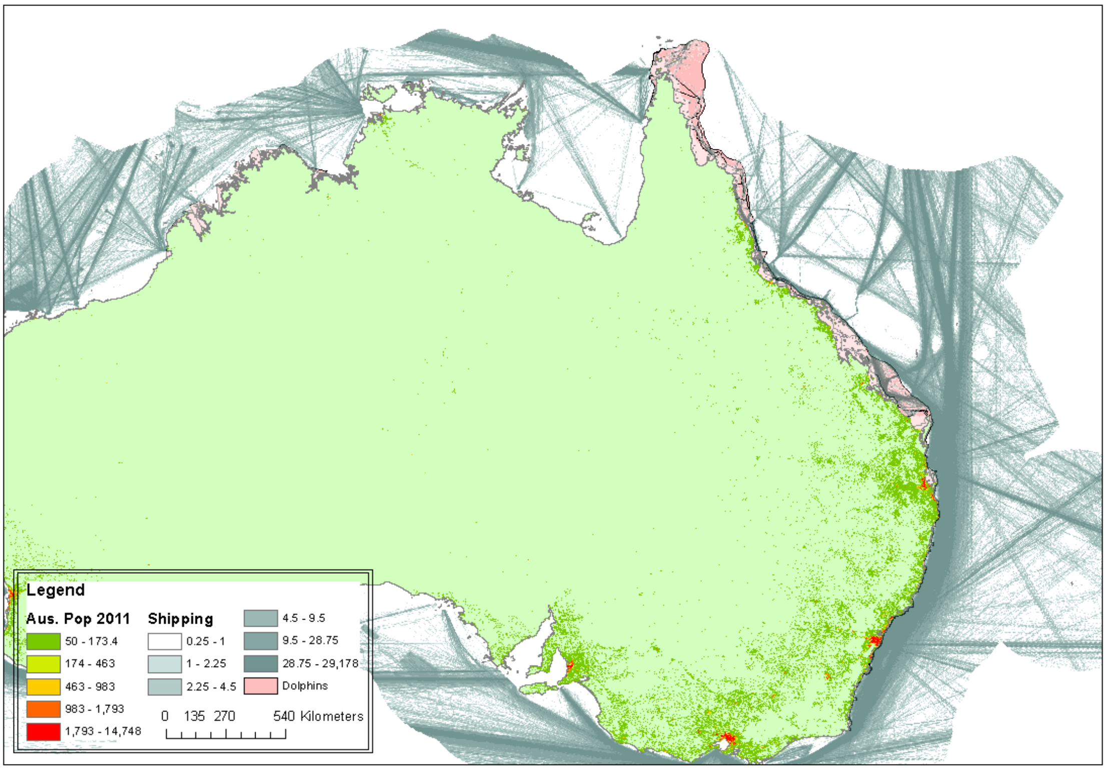
Apx Figure 15 Whale shark biologically significant area with general shipping density (all vessels >22m) and human population density.



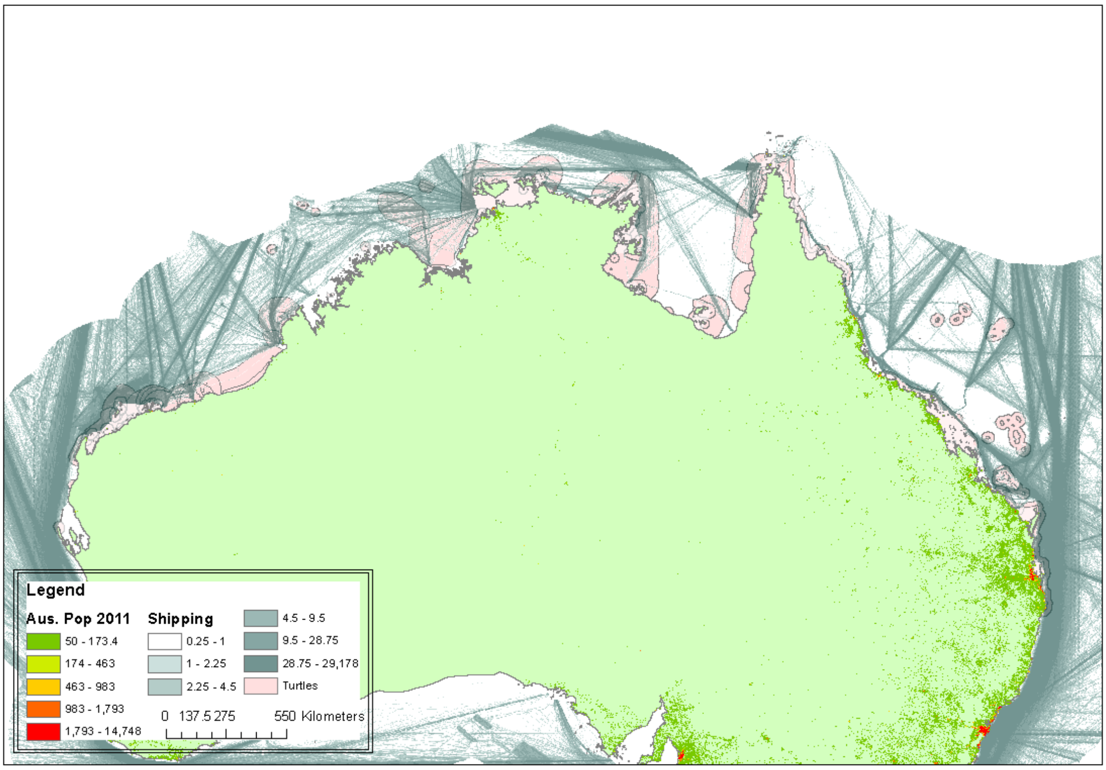
Apx Figure 16 Little penguin biologically significant area with general shipping density (all vessels >22m) and human population density.



Apx Figure 17 Whale biologically significant area with general shipping density (all vessels >22m) and human population density.



Apx Figure 18 Dolphin biologically significant area with general shipping density (all vessels >22m) and human population density.



Apx Figure 19 Turtle biologically significant area with general shipping density (all vessels >22m) and human population density.

APPENDIX D – NOAA INFORMATION HIERARCHY

In 2011, the U.S. National Oceanic and Atmospheric Administration (NOAA) convened a working group to map cetacean density and distribution within U.S. waters[10]. The specific objective of the Cetacean Density and Distribution Mapping Working Group (CetMap) was to create comprehensive and easily accessible regional cetacean density and distribution maps that are time- and species-specific, ideally using survey data and models that estimate density using predictive environmental factors. In order to depict the best comprehensive cetacean density and distribution maps it was necessary to evaluate the quality of data available and to systematic evaluate them. CetMap identified and broadly evaluated the information-types and modelling methods available for estimating marine mammal density and distribution and ranked them in Tiers based on their expected ability to accurately predict presence, distribution, or density in a spatially and temporally explicit manner. The information hierarchy developed and applies by CetMap includes 5 ranked Tiers defined as:

Tier 1: Habitat-based Density Models - Density predicted heterogeneously across a surface of cells based on environmental covariates. Probability of detection was accounted for as a function of distance from the transect line to the sighting, and possibly other covariates such as group size or Beaufort sea state. Density was derived from the estimates of encounter rate, effective strip width, average group size, and an assumed or estimated value for the trackline detection probability, any of which may have been assumed to vary with the environment.

Tier 2: Stratified Density Models - Density predicted homogeneously across an area. Probability of detection was accounted for as a function of distance from the transect line to the sighting, and possibly other covariates such as group size or Beaufort sea state. Density was derived from the estimates of encounter rate, effective strip width, average group size, and an assumed or estimated value for the trackline detection probability.

Tier 3: Probability of Occurrence - Spatially heterogeneous predictions of the probability of encountering the species, population, or guild across a surface of cells, based on environmental covariates.

Tier 4: Records Exist - Presence-only observations in the CetMap data system, or known to exist in published literature or with other investigators. Principally, these observations were collated at OBIS-SEAMAP based on visual observations aboard ships or aircraft on scientific surveys. Acoustic observations and opportunistic visual observations were also included. The observations were not corrected for heterogeneity in survey effort or detection probabilities across the study area.

Tier 5: Expert Knowledge - Species status (Present, Likely Absent) for a given region. This tier was populated with information from regional species lists generated by the CetMap Working Group and regional experts. This tier was created at the temporal resolution of an entire year, such that if a species occurs at any time during the year, then all cells for that species/region that are not populated with Tier 1-4 data are designated as “expert-based presence”. It is important to note that this does not provide information on species presence during specific months.

As part of this project, we have applied the same Tier system for ease in comparability with existing and ongoing USA research and also as they provide a robust and consistent system for the assessment of data quality.

[10] See http://cetsound.noaa.gov/index

APPENDIX E - AVAILABLE SPECIES DISTRIBUTION INFORMATION

Much of this information has been gathered from the Department of the Environment (2016). Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat.

E.1 Baleen Whales

E.1.1 Humpback whale (*Megoptera novaeangliae)*

Australian Distribution
The distribution, core calving, resting and feeding areas for humpback whales in Australian waters are illustrated in Figure E1. In addition, the indicative migratory pathways and times of peak migration through Australian waters are also shown in Figure E1. Both the west and east coast populations of humpback whales migrate along the Australian coast from May to November each year. Cow and calf migration can occur up to four weeks after the southern peak migration period.

Calving
Known calving areas (based on observations of mothers with very young calves) for Australian humpback whales include:

- Western Australia - Southern Kimberley between Broome and the northern end of Camden Sound;
- Queensland - Great Barrier Reef between approximately 14°S and 27°S; and
- less frequently, along the migratory pathways.

Major calving areas have been identified for the western Australian population in the Kimberley region and particularly between Lacepede Islands (16°8S) and Camden Sound (15°38S) (Jenner et al., 2001). There is a migration path between Point Cloates and North West Cape and high concentrations of humpback whales are observed in Camden Sound and Pender bay between June and September each year (DEWHA 2008). Humpback whales migrate north from their Antarctic feeding grounds around May each year, reaching the waters of the north-west marine region in early June. Immature individuals and lactating females arrive first, followed by non-pregnant females arriving last. Breeding and calving takes place between mid-August and early September when the southern migration starts. Females with calves are the last to leave the breeding grounds stopping to rest in Exmouth Gulf and Shark Bay.

The calving area for the eastern Australian humpback whale population is presumed to be off the coast between central and northern Queensland (Chittleborough 1965; Smith et al., 2012). Although the exact location is still unknown, recent research using a predictive habitat model, has isolated two core areas for humpback whale distribution in the southern Great Barrier Reef region east of Mackay and further south in the Capricorn and Bunker island groups off Gladstone (Smith et al., 2012). Further research is required to conclusively identify breeding habitats for humpback whales, although this research has identified key areas on which to focus future surveys.

After spending the winter months breeding and calving in the Great Barrier Reef east coast humpback whales migrate south, stopping for variable resting periods in areas with shallow waters such as Hervey Bay, Queensland (Franklin et al., 2011) and Jervis Bay, NSW (Bruce et al., 2014).

Resting
Resting areas are used by cow-calf pairs and attendant males during the southern migration. These whales appear to use sheltered bays to opportunistically rest during migration to the feeding grounds and include:

- Western Australia - southern Kimberley region, Exmouth Gulf, Shark Bay, Geographe Bay, and Augusta;
- Queensland - the Whitsundays, Hervey Bay, Moreton Bay, the Swain Reefs complex, Bell Cay, and the Palm Island Group; and
- NSW - Twofold Bay and Jervis Bay

In Western Australia there are additional areas of potential importance around Houtman Abrolhos, Montebello and Barrow islands although further research is needed to conclusively determine these as resting areas. Areas such as Shark Bay may also provide resting areas during the northern migration (Jenner et al., 2001). It is also possible that the resting area in Kimberley region may extend further south towards Broome.

Migration
During winter months, humpback whales migrate from their polar summer feeding grounds to their tropical winter breeding grounds (Clapham 2000; Clapham & Mead 1999; Dawbin 1966), an annual migration of up to 10 000 km (DEWR 2007).

Humpback whales migrate between May and November each year. Peak migration times for both populations occur between June and July each year (Northern migration). There has been no such peak observed during the southern migration with more diffuse and irregular movements of whales. Predominantly humpback whales migrate within 50 km of the coast of mainland Australia. In addition, whales are known to travel widely through the waters to the south of Australia during migrations to and from Antarctic feeding areas.

The migration pathway for the western Australian population was found to be within the continental shelf boundary or 200 m bathymetry (Jenner et al., 2001). The eastern Australian humpback whales also migrate in close proximity to the coast of Australia on their way to and from their winter breeding areas. As with the western Australian population, the eastern Australian population tend to migrate further offshore during their northward migration (Paterson et al., 1994; Noad & Cato 2001).

Along parts of the migratory route there are narrow corridors and bottlenecks resulting from physical and other barriers where the majority of the population passes close to shore (within 30 km of the coastline). These habitat areas are important during the time of migration and include:

- Western Australia - Geraldton/Abrolhos Islands, and Point Cloates to North West Cape
- Queensland – east of Stradbroke Island, and east of Moreton Island; and
- NSW - Cape Byron

Anthropogenic disturbances in migratory routes have unpredicted consequences as overcoming such disturbances depends on whether humpback whales have the ability to adapt their migratory routes. Additionally, migratory routes include other biologically important areas such as resting areas and feeding areas that are essential for whales during migration. There is likely to be considerable individual site fidelity in migratory routes, and changes in usage of migratory routes depending on yearly changes in primary productivity at feeding aggregations, or differences in sex or cohort migration timing or migratory route choice.

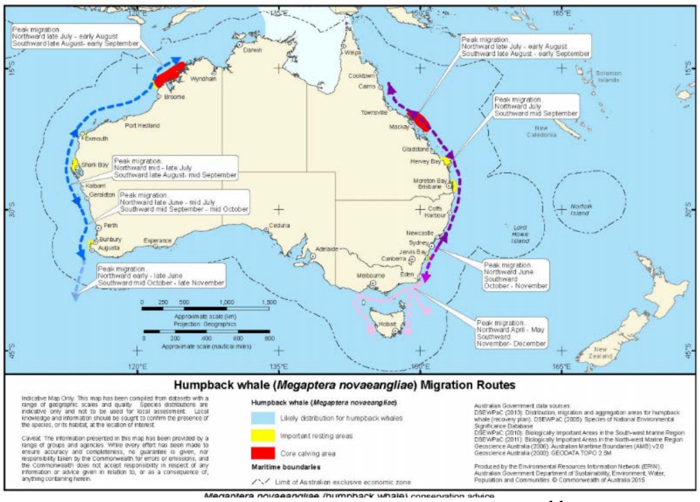


Figure E1. Generalised distribution map of Humpback whales[11]

E.1.2 Pygmy blue whale (*Balaenoptera musculus brevicauda)*

Blue whale sightings in Australian waters are widespread, and it is likely that the whales occur around the continent at various times of the year. However, much of the Australian continental shelf and coastal waters have no particular significance to the whales and are used only for migration and opportunistic feeding. The only known areas of significance to the blue whale are feeding areas around the southern continental shelf, notably the Perth Canyon, in Western Australia, and the Bonney Upwelling and adjacent upwelling areas of South Australia and Victoria (DEH 2005).

In addition to whaling records (Branch et al. 2007), most of the current knowledge of blue whale distribution within Australian waters has been derived from long term passive acoustic monitoring (Samaran et al. 2013). Antarctic blue whale calls have been detected year-round suggesting some individuals may not leave Antarctica (Samaran et al. 2010). In comparison, the pygmy blue whale has a more widespread distribution, found throughout the Indian Ocean and usually north of 54° S (Branch et al. 2009) at lower latitudes, with individuals migrating between Australian waters and Indonesia along the Western Australian coastline (Branch et al. 2007, Double et al. 2014).

<u>Areas of blue whale aggregation</u>
The pygmy blue whale is known to aggregate each year during the summer off southern Australia due to seasonal upwellings that concentrate high densities of prey (Attard et al. 2010, Gill et al. 2011).

Key areas of aggregation include the Perth Canyon off Western Australia, the Bonney Upwelling and adjacent waters off South Australian and Victoria (Rennie et al. 2009, Attard et al. 2010, Gill et al. 2011). Genetic analysis suggests the same breeding stock of the pygmy blue whale utilises both of the Australian feeding aggregations (Attard et al. 2010).

