Australian Government

Department of the Environment

Conservation Management Plan for the Blue Whale

A Recovery Plan under the *Environment Protection and Biodiversity Conservation Act 1999*

2015–2025

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Table of contents

Executive Summary 1

Introduction 1

Recovery Objective 1

Interim Recovery Objectives 1

Blue Whale Biology 2

Pygmy blue whales 2

Antarctic blue whales 2

Threats 3

Actions 4

1. Introduction 5

1.1. Review of the Blue, Fin and Sei Whale Recovery Plan (2005–2010) 5

1.2. Objectives and targets of the Conservation Management Plan for blue whales 6

Long-term recovery objective 6

Interim recovery objectives 6

Performance of the plan and progress towards long-term objectives 7

1.3. Defining population 8

2. Legal Framework 9

2.1. International Conventions and Agreements 9

2.2. National, State and Territory Legislation and Management Arrangements 9

National legislation 9

State and territory legislation 11

3. Governance 12

3.1. Interested and responsible agencies for the Plan 12

Australian Government 12

Industry, non-government organisations, research centres and community groups 12

State and territory governments 12

4. Science 13

4.1. The Biology, Status and Environmental Parameters 13

General biology 13

Distribution, migration and behaviour 15

Conservation Values Atlas 19

Population structure 19

Abundance and population trends 19

4.2. Biologically Important Areas for blue whale 20

4.3. Attributes to be Monitored 21

5. Threats **23**
5.1. Description of Threats 23
5A Whaling 23
5B Climate Variability and Change 23
5C Noise Interference 24
5D Habitat Modification 27
5E Vessel Disturbance 29
5F Overharvesting of prey 30
5.2. Threat Prioritisation 30
6. Actions **33**
6.1. Summary of Actions to be implemented 33
Previous and existing management actions 34
Existing research actions 35
Assessing and addressing threats 36
Enabling and measuring recovery 39
Cumulative Impacts 40
6.2. Implementation of the Conservation Management Plan 40
6.3. Reporting Process 42
Monitoring the population 42
Monitoring progress towards the actions of the Conservation Management Plan 42
Data management 42
7. References **44**

List of tables

Table 1. Summary of Actions and Priority Ratings identified in the Conservation Management Plan for pygmy and Antarctic blue whales. 4
Table 2. Performance measures for the Blue Whale Conservation Management Plan 8
Table 3. Risk matrix template 31
Table 4. Pygmy blue whale risk matrix 32
Table 5. Antarctic blue whale risk matrix 32
Table 6. Summary of actions with interim objectives and recovery targets 33
Table 7. Key mechanisms and indicative costing to carry out some of the priority actions for blue whales under the Conservation Management Plan for the Blue Whale 41

List of figures

Figure 1. Pygmy blue whale distribution around Australia 17
Figure 2. Pygmy blue whale migration routes 18

Executive Summary

Introduction

The blue whale (*Balaenoptera musculus*) is currently listed as an endangered species under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). There are two subspecies of blue whales that use Australian waters (including Australian Antarctic waters), the pygmy blue whale (*B. m. brevicauda*) and the Antarctic blue whale (*B. m. intermedia*). The Antarctic blue whale subspecies remains severely depleted from historic whaling and its numbers are recovering slowly. For the pygmy blue whale there is uncertainty in the numbers pre-exploitation, and their current numbers are not known.

A recovery plan for blue, fin and sei whales was developed for the period 2005 to 2010. Post 2010 it was decided that a revised recovery plan solely for blue whales (including both subspecies) was needed to re-evaluate threats and establish actions for assisting the recovery of blue whale populations using Australian waters. This plan conforms to the International Whaling Commission's (IWC) 'Conservation Management Plan' (Plan) format, while also meeting the requirements of a recovery plan under the EPBC Act.