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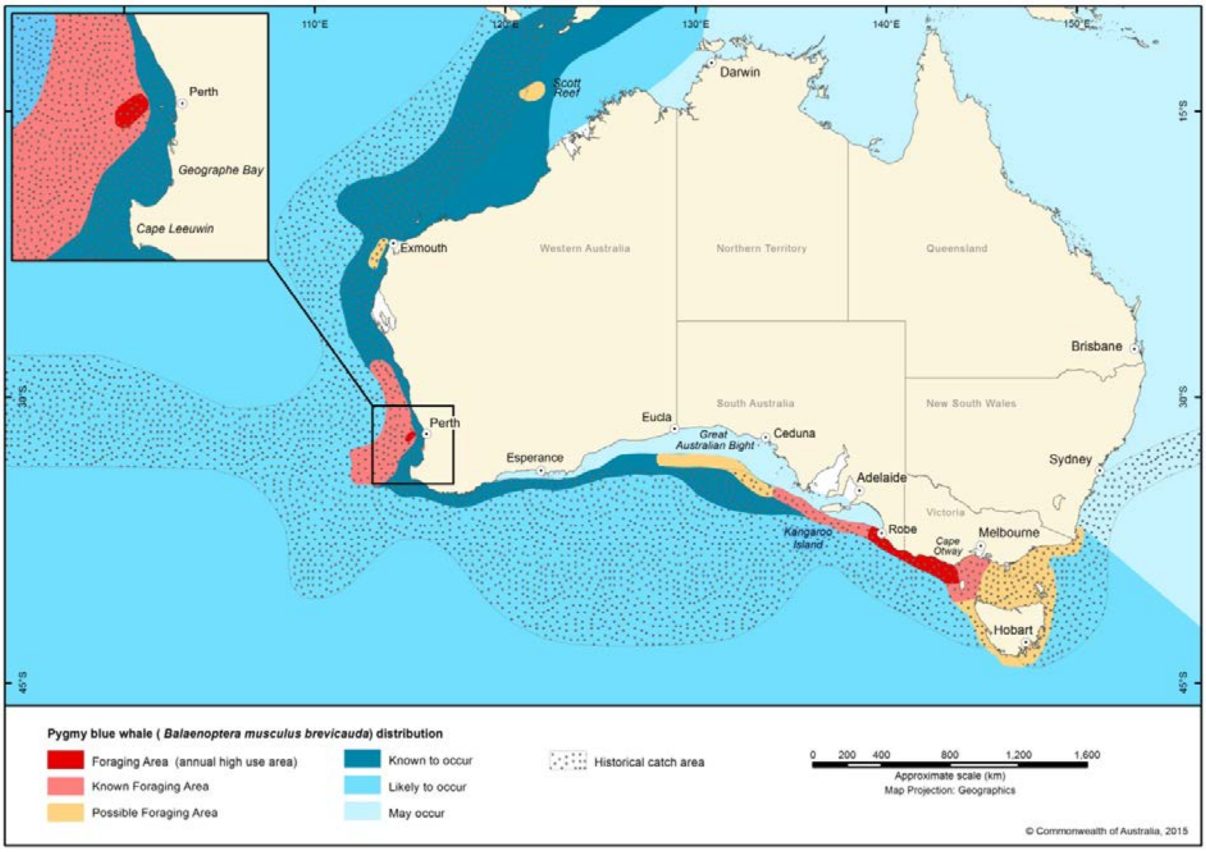
[11] Commonwealth of Australia (2015) Approved Conservation Advice for *Megaptera* novaeangliae (humpback whale). Available at http://www.environment.gov.au/biodiversity/threatened/species/pubs/38-conservation-advice-10102015.pdf

Aggregation areas were confirmed during an International Whaling Commission (IWC) survey in late 1995 (Kato et al. 1996). The Bonney Upwelling and Perth Canyon are the best known Blue Whale aggregation areas in Australian waters. Bass Strait and the waters of the eastern Great Australian Bight are also known feeding areas, although perhaps only in certain years (Mustoe 2003 pers. comm.). Other important areas of aggregation include Geographe Bay and Quondong Point, which are used as migratory waypoints, the upwellings around Browse Island, which is likely feeding area during migration to Indonesia, and areas around Cape Naturaliste and Rottnest Island, which are also feeding grounds (DEWHA 2008).

The Subtropical Front (the confluence of subtropical and subantarctic waters (40–45° S)), not far to the south of Australia, is also likely to be a large-scale feeding area (Mikhalev 2000). Satellite tagging has shown rapid movement from western and eastern Australia to the Subtropical Front. This area of aggregation was targeted by Soviet whalers during the 1960s (Mikhalev 2000). Anecdotal feeding areas include offshore of Eden and Merimbula, NSW (especially during October) (Butt 2001) and the continental shelf from Rottnest Island to Northwest Cape (McCauley 2004).

Outside of the recognised feeding areas, possible foraging areas for the pygmy blue whale include the greater region around the Perth Canyon, off Exmouth and Scott Reef in Western Australia, in Bass Strait off Victoria and diving and presumably feeding at depth off the West coast of Tasmania (P. Gill pers. Comm., cited in Department of the Environment 2015). Evidence for feeding is based on limited direct observations or through indirect evidence, such as the occurrence of krill in close proximity of whales, or satellite tagged whales showing circling tracks. Further feeding grounds may be identified in the future.



Foraging Area (Annual high use area)	Blue whales are regularly observed feeding on a seasonal basis
Known Foraging Area	Known foraging occurs in these areas but is highly variable both between and within seasons
Possible Foraging Area	Evidence for feeding is based on limited direct observations or through indirect evidence, such as occurrence of krill in close proximity of whales, or satellite tagged whales showing circling tracks. Blue whales travel through on a seasonal basis, possibly as part of their migratory route
Known to occur	Blue whales are known to occur based on direct observations, satellite tagged whales or based on acoustic detections
Likely to occur	Blue whales are likely to occur based on occasional observations in the area and nearby areas
May occur	Evidence for the presence of blue whales through strandings or rare observations
Historical catch area	Blue whales were caught during the whaling period based on whaling data

Figure E.2 Generalised distribution map of Pygmy blue whales[12]

[12] Commonwealth of Australia (2012) Conservation Management Plan for the Blue Whale. Available at http://www.environment.gov.au/biodiversity/threatened/publications/recovery/blue-whale-conservation-management-plan

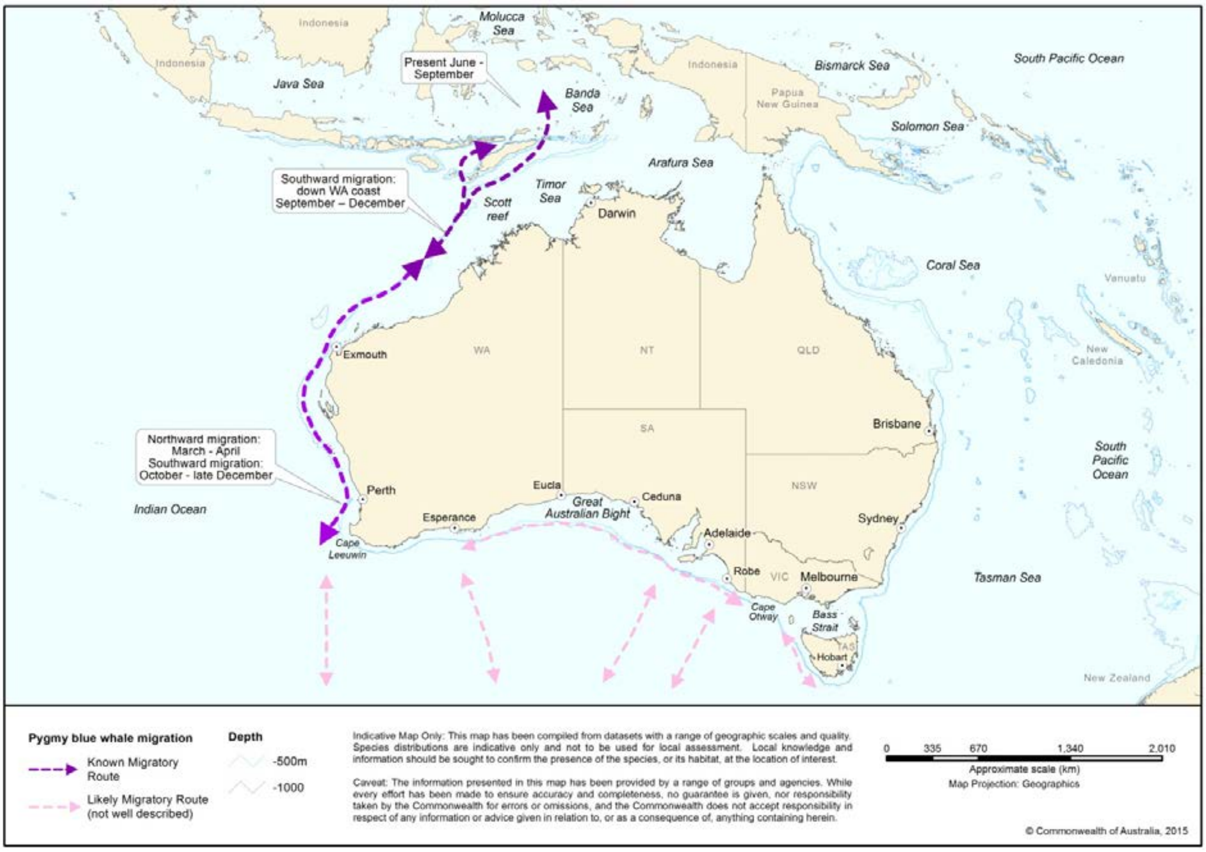


Figure E.3 Pygmy blue whale migration routes[13]

E.1.3 Antarctic blue whale (*Balaenoptera musculus intermedia*)

Blue whale sightings in Australian waters are widespread, and it is likely that the whales occur around the continent at various times of the year. However, much of the Australian continental shelf and coastal waters have no particular significance to the whales and are used only for migration and opportunistic feeding. The only known areas of significance to the blue whale are feeding areas around the southern continental shelf, notably the Perth Canyon, in Western Australia, and the Bonney Upwelling and adjacent upwelling areas of South Australia and Victoria (DEH 2005a).

In addition to whaling records (Branch et al. 2007), most of the current knowledge of blue whale distribution within Australian waters has been derived from long term passive acoustic monitoring (Samaran et al. 2013). Antarctic blue whale calls have been detected year-round suggesting some individuals may not leave Antarctica (Samaran et al. 2010).

Antarctic blue whale winter migratory destinations include lower latitudes of the Pacific and Indian Oceans based on acoustic recordings. Interestingly, Antarctic blue whales have been detected acoustically in the Australian Antarctic Territory and the Western Antarctic Peninsula throughout the year suggesting that either some whales may not migrate every year, and / or that migration may be staggered in time. Off Australia, Antarctic blue whales have been acoustically recorded off Cape Leeuwin in Western Australia from May to November, at the Perth Canyon from May to October (with a few occurrences recorded in

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[13] Commonwealth of Australia (2012) Conservation Management Plan for the Blue Whale. Available at http://www.environment.gov.au/biodiversity/threatened/publications/recovery/blue-whale-conservation-management-plan

March), and off Tasmania predominately from May to December, which suggests these areas may be breeding grounds and/or migratory corridors, and/or winter feeding grounds.

Areas of blue whale aggregation
The distribution of each subspecies varies and is not fully understood (Double et al. 2014). The Antarctic blue whale tends to remain at higher latitudes and migrate to lower latitudes for feeding, breeding and calving during the Australian summer (Branch 2007, Širovic et al. 2009, Woinarski et al. 2014).

Evidence for feeding is based on limited direct observations or through indirect evidence, such as the occurrence of krill in close proximity of whales, or satellite tagged whales showing circling tracks. Further feeding grounds may be identified in the future.

E.1.4 Southern right whale (*Eubalaena australis)*

Southern Right Whales are seasonally present on the Australian coast between about May and November. The distribution and recognised aggregation areas of Southern Right Wales in Australian waters are illustrated in Figure E.4.

Southern Right Whales have been recorded in the coastal waters of all Australian states with the exception of the Northern Territory (Bannister et al. 1996). Principally found around the southern coastline off southern Western Australia and far west South Australia, Southern Right Whales occur anywhere between Sydney and Perth, including off Tasmania (Bannister 1979-2005; Bannister 1990; Burnell & McKenna 1996; Burnell & Bryden 1997; Kemper et al. 1997; Ling & Needham 1985-91; Warneke 1989). Evidence suggests that fewer than 10% of reproductively mature females calving on the coast in any one year use the coast off Tasmania, Victoria, New South Wales and eastern South Australia (Burnell & McKenna 1996; Kemper et al. 1997). Sightings in more northern waters are relatively rare, but there have been records from Exmouth (22°23'S, 114°07'E) on the west coast (Bannister 2001) and Moreton Bay (27°10'S, 153°20'E) (Chilvers, 2000), Stradbroke Island (27°26'S, 153°32'E) (Noad, 2000) and Hervey Bay (25°S, 153°E) on the east coast.

Within their broader geographic range Southern Right Whales in Australia concentrate in certain areas to breed. Major calving areas are located in Western Australia at Doubtful Island Bay (34°10'S, 119°40'E), east of Israelite Bay (33°15'S, 124°10'E); and in South Australia at Head of Bight (31°30'S, 131°10'E) (Bannister 1979-2005; Burnell 1999). Smaller numbers of calving females are regularly seen in Victoria at Warrnambool (38°23'S, 142°29'E); South Australia at Encounter Bay (35°34'S, 138°37'E) and Fowlers Bay (31°59'S, 132°34'E); and Western Australia at Twilight Cove (32°17'S, 126°05'E), Flinders Bay (34°20'S, 115°15'E), Albany/Cape Riche area (35°2'S 118°E), Yokinup Bay/Cape Arid area (33°25'S 123°E) (Bannister 1979-2005; Burnell & McKenna 1996; Kemper et al. 1994; Ling & Needham 1985-91). Areas used intermittently include a number of locations on the Western Australian coast west of Israelite Bay between more regular calving grounds, Sleaford Bay (South Australia), Port Fairy and Portland (Victoria), Eden (NSW), and Maria Island and Bruny Island (Tasmania) (DEH, 2005b).

The distribution of Southern Right Whales in Australian waters other than near to the coast is unknown.

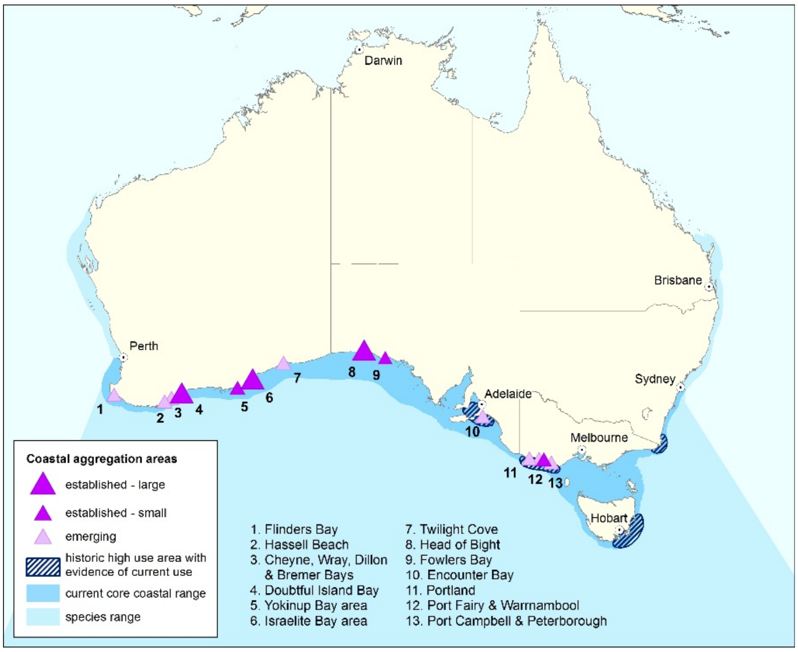

Figure E.4 Generalised distribution maps of the Australian distribution of the Southern Right Whale[14]

E.1.5 Dwarf minke whale (*Balaenoptera acutorostrata subsp.)*

Dwarf Minke Whales are known to occur as far north as 11° S in the western Pacific off Australia (Perrin & Brownell 2002) and likely occur up the west coast to similar low latitudes. The southern distribution of Dwarf Minke Whales extends down to approximately 41° S, but it is unlikely that this species normally migrates to such high latitudes of the Antarctic (Best 1985). It is more likely that Australian Dwarf Minke Whales are distributed close inshore. Off South Africa, for example, 77% of Dwarf Minke Whales taken by whalers were caught within 30 nautical mile (nm) of the coast (Best 1985).

The current extent of occurrence for Dwarf Minke Whales is thought to be greater than 20 000 km², calculated to the edge of the Australian Economic Exclusion Zone (200 nm off the coast), down to about 41°S (Best 1985). Increasing ocean temperatures predicted by climate change scenarios could potentially increase the extent of occurrence of Dwarf Minke Whales, with warmer water extending southwards along both coasts.

The area of occupancy of Dwarf Minke Whales is estimated to be likely to be greater than 2000 km² (Peddemors & Harcourt 2006, pers. comm.). The apparent near-shore distribution of Dwarf Minke Whales makes them vulnerable to human disturbance. The area of occupancy may be determined, in some areas, by avoidance of areas with high levels of anthropogenic noise (petro-chemical exploration and mining).

Dwarf Minke Whales are currently considered to occur in one location (Peddemors & Harcourt 2006, pers. comm.). However, taxonomic confusion within the Minke Whales and possible future taxonomic revision of this genus may lead to changes in understanding the distribution of the Dwarf Minke Whale. In particular, if the Dwarf Minke Whale is found to be restricted to near-shore areas (Best 1985), its distribution may be fragmented by regions of deep water.

[14] Commonwealth of Australia (2012) Conservation Management Plan for the Southern Right Whale. Available at http://www.environment.gov.au/resource/conservation-management-plan-southern-right-whale-recovery-plan-under-environment

E.1.6 Antarctic minke whale (*Balaenoptera bonaerensis)*

Antarctic Minke Whales have been recorded from all States but not in the Northern Territory (Bannister et al. 1996). The paucity of records of the colouration of stranded Minke Whales in Australia obscures the determination of the range of Antarctic Minke Whales along the Australian coast, although they are known to occur north to 21° S off the east coast (Bannister et al. 1996). The distribution up the west coast of Australia is currently unknown. Antarctic Minke Whales probably do not migrate as far north as Dwarf Minke Whales (to 11° S) (Bannister et al. 1996; Perrin & Brownell 2002), but records for Brazil suggest they may move up to 8° S (Zerbini et al. 1997). The southern distribution of Antarctic Minke Whales extends down to approximately 65° S in the Australian Antarctic Territory (Thiele & Gill 1999). In the high latitudinal winter breeding grounds in other regions, Antarctic Minke Whales appear to be distributed off the continental shelf edge (Best 1985; Zerbini et al. 1997), suggesting a similar winter distribution could be expected for Australian Antarctic waters.

The current extent of occurrence for Antarctic Minke Whales is estimated to be greater than 20 000 km² (based on the Australian Economic Exclusion Zone (200 nautical mile, down to about 65° S) (Peddemors & Harcourt 2006, pers. comm.). Increasing ocean temperatures predicted by climate change scenarios could potentially decrease the extent of occurrence, with warmer water extending southwards along both coasts and restricting the northward range of this species. There are no data to indicate past declines in the Antarctic Minke Whale extent of occurrence, nor for any potential future changes in its extent of occurrence.

The area of occupancy of Antarctic Minke Whales cannot be calculated due to the paucity of confirmed records off Australia. The area of occupancy could potentially decline in the future as a result of interactions between Antarctic Minke Whales and fisheries or direct-take vessels.

Antarctic Minke Whales are currently considered to occur in one location, although taxonomic confusion within the Minke Whales and possible future taxonomic revision of this genus may lead to changes in understanding the stock structure of the Antarctic Minke Whale.

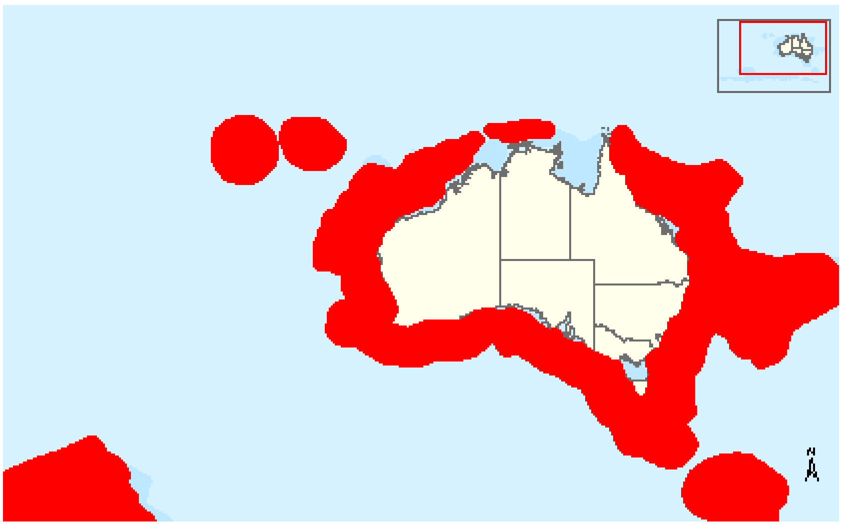

Figure E.5 Generalised distribution map of Antarctic minke whales[15]

[15] Department of the Environment (2016). *Balaenoptera bonaerensis* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 19 Feb 2016

E.1.7 Fin whale (*Balenoptera physalus)*

Fin Whale distribution in Australian waters is known primarily from stranding events and whaling records.

Fin Whale strandings have been reported in small numbers from Western Australia, South Australia, Victoria and Tasmania (Bannister et al. 1996). Two Fin Whale strandings have been reported in South Australia: one in 1925 off Port Wakefield, the other in 1999 north of Port Lincoln. One Fin Whale was reported stranded in Victoria in 1956 (Larcombe et al. 2002). There are two records of Fin Whale strandings in Western Australia: one yearling in 1951 near Mandurah, the other in 1996 at Cottesloe (Chittleborough 1996). There are three records of Fin Whale strandings in Tasmania (McManus et al. 1984).

Chittleborough (1996) reported that nine Fin Whales were taken during the whaling season in Western Australia between 1912 and 1937 and another three Fin Whales in the whaling seasons of 1953, 1956 and 1959. Fin Whales have been sighted inshore in the proximity of the Bonney Upwelling, Victoria, in the summer and autumn months during aerial surveys (Gill 2002). Fin Whale acoustics have been heard off the Rottnest Trench, Western Australia, between January and April 2000 (McCauley et al. 2000).

Several Fin Whales were sighted off Australia's Antarctic Territory (south of 55° S) during whale survey cruises (Ensor et al. 2002; Nishiwaki et al. 1998). The distribution of Fin Whales appears to be complex. In the Antarctic Circle and the subantarctic, this species is often found in areas of complex and steep bathymetry (sea floor topography), such as deep ravines where fish and other prey species are also known to concentrate (D. Thiele 2004, pers. comm.).

It is likely that Fin Whales migrate between Australian waters and the following external waters: Antarctic feeding areas (the Southern Ocean); subantarctic feeding areas (the Southern Subtropical Front); and tropical breeding areas (Indonesia, the northern Indian Ocean and south-west South Pacific Ocean waters) (D. Thiele 2004, pers. comm.)

Fin Whale extent of occurrence and area of occupancy cannot be calculated due to sparsity of sighting records.

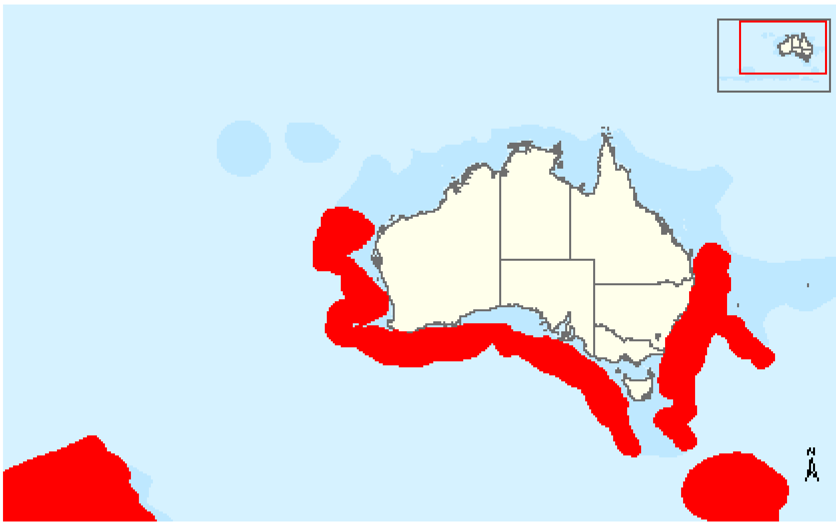

Figure E.6 Generalised distribution map of Fin whales[16]

[16] Department of the Environment (2016). *Balaenoptera physalus* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 19 Feb 2016

E.1.8 Sei whale (*Balaenoptera borealis)*

Sei Whales have been infrequently recorded in Australian waters (Bannister et al. 1996). The similarity in appearance of Sei Whales and Bryde's Whales (Balaenoptera edeni) has resulted in confusion about distributional limits and frequency of occurrence, particularly in warmer waters (>20 °C) where Bryde's Whales are more common. Sei Whales were thought to be the most common whales reported by whalers off Albany, Western Australia while Sperm whaling, however, these may have been misidentified Bryde's Whales (Bannister et al. 1996). There are several reports of presumed Sei Whale sightings by fishermen around the shelf edge (50 km offshore) off the coast of NSW. A trawled carcass of a Sei Whale was reported within 300 km of the Northern Territory coast (Chatto & Warneke 2000). There is one record of a Sei Whale stranding for Tasmania in 1963 (R. Warneke 2004, pers. comm.) and another stranding of a Sei Whale in Tasmania in 1980 (McManus et al. 1984).

Sei Whales have been sighted 20–60 km offshore on the continental shelf in the Bonney Upwelling (off the coast of south-western Victoria and south-eastern South Australia) between December and April 2000–03, presumably feeding (P. Gill 2002, 2004, pers. comm.). Sei Whales were reported 200 nautical miles (nm) south-west of Port Lincoln in December 1995 and a concentration of Sei Whales was reported at the western end of Bass Strait (Kato et al. 1996). Surveys passing through Commonwealth waters during the 2001–02 and 2002–03 International Whaling Commission (IWC) Southern Ocean Whale and Ecosystem Research (SOWER) cruises found a small number of Sei Whales, including cows with calves, about 40 km south of Hobart, Tasmania (Ensor et al. 2002). Seven Sei Whales were seen apparently feeding about 65 km south of Tasmania in January 1993, and a Sei Whale was seen close inshore off Tasman Peninsula, south-east Tasmania, in June 1996 (P. Gill 2004, pers. comm.).

Sei Whales are also found in waters off Australia's Antarctic Territory. In the 1960s and 1970s, Sei Whales formed the highest percentage of whales sighted during Australian National Antarctic Research Expedition (ANARE) voyages (Parker 1978). However, very few Sei Whales were seen during Japanese Research Whaling Program in the Antarctic (JARPA) cruises in Australian Antarctic waters between 1989–90 and 1995–96 (Nishiwaki et al. 1998). The diversity of habitat for Sei Whales may be driven by dynamic physical and prey processes (D. Thiele 2004, pers. comm.). There are no known mating or calving areas in Australian waters (Parker 1978). The extent of occurrence and area of occupancy of Sei Whales in Australian waters cannot be calculated due to the rarity of sightings records.

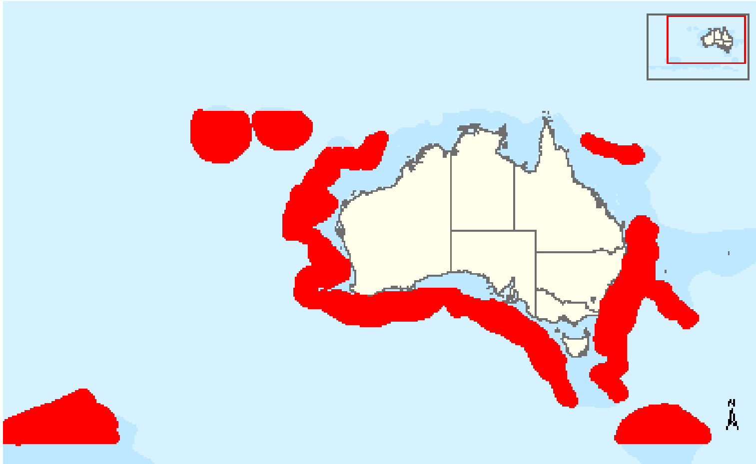

Figure E.7 Generalised distribution map of Sei whales[17]

[17] Department of the Environment (2016). *Balaenoptera borealis* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 19 Feb 2016

E.1.9 Bryde's whale (*Balaenoptera edeni*)

Bryde's Whales occur in temperate to tropical waters, both oceanic and inshore, bounded by latitudes 40° N and 40° S, or the 20 °C isotherm (Bannister et al. 1996). Bryde's Whales have been recorded from all Australian states except the Northern Territory (Bannister et al. 1996), including one sighting each in Victoria and NSW and 11 reported strandings in South Australia (7), NSW (2), Victoria (1) and Queensland (1) (DEW 2007). However, there has been some doubt over the exact identity of some of the specimens, with three individuals from Western Australia and two from the east coast reportedly intermediate between Bryde's Whale and the Sei Whale, while three Bryde's Whales from Victoria and another from Western Australia are typical of the species (Bannister et al. 1996).

The current extent of occurrence for Bryde's Whales is estimated to be greater than 20 000 km² (based on the Australian Economic Exclusion Zone (200 nautical mile (nm), down to about 40° S) (Peddemors & Harcourt 2006, pers. comm.). Increasing ocean temperatures predicted by climate change scenarios could potentially increase the extent of occurrence, with warmer water extending southwards along both coasts.

The area of occupancy of Bryde's Whales cannot be calculated due to the paucity of confirmed records for pelagic waters off Australia, however it is likely to be greater than 2000 km² (Peddemors & Harcourt 2006, pers. comm.). Future expansion of high-seas pelagic fisheries, particularly those targeting schooling pelagic fishes, may result in increased interactions with Bryde's Whales, including incidental catches and injury, potentially depleting local waters and leading to a decrease in area of occupancy (Lewinson et al. 2004).

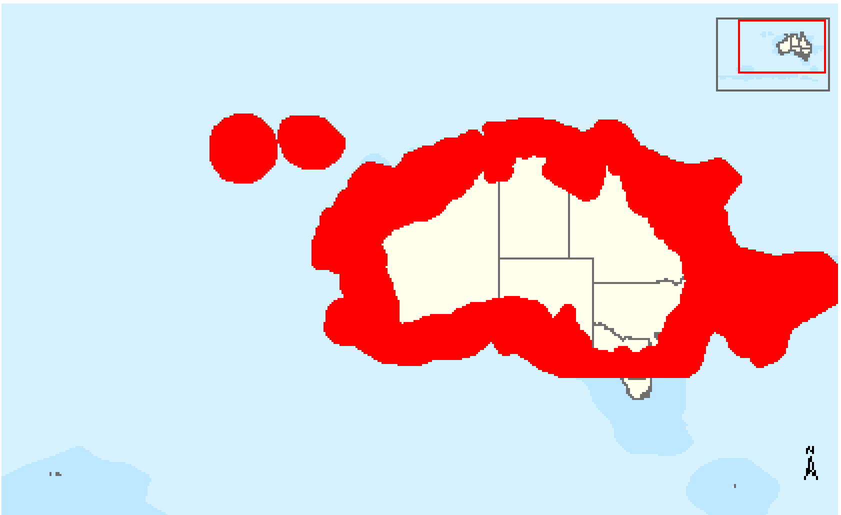

Figure E.8 Generalised distribution map of Bryde's whales[18]

[18] Department of the Environment (2016). *Balaenoptera edeni* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 19 Feb 2016

E.1.10 Pygmy right whale (*Caperea marginate)*

Records of Pygmy Right Whales in Australian waters are distributed between 32° S and 47° S, but are not uniformly spread around the coast (Kemper 2002a). The northern distribution of Pygmy Right Whales may be limited on the west and east coasts of Australia by the warm, south-flowing Leeuwin and East Australian currents (Kemper 2002a). Few or no records are available for NSW, eastern Victoria, and the northern part of the Great Australian Bight, while Western Australia has fewer records than comparative eastern Australian states (Kemper 2002a). Concentrations of stranded animals have occurred at the entrance of the gulfs in South Australia and around Tasmania, but live sightings have predominated in the former region (Kemper 2002a). The numerous strandings in Tasmania may be due to the proximity of the Subtropical Convergence, an apparently important feeding zone for Pygmy Right Whales.

Areas of coastal upwelling events appear to be an important component regulating Pygmy Right Whale distribution (Kemper 2002a), but further offshore it appears that the Subtropical Convergence may be an important area for sub adult and adult Pygmy Right Whales (Kemper 2002a; Matsuoka et al. 1996).