Recovery Objective

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

Interim Recovery Objectives

Acknowledging that the long-term recovery objective is unlikely to be achieved over the ten year period of this plan, the following interim recovery objectives have been set for the next ten years. The first two interim objectives assist in assessing the conservation status of the pygmy and Antarctic blue whale subspecies, and the remaining two relate to legal and management protection, and to minimising recognised threats. The interim recovery objectives are:

1. The conservation status of blue whale populations is assessed using efficient and robust methodology;
2. The spatial and temporal distribution, identification of biologically important areas, and population structure of blue whales in Australian waters is described;
3. Current levels of legal and management protection for blue whales are maintained or improved and an appropriate adaptive management regime is in place; and
4. Anthropogenic threats are demonstrably minimised.

Blue Whale Biology

Blue whales (*Balaenoptera musculus*) are the largest baleen whales and consist of four currently recognised subspecies. At least two subspecies are found in the Southern Hemisphere; the pygmy blue whale (*B. m. brevicauda*) and the Antarctic blue whale (*B. m. intermedia*), which are characterised by differences in morphology, distribution, genetics and vocal behaviour. As with other baleen whales, they generally migrate between breeding grounds at lower latitudes where both mating and calving takes place during the winter, and feeding grounds at higher latitudes during the summer and have overlapping but different spatial distributions. Australian blue whales are represented by three generally recognised and overlapping populations, namely:

1. Antarctic blue whale population—all those Antarctic blue whales occupying or passing through Australian waters;
2. Indo-Australian pygmy blue whale—all those pygmy blue whales occupying or passing through waters from Indonesia to western and southern Australia; and
3. Tasman-Pacific pygmy blue whale—all those putative pygmy blue whales occupying or passing through waters in south east Australia and the Pacific Ocean.

Pygmy blue whales

Indo-Australian pygmy blue whales inhabit Australian waters as far north as Scott Reef, the Kimberley region, and west of the Pilbara, as far south as south-west Australia, across to the Great Australian Bight and the Bonney Upwelling, and to waters as far east as off Tasmania.

They have known feeding grounds in the Perth Canyon off Western Australia, and the Bonney Upwelling System and adjacent waters off Victoria, South Australia and Tasmania. These areas are utilised from November to May. They migrate between these feeding aggregation areas, northwards and southwards along the west coast of Australia, to breeding grounds that are likely to include Indonesia.

Indo-Australian pygmy blue whales migrate north from the Perth Canyon / Naturaliste Plateau region in March / April reaching Indonesia by June where they remain until at least September. Southern migration from Indonesia may occur from September and finish by December in the subtropical frontal zone (the confluence of subtropical and subantarctic waters (40–45° S)) after which the animals may make their way slowly northwards again.

The pre- and post-whaling abundance and population trend of the pygmy blue whale population is unverified, but preliminary estimates of contemporary numbers from Australia are very low relative to estimates of the number of pygmy blue whale catches.

Antarctic blue whales

The Antarctic blue whale subspecies consists of one or more populations that feed off Antarctica, including off the Australian Antarctic Territory, and limited evidence suggests that some proportion migrate at least to subtropical latitudes of the Pacific and Indian Ocean to breed. However, some proportion of Antarctic blue whales may not migrate every year and/or migration may be staggered throughout the year with some whales visiting waters surrounding the Antarctic Continent outside of the summer feeding season.

Off Western Australia, the Antarctic subspecies has been acoustically detected off Cape Leeuwin from May to November, and the Perth Canyon from May to October (with a few occurrences recorded in March), and off the west and north coasts of Tasmania predominately from May to December. Based on the seasonality of recordings, these areas possibly form part of their migratory route, breeding habitat or a combination of the two.

Estimates of pre- and post-whaling abundance of Antarctic blue whales indicate that they have been increasing in abundance since the cessation of whaling. The estimated original population size was 239,000 (95% interval 202,000 – 311,000). A more recent estimate of the Antarctic Blue Whale population was 2,280 (95% interval 1,160 – 4,500) individuals in 1996 (estimated from the circumpolar International Decade of Cetacean Research, Southern Ocean Whale and Ecosystem Research survey conducted from the 1992/1993 to 2003/2004 season).

Threats

There are several anthropogenic threats that may inhibit the recovery of blue whale populations in Australian waters. The relevance of these threats to the two subspecies varies depending on the habitats they occupy, timing of habitat occupancy and their population abundance and trend. The highest rated threats (as identified through a risk assessment process outlined in Section 5.2) are below.