The current extent of occurrence for Pygmy Right Whales is estimated to be greater than 20 000 km² (based on the Australian Economic Exclusion Zone <200 nautical mile (nm), including subantarctic waters down to about 47° S) (Peddemors & Harcourt 2006, pers. comm.). Increasing ocean temperatures predicted by climate change scenarios could potentially decrease the extent of occurrence, with warmer water extending southwards along both coasts.

The area of occupancy of Pygmy Right Whales cannot be calculated due to the paucity of records for pelagic waters off Australia and the subantarctic. However, it is likely to be greater than 2000 km² (Peddemors & Harcourt 2006, pers. comm.). Future expansion of high-seas pelagic gillnet fisheries may result in increased interactions with Pygmy Right Whales, including incidental catches and injury, potentially reducing local populations and thus leading to a decrease in area of occupancy (Lewinson et al. 2004).

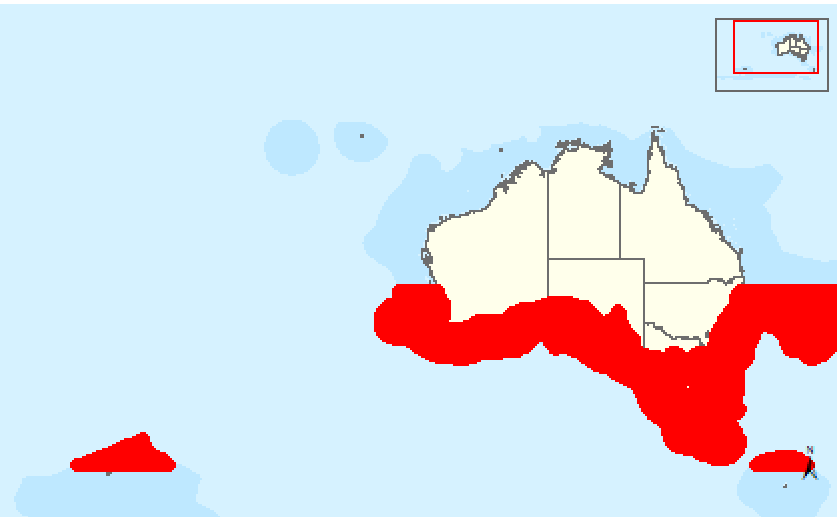

Figure E.9 Generalised distribution map of Pygmy right whales[19]

[19] Department of the Environment (2016). *Caperea marginata* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 19 Feb 2016

E.2 Toothed whale

E.2.1 Sperm whale (*Physeter macrocephalus*)

Sperm Whales have been recorded from all Australian states. The area of occupancy of Sperm Whales cannot be calculated due to the paucity of records for pelagic waters off Australia and the Australian subantarctic and Antarctic territories. Sperm Whales are currently considered to occur in one location throughout the Southern Hemisphere, however, genetic techniques indicate that inter-oceanic movements are more prevalent among male Sperm Whales than females. This is consistent with observations that female Sperm Whales have smaller geographic ranges. It is possible that Sperm Whales, in Australian waters, occur in severely fragmented populations. Although no subspecies are currently recognised, recent genetic analysis (mtDNA control region) of Australian Sperm Whales suggests that there is the potential for Australian stocks to be differentiated from those in other major ocean regions and to possess unique genetic variability.

Recent visual surveys have produced population estimates for a total of 24% of the Sperm Whale's global habitat, allowing the revised calculation of a global population of 300 000–450 000 whales (Whitehead 2002). Estimates of the pre-whaling (1712) Sperm Whale population size are about 1 267 000 individuals (Whitehead 2002). This suggests that the current population is about 32% of the pre-whaling level and is therefore considerably depleted.

There are currently no estimates of the Australian Sperm Whale population size, the proportion of the global population in Australian waters is unknown. Sperm Whales are not well surveyed within mainland Australian waters. An aerial survey conducted in the late 1960s (Bannister 1968) and another in 2009 off Albany are the only surveys undertaken to date, which provide an index of abundance. (Taken from SPRAT).

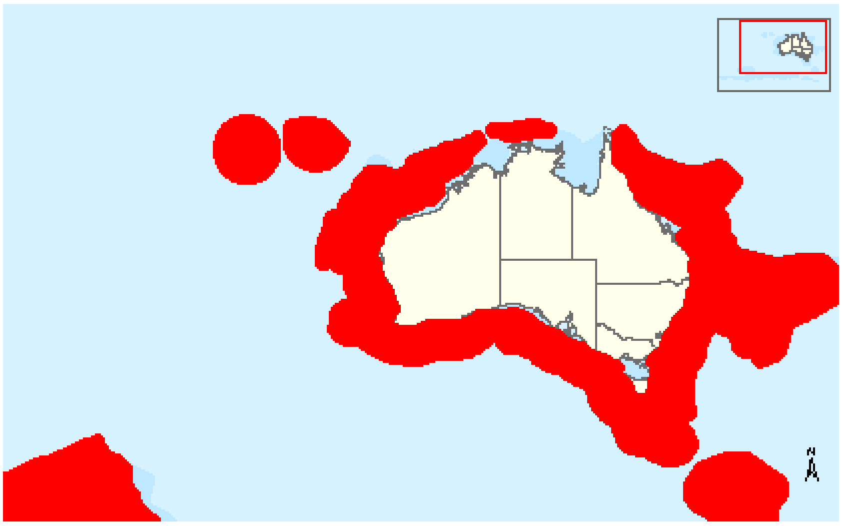

Figure E.10 Generalised distribution map of sperm whales[20]

[20] Department of the Environment (2016). *Physeter macrocephalus* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Mon, 22 Feb 2016

E.2.2 Pygmy sperm whale (*Kogia breviceps*)

Two reported sightings of Pygmy Sperm Whales have occurred in Australian waters, along with 82 strandings. Stranded animals have been reported for all states, but not the Northern Territory (DEW 2007; Ross 2006). In other regions, Pygmy Sperm Whales are reported to stay in deeper water off the continental shelf, apparently not approaching as close inshore as Dwarf Sperm Whales (Bannister et al. 1996; Ross 1984). The area of occupancy of Pygmy Sperm Whale cannot be accurately calculated due to the paucity of records for Australia.

No estimates of the global population size exist. Worldwide, the Pygmy Sperm Whale is not well surveyed. Their Australian distribution is primarily assumed from incidental sightings, plus beach-cast animals, for all areas. The size of the Australian population of Pygmy Sperm Whales is unknown. (Taken from SPRAT).

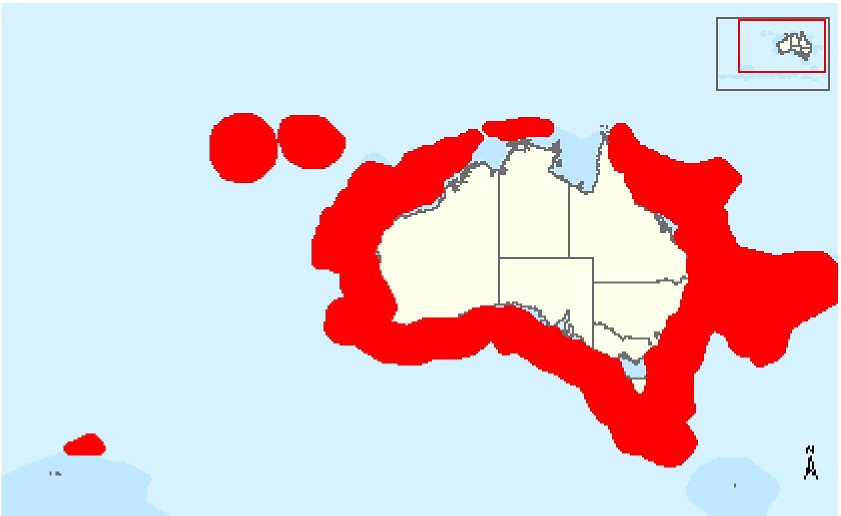

Figure E.11 Generalised distribution map of Pygmy sperm whales[21]

[21] Department of the Environment (2016). *Kogia breviceps* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Mon, 22 Feb 2016

E.2.3 Dwarf sperm whale (*Kogia sima*)

Dwarf Sperm Whales are considered oceanic, but approach coasts more than Pygmy Sperm Whales (Ross 2006). Dwarf Sperm Whales have been recorded (as stranded animals) from Western Australia, South Australia, Tasmania, NSW and the Northern Territory (Chatto & Saalfeld 2000), with only one live sighting report from South Australia (Ross 2006).

Worldwide, the Dwarf Sperm Whale is not well surveyed. Other than an estimate of 650 Dwarf Sperm Whales in the eastern Sulu Sea (Dolar 1999), there are no estimates of abundance for either *Kogia* species. Their Australian distribution is primarily assumed from beach-cast animals. However, this method is believed to result in reliable distributional information for the species. Dwarf Sperm Whales are not considered abundant in Australian waters as sightings and strandings are rare, with possibly less than 10,000 individuals. (Taken from SPRAT).

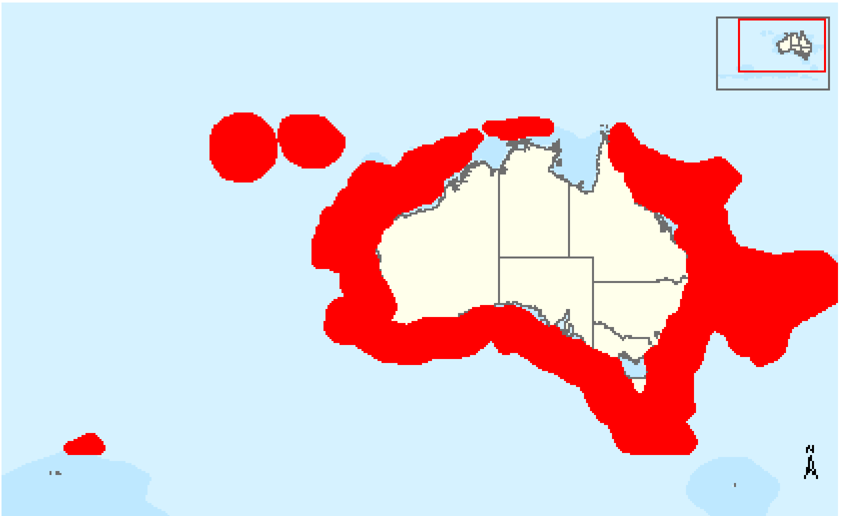

Figure E.12Generalised distribution map of Dwarf sperm whales[22]

E.2.4 Pilot whale (long & short finned) (*Globicephala melas* & *macrorhynchus*)

The Long-finned Pilot Whale occurs in two widely disjunct populations, one in the North Atlantic (*G. m. edwardi*), the other in the Southern Hemisphere. The Southern Hemisphere (*G. melas*) form is now generally recognised as a subspecies, *G. m. edwardi*. Little is known of the southern subspecies of the Long-finned Pilot Whale. This overview is based mainly on north-eastern Atlantic data, but includes some Australian observations.

The Long-finned Pilot Whale is widely recorded in waters off southern Australia, and at Macquarie and Heard Island. Eighteen sightings and 55 strandings have been recorded in Australian territories. The area of occupancy of Long-finned Pilot Whales cannot be calculated due to the paucity of records for Australia. Long-finned Pilot Whales are not well surveyed within Australian waters and no population estimates are available for Long-finned Pilot Whales in Australian waters.

[22] Department of the Environment (2016). *Kogia sima* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Mon, 22 Feb 2016

In the Australian region, Short-finned Pilot Whales occur in tropical (22–32 °C) to temperate (10–22 °C) oceanic waters, approaching coastal seas (Ross 2006). Relatively few stranding events have occurred in Australia, but have been recorded from all states and the Northern Territory (recorded until 1994). No distribution fragmentation is anticipated for the Short-finned Pilot Whale population. There are no estimates of Short-finned Pilot Whale population size, either globally or for Australia, but it is considered abundant globally. (Taken from SPRAT).

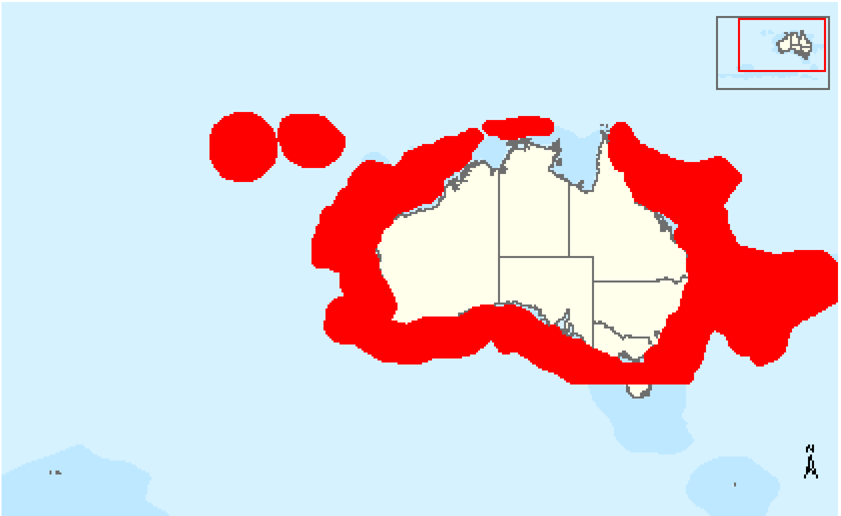

Figure E.13 Generalised distribution map of Short-finned pilot whales[23]

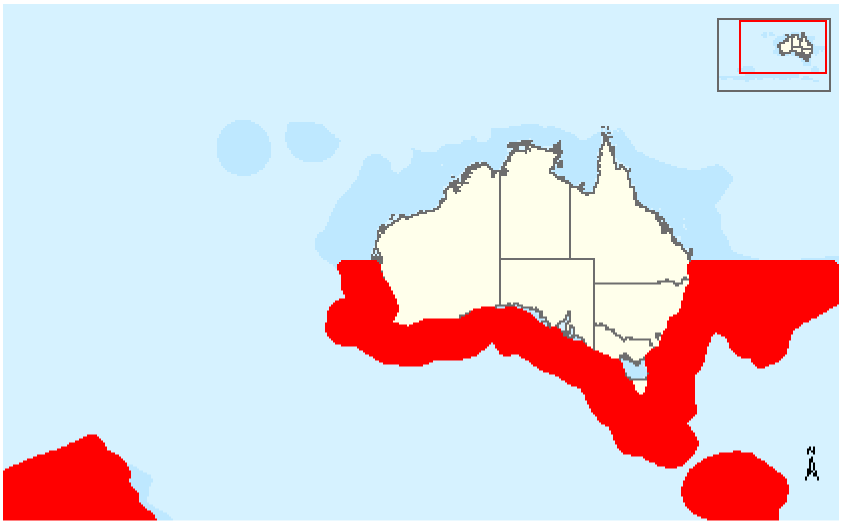

Figure E.14 Generalised distribution map of Long-finned pilot whales[24]

E.2.5 Killer whale (*Orcinus orca*)

The Killer Whale is probably the most cosmopolitan of all cetaceans and may be seen in any marine region. Killer Whales occur throughout all oceans and contiguous seas, from equatorial regions to the polar pack ice zones, and may even ascend rivers. However, they

[23] Department of the Environment (2016). *Globicephala macrorhynchus* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Mon, 22 Feb 2016

[24] Department of the Environment (2016). *Globicephala melas* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Mon, 22 Feb 2016

are most numerous in coastal waters and cooler regions where productivity is high. In Australia, Killer Whales are recorded from all states, with concentrations reported around Tasmania and sightings are also frequent in South Australia and Victoria. It is possible that Killer Whales in Australian waters occur in severely fragmented populations. It is possible that the extinction of small subpopulations could occur if population fragmentation were to occur with Killer Whales found in Australian territorial waters.

The widespread nature of Killer Whale distribution does not enable a global estimate of population size. Abundance estimates are only available on a regional basis. Consequently, there are no estimates of the total Killer Whale population size, either globally or for Australia. Lack of taxonomic resolution, plus a lack of abundance and distribution data, do not allow definitive assessment of the number of subpopulations of Killer Whales in Australian waters. No key localities are known for Killer Whales within continental Australian waters, however, all populations are considered important for the species' long-term survival. (Taken from SPRAT).

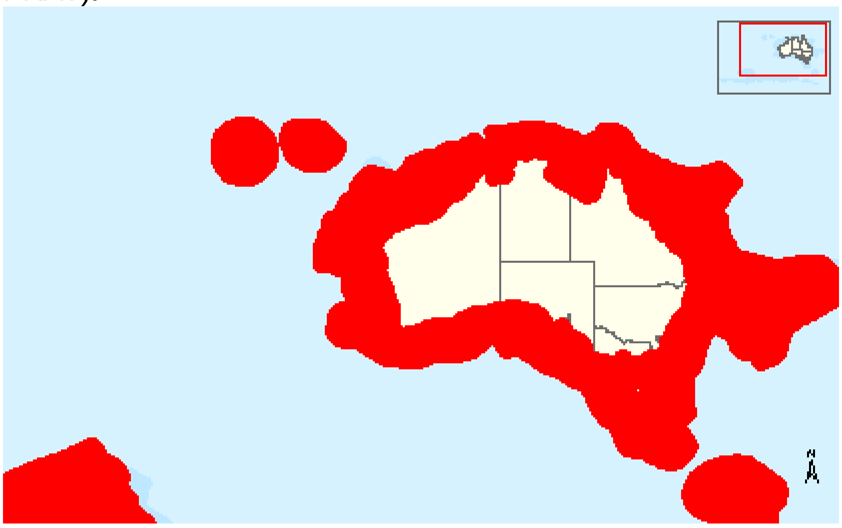

Figure E.15 Generalised distribution map of Killer whales[25]

E.2.6 False killer whale (Pseudorca crassidens)

False Killer Whales are found worldwide in deep tropical and temperate waters and while no subspecies are currently recognised, although considerable differences exist between groups from Scotland, South Africa and Australia. False Killer Whales are widely recorded in Australia through strandings in each of the coastal states. False Killer Whales are not well surveyed within Australian waters. Their distribution is primarily assumed from incidental sightings, plus beach-cast animals.

The False Killer Whale is generally poorly known and there are no estimates of False Killer Whale population size, either globally or for Australia. However, it is likely they occur in low abundance (Reeves et al. 2003) and therefore likely that the total number of mature False Killer Whales within Australian waters is less than 10 000 (V.M. Peddemors & R. Harcourt 2006, pers. comm.), considering an average group size of about 100 individuals in the recorded strandings within Australia (Ross 2006).

[25] Department of the Environment (2016). *Orcinus orca* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Mon, 22 Feb 2016

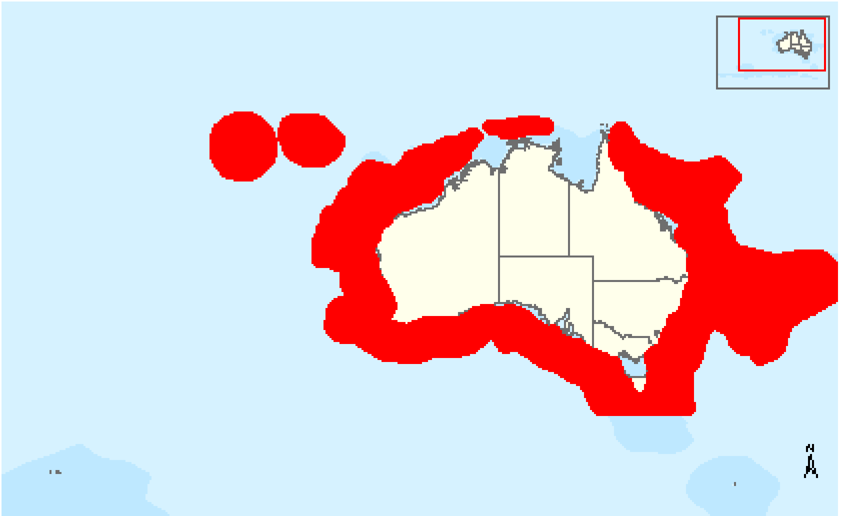

Figure E.16 Generalised distribution map of False killer whales

E.2.7 Pygmy killer whale (Feresa attenuata)

The Pygmy Killer Whale is a tropical and subtropical species that inhabits oceanic waters around the globe. The distribution of the Pygmy Killer Whale is poorly known and comes from sparse but widely distributed records worldwide. Pygmy Killer Whales are not well surveyed within Australian waters and their distribution is primarily assumed from incidental sightings. Dated records for several regions (spanning several months of the year) are, at present, too few to permit assessment of the migratory status of this species

The Pygmy Killer Whale is a poorly known species. The only abundance estimates are for the eastern tropical Pacific and it is unlikely that the Australian Pygmy Killer Whale represents a distinct population, as no subspecies are currently recognised.

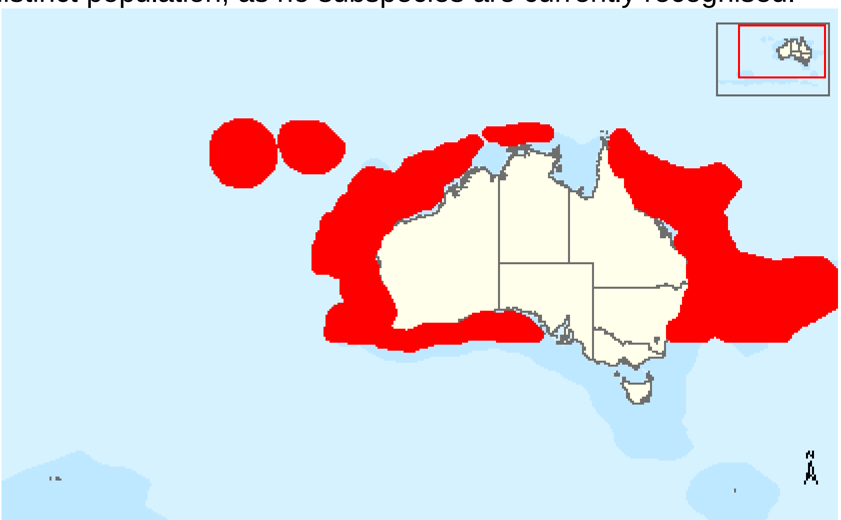

Figure E.17 Generalised distribution map of Pygmy killer whales

E.2.8 Omura's whale (*Balaenoptera omurai*)

Omura's whale or the dwarf fin whale (*Balaenoptera omurai*) is a species of rorqual about which very little is known. Omura's whale appears to be restricted to the shelf and deep waters of tropical and subtropical regions. There are only two sightings of Omura's whale that has been recorded in Australia. It currently does not occur on Australia's SPRAT website.

E.3 Dolphins

E.3.1 Australian snubfin dolphin (*Orcaella heinsohni*)

Australian Snubfin Dolphins occur only in waters off the northern half of Australia, with aerial and boat-based surveys indicating they occur mostly in protected shallow waters close to the coast, and close to river and creek mouths. The population in Australian waters is endemic to Australia and separate from populations in Asia. There appears to be 'hotspots' of higher Australian Snubfin Dolphin densities along the Queensland and Western Australian coast and preliminary data suggest that they occur in small, localized populations. However, available data is currently too limited to examine the likelihood for fragmentation.

In Australian waters, population sizes are estimated to be low, thus making population changes extremely difficult to detect within the space of a few years unless changes are severe (e.g. >20% p.a) and no global population size is known. This species is not well surveyed across its range and only recently have systematic surveys been undertaken in Western Australia, Northern Territory and Northern Queensland. Based on the low numbers of Australian Snubfin Dolphins sighted during aerial and boat based surveys of the east coast of Queensland the population at a national level is likely to be in the thousands rather than tens of thousands. (Taken from SPRAT)

E.3.3 Australian humpback dolphin (was Indo-Pacific humpbacked dolphin) (*Sousa sahulensis*)

Knowledge of population sizes and trends across the species range is lacking. Recent genetic studies indicate Australian humpback dolphins live in small and relatively isolated populations with limited gene flow among them. The available abundance estimates range from 14 to 207 individuals and no population studied to date is estimated to contain more than 104 mature individuals. The Potential Biological Removal method indicates populations are vulnerable to even low rates of anthropogenic mortality. (Taken from Parra & Cagnazzi, 2015).

The total population size of the Indo-Pacific Humpback Dolphin in Australian waters is unknown. Populations at various locations along the Queensland coast have been surveyed, and some regional population estimates made. Regional population levels (e.g. Queensland) are likely to be in the order of thousands rather than tens of thousands. (Taken from SPRAT).

E.3.4 Common Bottlenose dolphin (*Tursiops truncatus*)

Common Bottlenose Dolphins are distributed worldwide through tropical and temperate inshore, coastal, shelf, and oceanic waters. In the Australian region, they are usually found offshore in waters deeper than 30 m but also appear be found in some coastal water. The distribution of Bottlenose Dolphins in Australia is not well known due to its offshore occurrence and the current taxonomic uncertainties regarding the status of several coastal populations. In eastern Australia some populations have been confirmed as belonging to the Indo-Pacific species, *T. aduncus*. The species total population size is not known but it is likely to be common in offshore waters. (Taken from SPRAT).

E.3.5 Indo-Pacific Bottlenose dolphin (*Tursiops aduncus*)

Bottlenose dolphins are distributed continuously around the Australian mainland, but the taxonomic status of many populations is unknown. Indo Pacific Bottlenose Dolphins have been confirmed to occur in estuarine and coastal waters and common within inshore and nearshore waters of eastern, western, southern and northern Australia. The species distribution does not appear to be severely fragmented and the total population size is not known.

E.3.6 Risso's dolphin (*Grampus griseus*)

Risso's Dolphin inhabits tropical, subtropical, temperate and subantarctic waters and has been sighted both inshore and well offshore, although is generally considered pelagic and oceanic. Risso's Dolphin are abundant in tropical and temperate latitudes throughout the world's oceans. It is likely that Risso's Dolphins move between Australia and other countries due to the lack of any deep water barriers. In Australia, Risso's Dolphins have been recorded from all states except Tasmania and the Northern Territory.

There are no estimates of population size, either globally or for Australia, although they are believed to be common throughout their range. In Australia, depths from the limited sighting data range from 180 m to 1500 m. Approximately 175 000 individuals occur in the Eastern Tropical Pacific, with similarly high densities in all areas where surveys have been conducted. The species is therefore potentially abundant in Australian waters. (Taken from SPRAT).

E.3.7 Short beaked common dolphin (*Delphinus delphis*)

Globally, *Delphinus* dolphins are found in tropical, subtropical and temperate waters of the Atlantic, Pacific and Indian Oceans (Rice 1998) occurring in both shallow and deep offshore waters (Evans 1994). However, there some uncertainty regarding the distribution of each of the three recognised species as in many cases records were not identified to the species level. Common Dolphins have been recorded in waters off all Australian states and territories, but are rarely seen in northern Australian. Common Dolphins appear to occur in two main locations around Australia, with one cluster in the southern south-eastern Indian Ocean and another in the Tasman Sea. Neither the extent of occurrence nor the area of occupancy of the Common Dolphin have been estimated. Due to its offshore distribution, it is unlikely that Common Dolphin populations are severely fragmented in Australia. Common Dolphins have not been well surveyed in Australia, and specific range and population sizes are currently unknown. (Taken from SPRAT) E.4 Dugong (*Dugong dugon*)

The dugong has a very large and fragmented Indo-West Pacific range that extends between about 26-27° north and south of the equator and their range includes the coastal waters of between 38-44 nations and territories. Dugongs occur in coastal and island waters from Shark Bay in Western Australia (25° S) across the northern coastline to Moreton Bay in Queensland (27° S). Over most of its range in Australia, the dugong is known only from incidental sightings, except for systematic aerial surveys that have been undertaken in Western Australia and northeast Australia. Aerial surveys of northeast Australia have been conducted in seven survey regions (Moreton Bay, Hervey Bay, northern and southern Great Barrier Reef, Torres Strait, and the Queensland and Northern Territory Gulf of Carpentaria) approximately every five years from 1985–2013.

The distribution and relative abundance of dugongs in nine survey regions across their range, covering most of their range except the Northern Territory. A systematic aerial survey in the Northern Territory has recently been undertaken in 2015. These surveys indicate that the dugong is the most abundant marine mammal in the coastal waters of northern Australia.

E.5 Turtles

E.5.1 Green turtle (*Chelonia mydas)*

Nesting Beaches

Green Turtles nest on mainland and island beaches in tropical northern Australia from Mon Repos, Qld, to Shark Bay, WA (Prince 1994; Limpus 2008). Nine distinct populations that nest in Australian jurisdictions have been recognised at present based on genetic studies (Norman et al. 1994; FitzSimmons et al. 1997b; Dethmers et al. 2006; Jensen 2010; FitzSimmons & Limpus 2014a). These are the genetic stocks of Cocos (Keeling) Island, North West Shelf, Scott Reef-Browse Island, Ashmore Reef, Cobourg Peninsula, Gulf of Carpentaria/north-east Arnhem Land, northern Great Barrier Reef (nGBR), southern Great Barrier Reef (sGBR) and Coral Sea Platform.

Inter-nesting habitat, where females live between laying successive clutches within a season, is typically located within 10 km of the nesting beach (Pendoley 2005) but may be up to 50 km away from the beach (Waayers et al. 2011). The main nesting beaches used by green turtles in different jurisdictions and representing different genetic stocks include:

- Commonwealth
    - Ashmore Reef and Cartier Island (Whiting et al. 2000; Guinea 2013)
        - West Island
        - Cocos (Keeling) Island (Whiting 2004; 2006; 2010; Whiting, S. et al. 2008)
            - North Keeling Island
        - Coral Sea
            - Sand cays of Coringa-Herald National Nature Reserve (Harvey et al. 2005)
- Queensland
    - sGBR genetic stock (Limpus et al. 2013)
        - Largest rookeries: Northwest Is., Wreck Is, Hoskyn Is,
        - Major rookeries: Tryon Is., Heron Is., Lady Musgrave Is., Masthead Is., Erskin Is., Fairfax Is., North Reef Is., Wilson Is.
        - Minor rookeries: Bushy Is., the Percy Islands. Bell Cay, Lady Elliott Is., mainland coast from Bustard Head to Bundaberg, northern Fraser Is.
    - nGBR genetic stock (Limpus 2008)
        - Largest rookery: Raine Island; and major nesting in vicinity at Moutler Cay (Limpus et al.2003)
        - Minor rookeries: Murray Is., Bramble Cay, No. 7 & No. 8 Sandbanks, various islands on outer barrier of nGBR, inner shelf sand cays and mainland coast from Cape Grenville to Strait (Limpus et al. 1983; 1989; Miller & Limpus 1991; Loop et al. 1995; Miller et al. 1995)
    - Gulf of Carpentaria/north-east Arnhem Land stock
        - Wellsley Islands- particularly Bountiful, Pisonia and Rocky Island (Bustard 1972; Limpus & Preece 1992)
- Northern Territory (Guinea 1994; Chatto & Baker 2008)
    - Gulf of Carpentaria/north-east Arnhem Land stock
        - Most significant rookeries: Larger islands of Groote Eylandt, North and Vanderlin Islands of the Sir Edward Pellew Islands, mainland beaches south of Cape Arnhem to Blue Mud Bay
        - Other significant areas: Drysdale Is.*, Bridgland Is., Dudley Is., Isle Woodah, Wedge Rock*, Hawknest Is.*, North East Isle, Sandy Is.*, Watson Is., Pearce Is. (* = probable)
    - Coburg Peninsula stock (Limpus & Preece 1992; Hope & Smit 1998).
        - Black Smith Point and Lawson Island

- Western Australia
    - North West Shelf stock (Prince 1994; Burbidge et al. 2000; Limpus 2008; Goddard et al. 2013; Pendoley & Bell 2013; Hattingh et al. 2014)
        - Major rookeries: Lacepedes Islands, Montebello Islands, Barrow Island, North West Cape and Murion Islands, Browse Island
        - Other rookeries: Boodie Is., Middle Is., Serrurier, Thevenard Is., scattered mainland beaches Shark Bay to Ningaloo, Lowendal Islands, Rosemary Is., Legendre Is., Delambre Is., various locations on the Kimberley Coast and islands
    - Scott Reef/Browse Island stock
        - Sandy Island, Browse Island

<u>Foraging Grounds</u>
Green Turtles primarily forage in shallow tropical and subtropical waters as well as foraging in warm temperate waters over coral and rocky reefs and seagrass beds. Turtles from a particular rookery are generally distributed among several different foraging grounds and conversely, turtles at a particular feeding ground typically come from different rookeries or genetic stocks (Limpus et al. 1992; 2003; 2005; 2009; Limpus 2008; Jensen et al. 2010). Exceptions to this appear to be the Gulf of Carpentaria genetic stock that breeds and uses foraging grounds within the Gulf (Kennett et al. 1998; 2004) and the Cocos (Keeling) stock that remains within the Cocos (Keeling) islands atolls (Whiting, S. et al. 2008). Some Green Turtles migrate more than 3000 km between breeding and feeding grounds, though most migrate <1000 km (Limpus et al. 2008; 2013) and some travel <10 km between sites (Limpus et al. 1992)

Foraging ground locations for sGBR Green Turtles are well known and include waters from northern New South Wales, north throughout the GBR and in coastal waters to Torres Strait, the Gulf of Papua, Gulf of Carpentaria, eastern Arafura Sea, and east into the Coral Sea, New Caledonia and Fiji. Most foraging for this population occurs in waters south of Princess Charlotte Bay to northern New South Wales and in New Caledonia (Limpus et al. 2013; Read et al. 2014). Tag recoveries of nGBR Green Turtles show they use foraging grounds in the nGBR, sGBR, Moreton Bay, Gulf of Carpentaria, Northern Territory to Melville Island, Indonesia (Aru, Ambon, Kei, Papua), Papua New Guinea, Vanuatu and New Caledonia (Miller & Limpus 1991; Limpus et al. 1992; 1994b; 2001; 2003).