A. Whaling—The impacts of commercial hunting on blue whales are well documented. While currently banned under the IWC moratorium on commercial whaling due to the classification of all blue whale populations as Protected Stocks, the potential for commercial whaling on large baleen whale species to recommence exists and pressure to take blue whales may well increase as the population recovers.

B. Climate variability and change—Climate variability and change may cause distribution and migratory timing changes and decreased health of individuals in a population. Climate change can lead to ocean temperature increases, changes in ocean heat transfer resulting in changes to circulation patterns (e.g. upwellings), ocean acidification and melting of Antarctic sea ice. This may impact krill availability, the major food source for blue whales.

C. Noise interference—Blue whales rely on sound to find prey and mates. Man-made noise can potentially result in injury or death, masking of vocalisations, displacement from essential resources (e.g. prey, breeding habitat), and behavioural responses. Potential sources of man-made underwater noise interference in Australian waters include seismic surveys for oil, gas and geophysical exploration, industrial development activities (such as drilling, pile driving, blasting and dredging), gas processing and shipping.

D. Vessel disturbance—Vessel disturbance can occur in the form of collisions or by disrupting the behaviour of animals. Vessel collision can lead to mortality or significant injury, and could impede recovery of blue whale populations. Vessel disturbance or collisions can result from industrial, recreational or commercial activities including whale watching.

Actions

Actions were prioritised to deliver tangible results to meet the Interim Recovery Objectives (Section 1.2) over time. There are a number of action areas identified in this Plan that address the 'very high' and 'high' risk threats to pygmy and Antarctic blue whales. Actions that support measuring population recovery, distribution and identification of important habitat were also prioritised. These actions and their ratings are summarised in Table 1.

Table 1. Summary of Actions and Priority Ratings identified in the Conservation Management Plan for pygmy and Antarctic blue whales.

Action	Pygmy blue whale Priority Rating	Antarctic blue whale Priority Rating
Assessing and addressing threats		
Maintain and improve existing legal and management protection	Very high	Very high
Assessing and addressing anthropogenic noise	Very high	High
Understanding Impacts of climate variability and change	High	High
Minimising vessel collisions	High	High
Enabling and measuring recovery		
Measuring and monitoring population recovery	Very high	Very high
Describe the population structure of blue whales	High	High
Describe the spatial and temporal distribution of blue whales and further define Biologically Important Areas	High	High

1. Introduction

The blue whale (*Balaenoptera musculus*) is currently listed as an endangered species under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). There are two subspecies of blue whales that use Australian waters (including Australian Antarctic waters), the pygmy blue whale (*B. m. brevicauda*) and the Antarctic blue whale (*B. m. intermedia*). The last recovery plan under the EPBC Act that considered blue whales was jointly developed for Blue, Fin and Sei whales for the period 2005–2010.

Australia's national cetacean policy and management initiatives seek to both give effect to our obligations under the EPBC Act, and to underpin our international work, in collaboration with the International Whaling Commission (IWC). Conservation Management Plans (CMPs) have been identified as a modern, flexible and adaptive tool for cetacean conservation management. They aim to protect whale populations from the full range of known and emerging threats and to lead to improved conservation status for threatened populations through effective management. This new Plan reviews and builds on the previous recovery plan and is presented in a format that conforms with the IWC's CMP format, while meeting the requirements of a recovery plan under the EPBC Act.

Blue whales were over-exploited by commercial whalers in the 19th and 20th centuries. By 1967 the IWC banned the taking of blue whales in the North Atlantic, North Pacific and southern hemisphere. However, illegal unreported and unregulated hunting may have continued through to the early 1970's. There was a near catastrophic decline in Antarctic Blue whales due to whaling, from an estimated 239,000 individuals pre-whaling to an estimated 360 individuals by 1973[17]. The most recent estimate in 1996 of the population size of Antarctic blue whales suggests that there were 2,280 (95% interval 1,160–4,500) individuals [14].