In Western Australia resident Green Turtles have been observed as far south as Rottnest Island, the Houtman Abrolhos Islands off Geraldton, the mouth of the Murchison River at Kalbarri and reefs south of Shark Bay (Prince 1994). Tag recoveries (Prince 1994; 1998) and satellite tracking (Pendoley 2005) of nesting turtles in the North West Shelf stock indicate the use of foraging grounds south to Shark Bay and north to the Kimberley coast, Arnhem Land, the Gulf of Carpentaria and Indonesia.

<u>Area of occurrence/ Area of Occupancy</u>
There are not enough data to separate the area of occurrence from area of occupancy. The area of occurrence for Green Turtles during the nesting period includes nesting beaches from Mon Repos Qld to Shark Bay, WA and up to 50 km offshore to encompass internesting habitat (Pendoley 2005; Waayers et al. 2011). It is not possible to determine the area of occurrence for foraging grounds for all genetic stocks until additional satellite tracking data, or tag recovery data are available. There are no data to indicate that there has been a decline in the extent of occurrence over the past three generations (e.g., Limpus 2008), nor are there sufficient empirical data to indicate future changes in the area of occupancy. However, changes to air and sea temperatures, sea level rise and other physical aspects that may change with global warming have the potential to alter the species occurrence (Hamann et al. 2007).

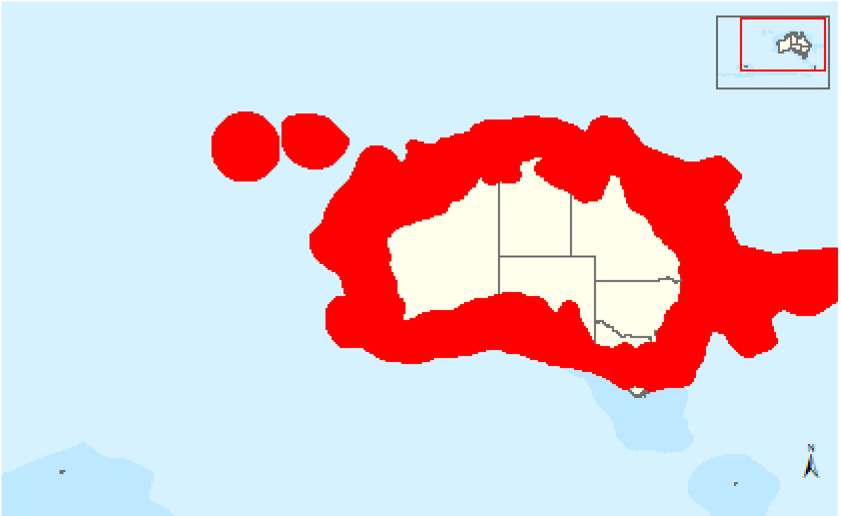

Figure E.18 Generalised distribution map of Green turtles[26]

E.5.2 Loggerhead turtle (*Caretta caretta)*

In Australia, the Loggerhead Turtle occurs in the waters of coral and rocky reefs, seagrass beds and muddy bays throughout eastern, northern and western Australia (Limpus 1995; Limpus et al. 1992; Prince 1994, Prince et al. 2012). Two genetically distinct populations nest in Australia and these are referred to as genetic stocks because they function independently and there is very limited (or no) breeding between the populations (FitzSimmons and Limpus 2014). The southwest Pacific (swPac) stock includes nesting Loggerhead Turtles in Queensland, New South Wales and New Caledonia, and the Western Australia (or southeast Indian Ocean) stock nests in Western Australia (Boyle et al. 2009; Pacioni et al. 2013; FitzSimmons and Limpus 2014). Nesting in Australia is concentrated at several beaches in southern Queensland and along the central coast of Western Australia. Foraging areas used by the populations are more widely distributed and include International waters (Limpus 2008).

<u>Nesting distribution</u>
Queensland: Limpus (2008) identifies three major nesting areas in Queensland at: (1) mainland beaches near Bundaberg at Mon Repos, the adjacent beaches of the Woongarra Coast and north to Wreck Rock Beach; (2) the Capricorn-Bunker Islands of the southern Great Barrier Reef, especially at Wreck, Tryon and Erskine islands, and (3) the islands of the Swain Reefs, especially Price, Frigate, Bylund, Thomas and Bacchi Cays and at Bushy Island off Mackay, where smaller numbers of turtles nest. Nesting at Mon Repos, Wreck Rock, Wreck, Tryon and Erskine islands accounts for 70% of the eastern Australia nesting effort (Limpus and Limpus 2003; Dobbs 2007). Low density nesting also occurs along the Sunshine Coast beaches and the northern ends of Fraser, Moreton and North Stradbroke Islands and southwards into northern NSW (Limpus 2008).
Western Australia: Most nesting occurs from the southern end of Shark Bay World Heritage Area (including on the mainland near Steep Point), north to the Ningaloo and Gnaraloo coastline, North West Cape and the Murion Islands. Major nesting beaches are at Dirk Hartog Island, South Murion Island, North West Cape and Gnaraloo Bay (Baldwin et al. 2003; Hattingh et al. 2014; Markovina & Prophet 2014; Riskas 2014). In addition, a single

[26] Department of the Environment (2016). *Chelonia mydas* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 19 Feb 2016

Loggerhead Turtle has been reported nesting at Ashmore Reef (Guinea 1995, 2013). Occasional late summer nesting crawls have also been recorded as far north as Barrow Island, the Lowendal Islands and Dampier Archipelago (WA DEC 2009).

Foraging Distribution

Females tagged at the southeast Queensland nesting areas have been recorded in waters off Indonesia, Papua New Guinea, the Solomon Islands, New Caledonia, Northern Territory, Queensland and New South Wales (Limpus and Limpus 2001; Limpus 2008). Loggerhead Turtles tagged at rookeries in Western Australian have been encountered foraging from Shark Bay, WA through to Arnhem Land, Gove Peninsula, NT and into the Java Sea of Indonesia (Baldwin et al. 2003; Limpus 2008). The WA and swPac stocks share feeding grounds off northeast Arnhem Land (Limpus & Limpus 2003; Limpus 2008). Genetic data have confirmed that post-hatchling Loggerhead Turtles born on beaches in eastern Australia travel south in the East Australian Current and then follow anticlockwise oceanic currents across the south Pacific to feed in rich upwelling waters off Peru, before returning with the South Equatorial Current (Boyle et al. 2009).

Area of occurrence

Habitat use for nesting and internesting activity within Australian waters is approx. 151,000 km² based on data in Limpus (2008) and using Goggle Earth and GE-Path 1.4.6 (http://www.sgrillo.net/googleearth/gepath.htm). The inclusion of foraging and migratory habitat, based on nesting locations and tag recovery data (Limpus et al. 2008) and data indicating that post-hatchling turtles traverse the South Pacific to waters off Chile and Peru (Boyle et al. 2009) increases the area of occurrence to over 30 million km². Future knowledge of where pelagic post-hatchling and juvenile Loggerhead Turtles forage in the Indian Ocean would increase the estimated area of occurrence. There are no data to indicate that there has been a decline in extent of occurrence over the past three generations (Limpus & Limpus 2003; Limpus 2008). There are no empirical data to indicate future changes in the extent of occurrence. However, changes to air and sea temperatures, sea level rise and other physical aspects that may change with climate change have the potential to alter the species future occurrence (Hamann et al. 2007).

Area of occupancy

There are not enough data to separate occurrence from occupancy. There are no data reported (i.e., Limpus 2008) to indicate that there has been a decline in the area of occupancy over the past three generations. There are no empirical data to indicate future changes in the extent of occupancy. However, changes to air and sea temperatures, sea level rise and other physical aspects that may change with climate change have the potential to alter the species future occurrence (Hamann et al. 2007). Southerly beaches that are currently used by low numbers of nesting Loggerhead Turtles are considered as potential sites that may see increased nesting activity due to increased temperatures from climate change, particularly the Sunshine Coast (Hamann et al. 2007), and islands offshore of Moreton Bay (Moreton and North and South Stradbroke). In Western Australia the most southerly beaches with Loggerhead Turtle nesting activity are in the southern end of Shark Bay World Heritage Area (Baldwin et al. 2003).

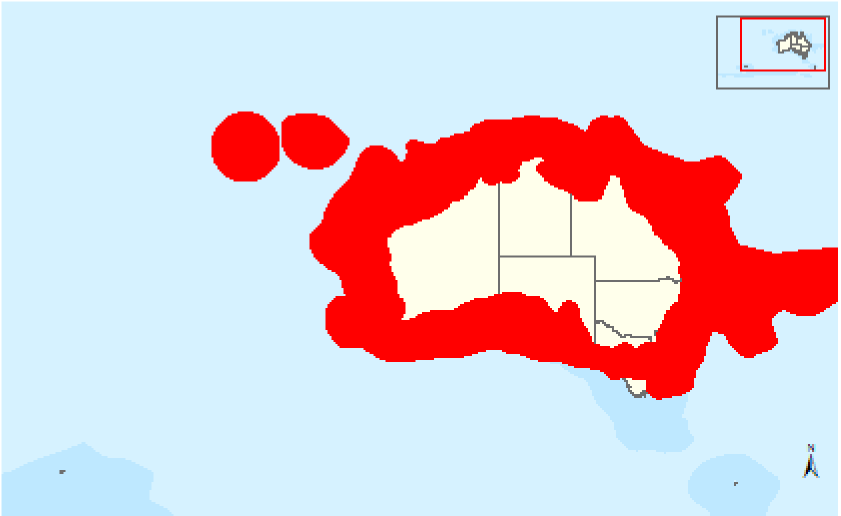

Figure E.19 Generalised distribution map of Loggerhead turtles[27]

E.5.3 Leatherback turtle (*Dermochelys coriacea)*

Nesting Beaches

Australia supports a small and declining number of nesting turtles and it is unknown whether they represent a unique genetic stock (or stocks) (Limpus 2009; FitzSimmons & Limpus 2014). Australian waters along the east coast and in Bass Strait support foraging turtles of the threatened western Pacific genetic stock that nests in north-west Papua, northern Papua New Guinea, the Solomon Islands and Vanuatu (Benson et al. 2011). Leatherback Turtles foraging off of Western Australia may come from a population that nests in the Andaman Sea and there has been one tag recovery of a turtle that nested in Java (R. Prince pers. comm, reported in Limpus 2009).

Scattered isolated nesting (one to three nests per annum) used to occur in southern Queensland at Wreck Rock, Moore Park and Mon Repos beaches (Limpus & MacLachlan 1979, 1994; Limpus et al. 1984). In northern NSW three, or possibly four, Leatherback Turtle clutches were laid on beaches near Ballina, NSW (Tarvey 1993). One clutch was laid in Bootie National Park, south of Forster, NSW (Limpus 2009). However, no nesting has occurred in Queensland or NSW since 1996 (Hamann et al. 2006, Limpus 2009, Limpus et al. 2013). Nesting in Western Australia is unknown, but there have been two unconfirmed reports (Prince 1994, R. Prince pers. comm., reported in Limpus 2009). Nesting sites in the Northern Territory were found at Cobourg Peninsula, Manangrida and Croker Island in earlier surveys (Chatto 1998) though the only confirmed nesting of Leatherbacks during Chatto and Baker's (2008) survey between 1991 and 2004 was at Danger Point, Cobourg Peninsula. Infrequent nesting continues to occur in the Northern Territory on Coburg Peninsula.

Foraging Grounds

The Leatherback Turtle is a pelagic feeder, found in tropical, subtropical and temperate waters throughout the world (Marquez 1990). Large body size, high metabolism, a thick adipose tissue layer and regulation of blood flow (Spotila et al.1997) allow them to utilise cold water foraging areas unlike other sea turtle species. For this reason this species is regularly found foraging in the high latitudes of all oceans including the South Pacific Ocean, Tasman Sea and Southern Ocean (Benson et al. 2011; Limpus & MacLachlan 1979; 1994). It has been recorded feeding in the coastal waters of all Australian States (Limpus & MacLachlan

[27] Department of the Environment (2016). *Caretta caretta* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 19 Feb 2016

1979; 1994; Hamann et al. 2006; Limpus 2009). The species is most commonly reported from coastal waters in central eastern Australia (from the Sunshine Coast in southern Queensland to northern NSW); south-east Australia (from Tasmania, Victoria and eastern South Australia) and in south-western Western Australia (Green 1971; Limpus & MacLachlan 1979; Bone 1998; Hamann et al. 2006; Limpus 2009). Satellite tracking of post-nesting females from north eastern Papua (Birds Head Peninsula) revealed migratory pathways that travel south and meet the east Australian coast off southern Queensland or along the NSW coastline to reach primary foraging areas off New South Wales and on the eastern edge of Bass Strait (Benson et al. 2011).

<u>Area of occurrence/ Area of Occupancy</u>
There are not enough data to separate the area of occurrence from area of occupancy, If considering only the known successful nesting beaches and surrounding internesting habitat, then the areas of occurrence and occupancy in the 1980s included approximately 1000 km of coastline in Queensland and New South Wales and approximately 340 km of coastline in the Northern Territory (based on Chatto 1998 and Limpus 2009) as well as inter-nesting habitat that may range from 50-300 km distant from the nesting beach (Benson et al. 2007a; 2011; Georges et al. 2007). Given the lack of observed nesting in eastern Australia since 1996 (Limpus et al. 2013) and results of more recent surveys in the Northern Territory (Chatto & Baker 2008) the areas of occurrence and occupancy have shrunk dramatically to only include the Danger Point area of the Coburg Peninsula, Northern Territory.
If including foraging grounds, based on observations (Limpus 2009) and satellite tagging data (Benson et al. 2001) the area of occurrence and occupancy would include all coastal waters of Australia. Focal areas of observation (Limpus 2009, Benson et al. 2011) suggest that the area of occupancy is probably substantially less than the area of occurrence. Given the low numbers of Leatherback Turtles nesting in Australia, most Leatherback Turtles that forage in Australian waters are expected to come from populations that nest outside of Australia. International areas of occurrence and occupancy for turtles foraging along the east coast of Australia include nesting beaches in Papua, the Solomon Islands and Vanuatu, and foraging or migratory waters in the western South Pacific Ocean, Coral Sea, Tasman Sea, off Papua, Papua New Guinea, the Solomon Islands, Vanuatu, New Caledonia and northern New Zealand (Benson et al. 2011). If the decline of the western Pacific population of Leatherbacks Turtles is not reversed (Spotilla et al. 2000), then the numbers of leatherback turtles using foraging grounds in eastern Australia will continue to decline (see below). Leatherback Turtles that forage off of Western Australia may have areas of occurrence and occupancy that include beaches in the Andaman and Nicobar Islands and southern Indonesia and foraging areas in the north and eastern Indian Ocean.