Given the differences between the two subspecies, mechanisms for recovery are likely to be different. The Antarctic blue whale population that utilises Australian waters are poorly described and given this lack of knowledge, the Plan focuses on estimating current abundance at the circumpolar scale. There are no robust abundance estimates for the Australian populations of pygmy blue whales.

Where appropriate, this Plan addresses the two subspecies separately. This includes outlining the current status of threats, and the prioritisation of recovery actions for the 2015–2025 period.

1.1. Review of the Blue, Fin and Sei Whale Recovery Plan (2005–2010)

A review of the Recovery Plan for the Blue, Fin and Sei Whale (2005–2010) was undertaken in 2010. The review recommended an update of the recovery plan for blue whales given the persistence of threats such as international whaling and climate change.

The review identified that blue whales are listed as 'Endangered' in the International Union for Conservation of Nature (IUCN) Cetacean Red List (2008) and that they remain in very low numbers both globally and also in Australian waters. Previously identified actions of the Blue, Fin and Sei Whale Recovery Plan were found to be still relevant including measuring and monitoring population recovery, characterising habitat use, and protecting blue whales from anthropogenic threats.

The review found that blue whales generally inhabit offshore waters and that this imposes difficulties for the collection of data relevant to their conservation. The migration patterns of blue whales are not well understood but appear to be highly diverse. Some populations may be resident

year-round in habitats of high productivity, while others undertake long migrations to high-latitude feeding grounds. The extent of migrations and the components of the populations that undertake them are poorly known.

The review also found that many actions proposed in the plan were appropriately delivered. However, due to the inherently low numbers of blue whales in Australian waters, it was difficult to estimate population abundance and trends and therefore an accurate determination of their status or level of recovery remained challenging. It also confirmed the value of research and its role in contributing to conservation and management measures.

Recommendations included within the review were:

- Increased focus on photo-identification, to facilitate use of mark-recapture methods to improve estimates of blue whales using identified habitats;
- Conducting satellite tagging studies to investigate whale migratory paths;
- Continued non-lethal collection of population data in collaboration with the IWC;
- Conducting research to better define potential impacts of climate change including prey depletion in recognition of the dependency of blue whales on krill;
- Direct management and research focusing on areas of high use and importance to blue whales, due to the increase of offshore industry and associated vessel traffic in those areas;
- Improving and maintaining the stranding database for all threatened whale species;
- Maintaining a strong anti-whaling stance on all threatened whale species in Australian waters;
- Improving the management of threatening processes by continuing to support research that better defines blue whale habitat use (e.g. migratory, pathways, feeding areas etc.); and
- Continued data collection using standardised survey methodologies, and contribution of data to long-term data sets.

1.2. Objectives and targets of the Conservation Management Plan for blue whales

Long-term recovery objective

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

Interim recovery objectives

While acknowledging that the long-term recovery objective is unlikely to be achieved over the ten year period of this Plan (due to their highly depleted status and slow reproductive rate of blue whales), the following interim recovery objectives and associated targets have been set for this Plan. The effectiveness of this Plan will be measured, and progress towards long-term objectives assessed, on the basis of how well the following targets for interim recovery objectives are met.

The first two interim objectives assist in assessing the conservation status of the pygmy and Antarctic blue whales in Australian waters, and the remaining two relate to legal and management protection, and to minimising recognised threats.

Interim objective 1: The conservation status of blue whale populations is assessed using cost effective and robust methodology.

> Target 1–1: A robust and cost effective monitoring technique to estimate the abundance of pygmy blue whales in Australian waters is developed.
>
> Target 1–2: The abundance and conservation status of each of the two known populations of pygmy blue whales in Australian waters is determined using the method developed in Target 1–1.
>
> Target 1–3: The abundance and status of the Antarctic Blue Whale subspecies in Australian and Antarctic waters is measured and monitored.

Interim objective 2: The spatial and temporal distribution, identification of biologically important areas, and population structure of blue whales in Australian waters is described.

> Target 2–1: The spatial and temporal distribution, including the identification of biologically important areas, are identified for all blue whales using Australian waters.
>
> Target 2–2: The population structure (e.g. using genetics and acoustics) of Antarctic and pygmy blue whales using Australian waters is described.