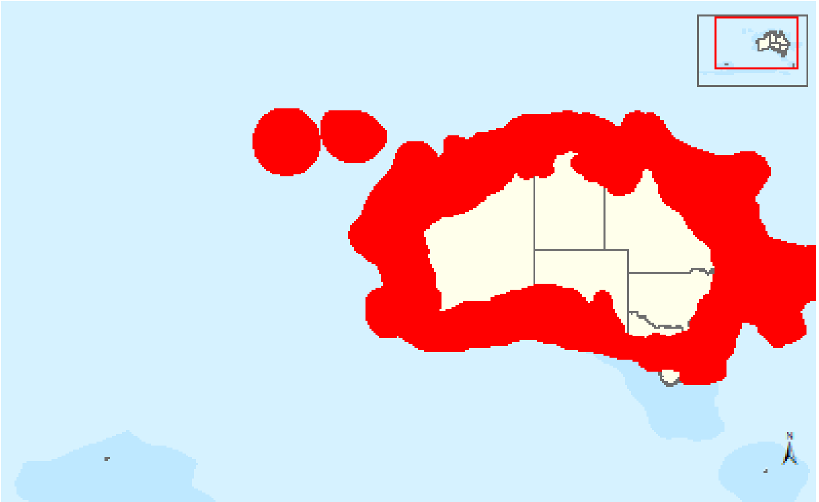

Figure E.20 Generalised distribution map of Leatherback turtles[28]

E.5.4 Hawksbill turtle (*Eretmochelus imbricate)*

<u>Nesting Beaches</u>
Major nesting of Hawksbill Turtles in Australia occurs at Rosemary Island and Varanus Island in Western Australia (Pendoley 2005), in the northern Great Barrier Reef and Torres Strait (Dobbs et al. 1999; Limpus et al. 1989) in Queensland and in the Groote Eylandt area in the Northern Territory (Limpus 2009). Important nesting beaches with more than 100 nesting females per year include: Aukane, Bet, Bourke, Dadalai, Dayman, Hawkesbury, Layoak, Long (Sassie), Mimi, Mt Adolphus, Saddle and Zuizin islands in Torres Strait; Milman and Boydong islands in the northern Great Barrier Reef; and Rosemary Island in Western Australia (Limpus 2009). Milman Island is an index beach for monitoring the Hawskbill Turtle nQld genetic stock (Limpus 2009).

Genetic studies of Hawksbill Turtle rookeries in the Indo-Pacific (Broderick et al. 1994; FitzSimmons 2010) indicate that the Western Australia rookeries form a distinct genetic stock, referred to as the Western Australia (Commonwealth of Australia 2014a) or eastern Indian Ocean (FitzSimmons & Limpus 2014) stock. These studies were unable to distinguish the population of turtles nesting in northeast Arnhem Land, NT from those nesting in Torres Strait and the northern Great Barrier Reef. However, these two populations mostly breed at different times of the year, with a winter-spring peak nesting period in the NT (Limpus et al 2008b) and a summer peak of nesting in Qld (Dobbs et al 1999). Although interbreeding between these populations is expected to be low (Limpus 2009), further genetic and mark-recapture studies are needed to confirm this. Based on the variation in breeding times, these are presently considered as distinct genetic stocks (Limpus 2009), and referred to as the northeast Arnhem Land (neArn) and north Queensland (nQLD) stocks (Commonwealth of Australia 2014a; FitzSimmons & Limpus 2014).

<u>Foraging Grounds</u>
Hawksbill Turtles are highly migratory and populations use a wide diversity of foraging grounds in Australia and neighbouring countries. Little is known about the post-hatchling pelagic phase, but limited data suggest that turtles with a curved carapace length (CCL) of <30 cm forage in oceanic waters of the Coral Sea (Limpus et al. 2013). Benthic feeding juveniles, subadult and adult Hawksbill Turtles forage in tidal and subtidal coral and rocky

[28] Department of the Environment (2016). *Dermochelys coriacea* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 19 Feb 2016

reef habitats, where they feed on algae, sponges and soft corals (Bell 2013). They forage in diverse habitats from clear water coral reefs to nearshore, turbid rocky reefs and occasionally forage in seagrass beds and in subtidal, soft-bottomed habitats (Limpus et al. 2013).

Tagging data have shown that the nQld genetic stock uses foraging grounds in north Queensland, the Gulf of Carpentaria, the south cost of Papua and Papua New Guinea and the Solomon Islands (Limpus 2009). Hawksbills are observed from the Solitary Islands in northern New South Wales (30°S) to Torres Strait (9°S) (Limpus et al. 2013). In north Queensland the foraging grounds have a high proportion of adult turtles whereas in the southern foraging grounds there is a low proportion of adult turtles. This suggests that there may be developmental habitats and that turtles migrate to different feeding grounds as they grow older (Limpus 2009).

In Western Australia, satellite tagging of nine Hawksbill Turtles nesting at Varanus and Rosemary islands indicate the use of foraging grounds that are 50 – 450 km distant from their rookery, either to the north and east or south along the coast (Pendoley 2005). Reefs west of Cape Preston and south to Onslow were identified as particularly important feeding grounds used by Hawksbill Turtles (Pendoley 2005). Stranded turtles are observed in Perth (Prince & Crane 1996), but foraging grounds are mostly further north from around Exmouth Gulf northwards (Limpus 2009).

Foraging Hawksbill Turtles have been studied in Fog Bay, Northern Territory, where 95% of the foraging population is immature, which may also suggest the use of developmental habitats (Whiting & Guinea 1998; Guinea & Whiting 2000; Whiting 2000). Foraging grounds in Australia are also used by Hawskbill Turtles that nest in Papua New Guinea, the Solomon Islands and Vanuatu (Parmenter 1983; Limpus 2009).

Area of occurrence/ Area of Occupancy
There are not enough data to separate the area of occurrence from area of occupancy. The area of occurrence for Hawksbill Turtles during the nesting period should include nesting beaches on the islands of Princess Charlotte Bay Qld to Gnaraloo Bay (north of Carnarvon), and up to 10 km offshore to encompass internesting habitat (Starbird 1993). It is not possible to determine the area of occurrence for foraging grounds until additional satellite tracking data, or tag recovery data are available.

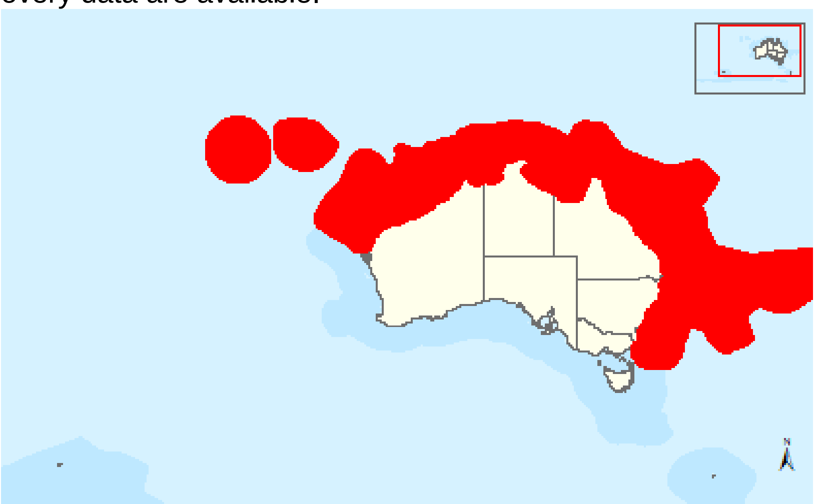

Figure E.21 Generalised distribution map of Hawksbill turtles[29]

[29] Department of the Environment (2016). *Eretmochelys imbricata* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 19 Feb 2016

E.5.5 Olive Ridley turtle (*Lepidochelys olivacea)*

Nesting Beaches

Nesting by Olive Ridley Turtles in Australia, occurs at low densities in the Northern Territory, the Western Cape York Peninsula and rarely along the Kimberley coast of Western Australia. Nesting densities of ~100 females per year has been observed in northeastern Arnhem Land at the Wessel and English Company Islands and Crocodile Islands and in northwestern Arnhem Land at Grant Island, the McCluer Island Group, Tiwi Islands (Melville and Bathurst) and on the Cobourg Peninsula (Cogger & Lindner 1969; Guinea 1990, 1994; Limpus & Preece 1992; Chatto 1998; Chatto & Baker 2008; Limpus 2008; Limpus et al. 2008). Small numbers of Olive Ridleys nest on islands in Fog Bay (Whiting 1997) and at Wadeye, Northern Territory (Chatto & Baker 2008). Chatto and Baker's (2008) long term study of nesting turtles in the Northern Territory (Chatto & Baker 2008) found that Olive Ridley Turtles were the second most widespread nesting species (after Flatback Turtles) in the Northern Territory. Areas that Chatto and Baker (2008) classify as "significant areas of Olive Ridley nesting" include Bathurst Island (northwest), Melville Island, Grant Island, Lawson Island (inferred), Oxley Island (inferred), New Year Island (inferred), Mooroongga Island, North-west Crocodile Island, Drysdale Island (inferred), Burgunngura Island (inferred), Stevens Island (inferred) and Raragala Island (inferred).

Scattered nesting occurs in the Gulf of Carpentaria (Hamann et al. 2006) with low density nesting in north-western Cape York Peninsula, Queensland, between Weipa and Bamaga (Limpus 2008). Nesting has not been recorded along the eastern Australian coast (Limpus 2008). In Western Australia, four documented records of Olive Ridley nesting in 2008 and 2009 occurred along the Kimberley coast and in the Bonaparte Archipelago (NAILSMA 2008; Prince et al. 2010). Low density nesting occurs in neighbouring countries including Papua New Guinea (Spring 1982) and Indonesia (Limpus 1997; Limpus 2008).

Genetic studies of Olive Ridley turtles indicate that turtles nesting in the Tiwi Islands, and McClure Island Group NT are part of the same population, but different from the turtle population nesting on beaches of western Cape York (Jensen et al. 2013). These genetic stocks are referred to as the western Northern Territory (wNT) and western Cape York stocks (wCY) (FitzSimmons and Limpus 2014). They are unique from Olive Ridley populations in Sri Lanka, but further studies are needed in Southeast Asia to determine the extent to which the Australian populations are unique (Jensen et al. 2013). Previously large populations in Peninsular Malaysia and Thailand were severely reduced through long-term overharvest of eggs leaving the combined breeding populations in Australia as probably the largest remaining concentration of Olive Ridley nesting in south-east Asia (Limpus 2008).

Foraging Grounds

Immature and adult Olive Ridley Turtles are known to forage over soft-bottomed substrates from southern Queensland to Torres Strait (inside of the Great Barrier Reef), in the Gulf of Papua, Gulf of Carpentaria, Arafura Sea and south to at least Exmouth Gulf in Western Australia (Limpus 1975; Harris 1994; Poiner & Harris 1996; Robbins & Mayer 1998; Robbins et al. 2002; Limpus 2008). Foraging habitat can range from depths of several metres (Conway 1994) to 200 m (Whiting et al. 2005; 2007b; McMahon et al. 2007). However, most individuals captured by trawlers in the East Coast Otter Trawl fishery in Queensland were in depths of between 11–40 m (Robins 2002). Trawling data from the east coast of Queensland indicate that this benthic foraging habitat supports turtles between 20 and 80 cm curved carapace length (Robins 1995). Apart from one exception, Olive Ridley Turtles have not been recorded in coral reef habitat or shallow inshore seagrass flats (Limpus 2008). Satellite tracking of post-nesting adult females indicates their use of coastal, continental shelf and continental slope habitats of distances >1000 km from their nesting beach (McMahon et al.

2007; Whiting et al. 2007b). These studies also indicated that turtles nesting in Australia used foraging grounds in Indonesia, but further research is needed to better establish the locations of foraging habitat.

<u>Area of occurrence/ Area of Occupancy</u>
There are not enough data to separate the area of occurrence from area of occupancy. The area of occurrence for Olive Ridleys during the nesting period should include nesting beaches from Cape York to the Kimberley coastline, and up to 50 km offshore to encompass interesting habitat (Whiting et al. 2007b; Hamel et al. 2008). It is not possible to determine the area of occurrence for foraging grounds until additional satellite tracking data, or tag recovery data are available. Limpus (2008) considers that the Olive Ridley populations in Australia may be in decline and that it is one of the most threatened marine turtle species in Australia.

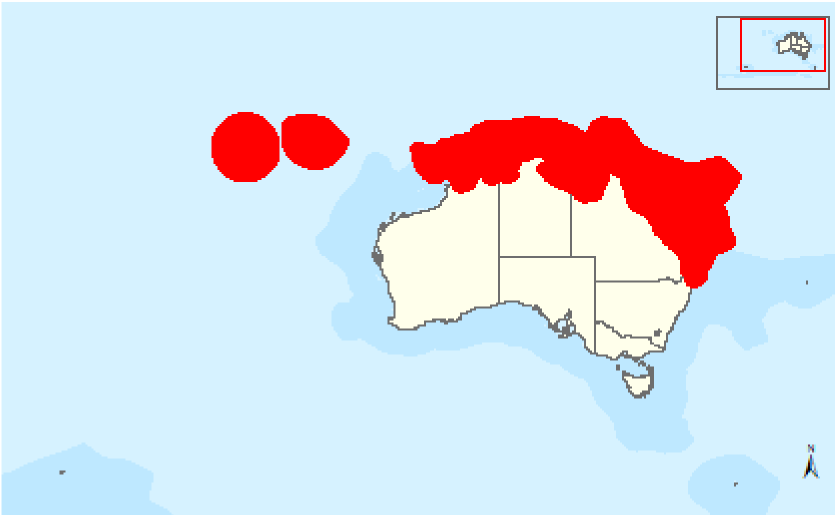

Figure E.22 Generalised distribution map of Olive Ridley turtles[30]

E.5.6 Flatback turtle (*Natator depressus)*

<u>Nesting Beaches</u>
Flatback Turtles are only known to nest in Australia, with a distribution from near Bundaberg, Queensland (Limpus 1971), around northern Australia to the islands and mainland of Northwest Cape where there is occasional nesting (Prince 1994a; b). Flatback Turtles are one of only two sea turtle species (along with Kemp's Ridley Turtles) that do not have a global distribution. Genetic studies of Flatback Turtle rookeries have identified five distinct populations to date (Pittard 2010; FitzSimmons & Limpus 2014a), also referred to as Management Units (MUs; Moritz 1994) or genetic stocks. These are the Pilbara Coast, southwest Kimberley, Joseph Bonaparte Gulf, Arafura Sea and eastern Queensland (eastern Australia) genetic stocks (FitzSimmons & Limpus 2014a). The geographic boundaries between these genetic stocks needs to be established by sampling additional rookeries and conducting genetic analyses.

Nesting along the Pilbara coast and offshore islands includes major rookeries at Barrow Island and at Mundabullangana Station near Cape Thouin on the mainland and lower numbers nesting at Thevenard Island, the Montebello Islands and Lowendal Islands (Prince 1994a,b; Pendoley 2005; Limpus 2007). This genetic stock may include the turtles that nest

[30] Department of the Environment (2016). *Lepidochelys olivacea* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 19 Feb 2016

at Cemetery Beach in Port Headland. Nesting beaches used by the southwest Kimberley genetic stock include at least 80-mile beach south of Broome. The Joseph Bonaparte Gulf genetic stock includes a major rookery at Cape Domett (Whiting et al. 2008) and lesser nesting at Lacrosse Island (Prince 1994a). The geographic extent of rookeries for each of the genetic stocks in Western Australia is unknown.

Rookeries of the Arafura Sea genetic stock include an area from at least Fog Bay, NT to Crab Island off western Cape York, and possibly the nesting beaches on islands in the Torres Strait. Nesting in the Northern Territory is scattered on the mainland and islands around the Territory with higher concentrations on Bare Sand Island, Quail Island, the Anson Beagle bioregion, Tiwi Island, Field Island, Coburg Peninsula and islands including Greenhill Island, and the McCluer Islands, islands off northeast Arnhem Land, Groote Island and the Sir Edward Pellew and Wellesley Islands (Cogger & Lindner 1969; Guinea 1994a; b; Limpus 1995; Hope & Smit 1998; Winderlich 1998; Guinea & Whiting 1999; Hamann et al. 2006; Schäuble et al. 2006; Limpus 2007; Chatto & Baker 2008). Nesting in the Torres Strait and the northwest Gulf of Carpentaria include major rookeries at Crab, Deliverance and Kerr Islands and along the mainland (Limpus et al. 1983a; 1989; 1993; Limpus 2007).

Major rookeries for the eastern Queensland genetic stock are on continental islands near the mainland at Peak, Wild Duck, Curtis and Avoid Islands (Limpus 1971; Limpus et al. 1981; Limpus 2007). Minor rookeries include the mainland beach at Mon Repos, various central Queensland islands (Inflex Islets, Flock Pigeon Island, Aquilla Island, Red Clay Island, Brampton Island, St Bee's Island, Rabbit Island, Cockermouth Island, Penrith Island, and Wigton Island) and mainland beaches around Mackay, and Townsville at Cape Cleveland and Cape Bowling Green (Limpus 2007).

<u>Foraging Grounds</u>
Foraging grounds for Flatback Turtles are found in the tropical waters of northern Australia, Papua New Guinea and Papua, Indonesia (Spring 1982; Zangerl et al. 1988; Limpus 2007). Tagging of turtles nesting at rookeries from Mon Repos to Wild Duck Island indicate the use of foraging grounds from Mon Repos to Torres Strait (Limpus et al. 1983b; Limpus 2007). Tag recoveries of turtles nesting at Crab Island include foraging grounds within a few hundred km, including off the south coast of Papua (Limpus 2007). Flatback turtles have been recorded from coastal waters of the Kai islands south of Papua, where low numbers are harvested (Suárez 2000).