Interim objective 3: Current levels of legal and management protection for blue whales are maintained or improved and an appropriate adaptive management regime is in place.

> Target 3–1: Domestic and international legislation and other agreements that support the recovery of Australian blue whales are maintained and, wherever possible, improved.

Interim objective 4: Anthropogenic threats are demonstrably minimised.

> Target 4–1: Robust and adaptive management regimes leading to a reduction in anthropogenic threats to Australian blue whales are in place.
>
> Target 4–2: Management decisions are supported by high quality information and high priority research projects identified in this plan are achieved or underway.

Performance of the plan and progress towards long-term objectives

At the completion of this Plan (i.e. 2025), progress will be assessed and assigned one of the performance ratings below. The performance rating attained will show how successful the plan has been in meeting interim recovery objectives, and will provide an indication of the degree of progress towards long-term recovery objectives over the 2015–2025 period.

A midterm (5 year) review of the plan will be conducted using a 'Measure of Success' for each Action Area (Section 6.3 Reporting Process).

Given that blue whales remain heavily depleted from whaling, have a high age at sexual maturity and a low reproductive rate, any population recovery to or near pre-exploitation size is likely to be a long process (e.g. multi-decadal) and, most likely, will occur outside the scope of this ten year Conservation Management Plan.

Table 2. Performance measures for the Blue Whale Conservation Management Plan

Performance rating for the Plan	Targets	Progress towards long-term recovery objective
Successful	All targets met	Excellent
Moderately successful	Six of eight targets met including 3–1, 4–1 and 4–2	Sound
Moderately unsuccessful	Five of eight targets met including 3–1.	Adequate
Unsuccessful	Less than five targets met or 3–1 not met.	Failure

1.3. Defining population

Various terms are used to describe groups of blue whales. These terms can mean very different things in different documents and fora. For the purposes of this document, the term population is used in two ways:

1. as a general term that refers to all blue whales (including both sub-species) within Australian waters (i.e. 'Australian blue whales'); and,
2. as a specific term in reference to the broadly recognised components of the overall Australian population, namely:
   a. Antarctic blue whale population—all those Antarctic blue whales occupying or passing through Australian waters;
   b. Indo-Australian pygmy blue whale population—all those pygmy blue whales occupying or passing through waters from Indonesia to western and southern Australia; and
   c. Tasman-Pacific pygmy blue whale population—all those putative pygmy blue whales occupying or passing through waters in south east Australia and the Pacific Ocean.

With respect to the three components of the Australian blue whale population, it is important to note that these do not represent completely distinct management units. For example, all three populations are likely to occur and overlap in Bass Strait in south east Australia although the core range of all three are mainly separate.

2. Legal Framework

2.1. International Conventions and Agreements

Internationally, blue whales are given a level of protection through their listing on Appendix 1 of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES), and Appendix 1 'Endangered migratory species' of the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS, Bonn Convention). The two blue whale subspecies that use Australian waters are both listed as endangered under the World Conservation Union Red List (IUCN) of Threatened Species. Blue whales are classified as a "Protected Stock" under paragraph 10(c) of the Schedule to the International Convention for the Regulation of Whaling (ICRW) meaning that they cannot be commercially whaled.

Australia is involved in several international agreements that directly or indirectly relate to the conservation of marine mammals. These include:

- Australia was a founding member of the IWC and supported the introduction of a global moratorium on commercial whaling in 1982. Whales are also protected in the IWC sanctuaries (e.g. Indian Ocean Sanctuary and Southern Ocean Sanctuary). However, Special Permits issued under Article Vlll of the ICRW may allow whaling to occur within these sanctuaries for scientific purposes;
- Hosting the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR);
- Playing a key role in the Antarctic Treaty Consultative Meetings (ATCM); and
- As a member of the CMS Memorandum of Understanding for Conservation of Cetaceans and their Habitats in the Pacific Islands region. This Memorandum facilitates cooperation, capacity building and region-wide coordination of conservation efforts for cetaceans and their habitats in the Pacific islands region, as well as assists in safeguarding the cultural values of cetaceans for the people of the South Pacific.