Satellite tagging data of post-nesting turtles from rookeries from Thevenard Island to Port Headland indicate the use of foraging grounds mostly along the Pilbara and Kimberley coastlines, with some use of foraging grounds off the coast of the Northern Territory and into the Gulf of Carpentaria (Pendoley et al. 2014a). Telemetry data from turtles nesting at Cape Domett showed that foraging grounds are used off the northern Kimberley coast, and in waters off the Northern Territory coast to northeast Arnhem Land (Whiting et al. 2012).

Post-hatchling and pelagic juvenile Flatback Turtles are unusual among sea turtles in that they apparently do not forage in oceanic waters, but stay over the continental shelf (Walker & Parmenter 1990; Walker 1991; 1994; Limpus et al. 1994; Limpus 2007), where they are thought to feed on planktonic macro zooplankton (Limpus 2007).

<u>Area of occurrence/ Area of Occupancy</u>
There are not enough data to separate the area of occurrence from area of occupancy. The area of occurrence for Flatback Turtles during the nesting period should include nesting beaches from Mon Repos, Qld to North West Cape, WA and up to 146 km offshore to encompass internesting habitat (Whittock et al. 2014). It is not possible to determine the area

of occurrence for foraging grounds until additional satellite tracking data, or tag recovery data are available. There are no data to indicate that there has been a decline in the extent of occurrence over the past three generations (Limpus 2007), nor are there sufficient empirical data to indicate future changes in the area of occupancy. However, changes to air and sea temperatures, sea level rise and other physical aspects that may change with global warming have the potential to alter the species occurrence (Hamann et al. 2007).

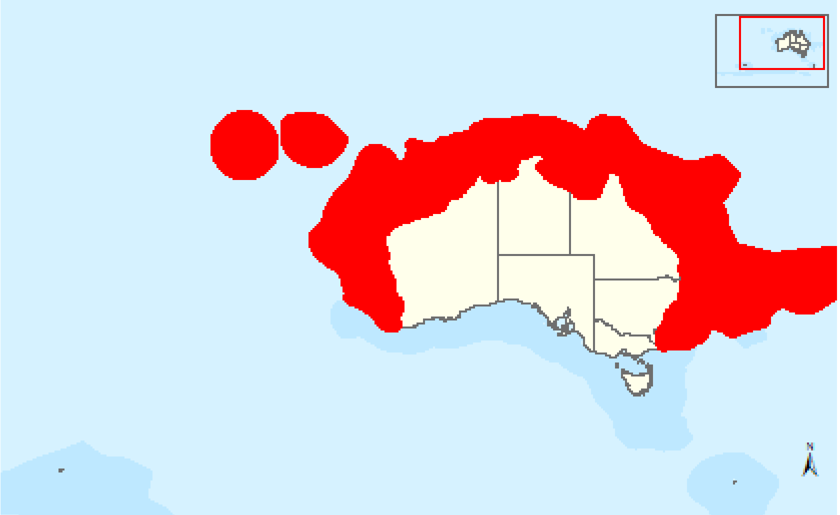

Figure E.23 Generalised distribution map of Flatback turtles[31]

E.6 Other

E.6.1 Whale shark (*Rhincodon typus)*

In Australia, the Whale Shark is known from NSW, Queensland, Northern Territory, Western Australia and occasionally Victoria and South Australia, but it is most commonly seen in waters off northern Western Australia, Northern Territory and Queensland (Compagno 1984; Last & Stevens 1994).

Ningaloo Reef, off the Western Australian coast, is the main known aggregation site of Whale Sharks in Australian waters. Taylor (1996) suggests that this aggregation is due to seasonal concentrations of krill and other zooplankton, which are a food source for the Whale Shark.

Detailed and informal surveys carried out in both 1991 and 1992 demonstrated that Whale Sharks congregate off Ningaloo Reef (Western Australia) from March to July, when the coral undergoes mass spawning. The number of Whale Sharks reaches a peak about two weeks after this coral spawning (DEH 2005c; Taylor 1996). Whale Shark aggregations around Ningaloo Reef are generally the greatest during La Niña years and are associated with the intensification of the Leeuwin Current in March (DEWHA 2008).

The Whale Shark also seasonally aggregates in coastal waters off Christmas Island between December and January and in the Coral Sea between November and December (DEH

[31] Department of the Environment (2016). *Natator depressus* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 19 Feb 2016

2005c). These seasonal aggregations are thought to be linked to localised seasonal 'pulses' of food productivity.

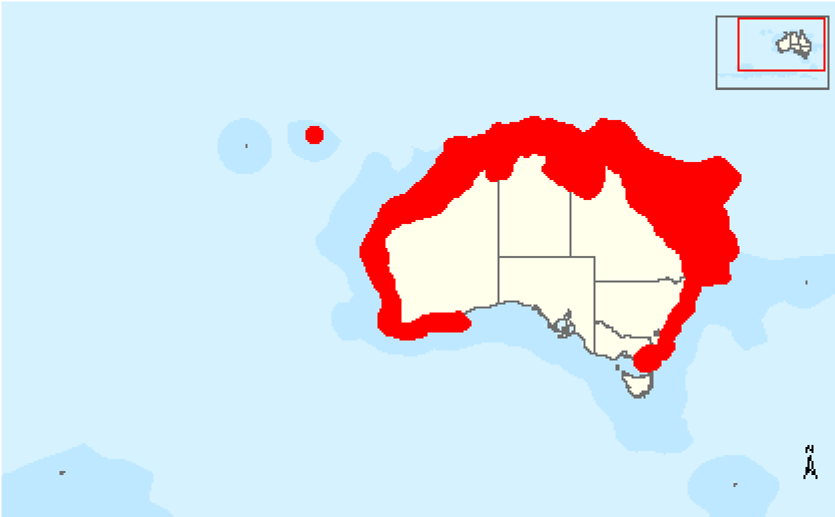

Figure E.24 Generalised distribution map of whale sharks[32]

E.6.2 Great white sharks (*Carcharodon carcharias)*

In Australia, Great White Sharks have been recorded from central Queensland around the south coast to north-west Western Australia, but may occur further north on both coasts (Bonfil et al. 2005; Bruce et al. 2006; Last & Stevens 2009; Paterson 1990). It has been sighted in all coastal areas except in the Northern Territory. The northern-most Queensland record is Mackay (Paterson 1990). Although capable of crossing ocean basins, the species is typically found from close inshore habitats (e.g. rocky reefs and shallow coastal bays) to the outer continental shelf and slope areas. Within Australian waters, the majority of recorded great white shark movements occur between the coast and the 100 metre depth contour. Both adults and juveniles have been recorded diving to depths of 1000 metres (Bruce et al. 2006; Bruce & Bradford 2008).

Great White Sharks are widely, but not evenly, distributed in Australian waters. Areas where observations are more frequent include waters in and around some Fur Seal and Sea Lion colonies such as the Neptune Islands (South Australia); areas of the Great Australian Bight as well as the Recherche Archipelago and the islands off the lower west coast of Western Australia (Environment Australia 2002; Malcolm et al. 2001). Juveniles appear to aggregate seasonally in certain key areas including the 90 Mile Beach area of eastern Victoria and the coastal region between Newcastle and Forster in NSW (Bruce & Bradford 2008). Other areas, such as the Portland region of western Victoria and the coast off the Goolwa region of South Australia, are also reportedly visited by juvenile Great White Sharks.

Most research on Great White Sharks has been conducted in and around the waters off South Australia, particularly at the Neptune Islands and Dangerous Reef (Bruce 1992, Bruce et al. 2005; Bruce et al. 2005b; Bruce et al. 2006; Robbins 2007). Research has also been conducted along the mid-north NSW coast (Bruce & Bradford 2008).

[32] Department of the Environment (2016). *Rhincodon typus* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 19 Feb 2016

Commonwealth south-east marine bioregion

The Great White Shark moves seasonally along the south and east Australian coasts, moving northerly along the coast during autumn and winter and returning to southern Australian waters by early summer (Bruce et al. 2006).

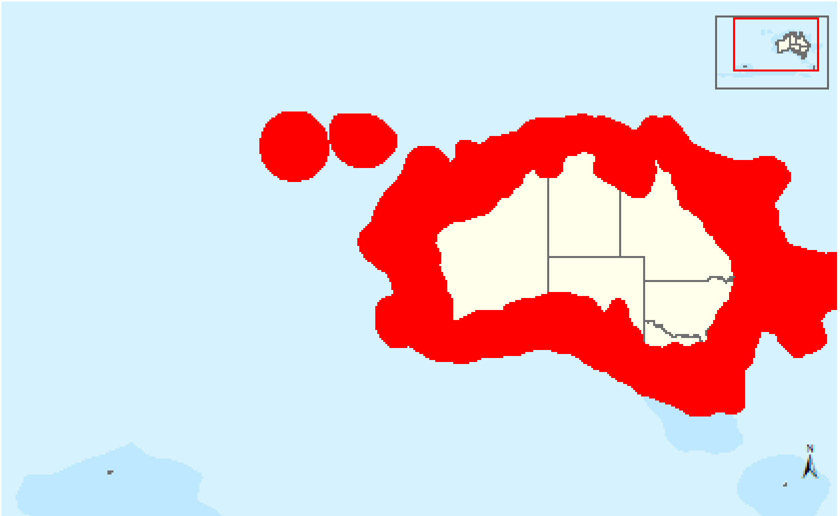

Figure E.25 Generalised distribution map of Great white sharks[33]

E.6.3 Ocean sunfish (*Mola mola)*

The Australian Museum summarises what is known about the distribution of Ocean Sunfish as[34]:

The Ocean Sunfish occurs in temperate marine waters worldwide.

In Australia, it has been recorded from the central coast of New South Wales to Tasmania and west to Mandurah, Western Australia.

The Ocean Sunfish belongs to the family *Molidae* and is one of three species recorded from New South Wales waters. The other two are the Southern Ocean Sunfish, *Mola ramsayi*, and the Slender Sunfish, *Ranzania laevis*. The fourth Australian species is the Sharptail Sunfish, *Masturus lanceolatus*. It occurs in southern waters of South Australia and Western Australia.

The map below shows the Australian distribution of the species based on public sightings and specimens in Australian Museums. Source: Atlas of Living Australia.

[33] Department of the Environment (2016). *Carcharodon carcharias* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 19 Feb 2016

[34] Australian Museum. Available at http://australianmuseum.net.au/ocean-sunfish-mola-mola. Accessed Fri, 19 Feb 2016.

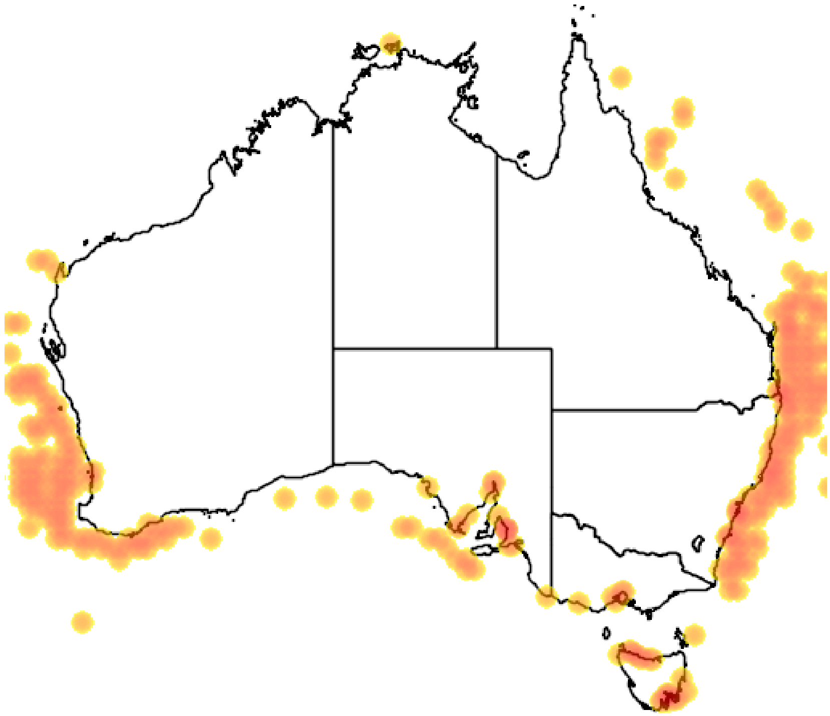

Figure E.26 Generalised occurrence records map of Ocean Sunfish[35]

E.6.4 Little penguin (*Eudyptula minor*)

The Marine Bioregional Plan for the Temperate East[36] notes that the Little penguin (*Eudyptula minor*) breeds around New Zealand and southern Australia. Within the region, this species breeds on several islands in New South Wales waters. The most significant sites include Montague Island (5000 pairs), Tollgate Island (5000 pairs), Brush Island (2500 pairs) and Five Islands (1500 pairs) (NSW OE&H 2011). This species usually forages in shallow waters close to the coast during the breeding season, although it can stay at sea for months, hundreds of kilometres from colonies (DECC 2009). The little penguin can dive to a depth of 60 metres (DECC 2009) and its diet includes squid, krill and small schooling fish (Marchant & Higgins 1990).

The Marine Bioregional Plan for the Temperate South West[37] notes that Little penguins (Eudyptula minor) are the only penguin species that occur regularly in the South-west Marine Region. The largest breeding population is in the Perth region, with around 700 pairs (JN Dunlop, pers. comm., 28 May 2008)—this represents the westernmost limit of little penguin distribution and the northernmost limit in Western Australia (DSEWPaC 2010). The population of little penguins on Penguin Island, near Perth, has been studied for over 20 years by researchers from Murdoch University and others, in collaboration with the Department of Environment and Conservation. In South Australia, the population has been

[35] Atlas of Living Australia Available from www. http://bie.ala.org.au/species/Mola+mola. Accessed on Fri, 19 Feb 2016.
[36] Commonwealth of Australia (2012) Marine bioregional plan for the Temperate East Marine Region. Available at http://www.environment.gov.au/system/files/pages/1e59b6ec-8b7e-42a8-9619-b5d728f878b2/files/temperate-east-marine-plan.pdf.
[37] Commonwealth of Australia (2012) Marine bioregional plan for the Temperate South Marine Region. Available at http://www.environment.gov.au/system/files/pages/a73fb726-8572-4d64-9e33-1d320dd6109c/files/south-west-marine-plan.pdf

estimated at 20 000–50 000 breeding pairs (Robinson et al. 1996), with large colonies at Pearson Island (around 15 000 pairs; S Goldsworthy, SARDI Aquatic Sciences, pers. comm., 29 July 2008) and Troubridge Island (around 3 000 pairs; Wiebkin 2010). The South Australian population is likely to comprise less than 50 per cent of Australia's entire little penguin population; however, the South-west Marine Region covers about half their distribution in Australia (SD Goldsworthy, SARDI Aquatic Sciences, pers. comm., 29 July 2008).

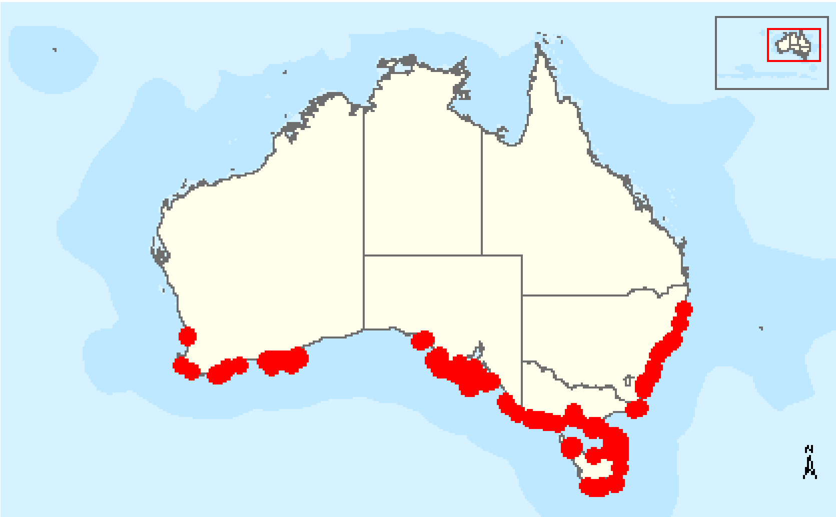

Figure E.27 Generalised distribution map of Little Penguin[38]

[38] Department of the Environment (2016). *Eudyptula minor* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 19 Feb 2016

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