2.2. National, State and Territory Legislation and Management Arrangements

National legislation

Blue whales are currently listed as endangered under the EPBC Act. The EPBC Act established the Australian Whale Sanctuary to protect all whales and dolphins found 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 (EEZ). The Australian EEZ generally extends to 200 nautical miles (approximately 370 kilometres) offshore, but extends further in some areas to cover offshore territorial waters and islands. The Australian EEZ includes the waters around the Australian Antarctic Territory and external territories including Christmas, Cocos (Keeling), Norfolk, Heard and Macdonald islands.

Within the Australian Whale Sanctuary it is an offence to kill, injure, take, trade, keep, move or interfere with a cetacean. Penalties apply to anyone convicted of such offences. The EPBC Act also makes it an offence for Australians to carry out any of these actions in international waters. Other than in the case of killing, or taking for live display, permits may be issued by the Minister for the Environment to carry out some activities that interfere with this species (e.g. for the purpose of research).

Under the EPBC Act, environment assessments are undertaken to support environmental and heritage protection and biodiversity conservation. A person must not take an action that has, will have or is likely to have a significant impact on any of the matters of environmental significance without approval from the Commonwealth Minister for the Environment. An action is a project, a development, an undertaking, an activity or a series of activities, or an alteration of any of these things.

Assessments for offshore petroleum and greenhouse gas activities in Commonwealth waters, including seismic surveys in the oil and gas sector, are currently undertaken by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA).

Under the EPBC Act, several other measures are currently in place to guide the management of human interactions with whales. These include the *EPBC Act Policy Statement 2.1—interaction between offshore seismic exploration and whales* and *Australian National Guidelines for Whale and Dolphin Watching 2005* for whale watching from private or commercial boats and aircrafts.

Management Plans for Commonwealth Marine Protected Areas under the EPBC Act allow the Director of National Parks to take management actions such as control of activities through zoning prescriptions and authorisations to mitigate potential threats and protect key areas and habitats for blue whales and other associated marine species. Several Commonwealth Marine Reserves (CMRs) have identified Blue whales as a major conservation value including Apollo, Murray, Nelson, Zeehan, Western Kangaroo Island, Western Erye, Great Australian Bight, South-west Corner, Perth Canyon, Two Rocks, Jurien, Abrolhos, Shark Bay, Gascoyne, Argo Rowley, Mermaid, Kimberley and Ashmore and CMRs.

To regulate the impact of fishing on whales, including by-catch and entanglements, Australian, state and territory governments are working together with the fishing industry and the Australian Fisheries Management Authority to develop methods to minimise these impacts.

Marine bioregional plans have been prepared under section 176 of the EPBC Act for the South-west, North-west, North and Temperate East marine regions of Commonwealth waters around Australia. Each marine bioregional plan describes the marine environment and conservation values of the region, identifies and characterises the pressures affecting these conservation values and identifies regional priorities and outlines strategies to address them. As part of this process, blue whales have been identified as a regional priority for the South-west Marine Region and are mentioned in the North-west Marine Region.

State and territory legislation

All Australian states and territories protect cetaceans within their waters (0–3 nautical miles offshore). All states and territories provide similar protection for cetaceans to that provided by the Australian Government in the Australian Whale Sanctuary.

New South Wales

New South Wales lists the blue whale as an endangered species on Schedule 1 part 1 of the *Threatened Species Conservation Act 1995.* Regulations for whale watching are provided for in the *NSW National Parks and Wildlife Amendment (Marine Mammals) Regulation 2006*. It is recognised by the New South Wales Government that blue whales of both subspecies may be encountered in its waters on rare occasions.

Northern Territory

In the Northern Territory, the blue whale is listed as data deficient under the *Territory Parks and Wildlife Conservation Act 2000.*

Queensland

In Queensland, the *Nature Conservation (Wildlife Management) Regulation 2006* provides guidelines for the protection of whales and dolphins.

South Australia

Blue whales are listed in South Australia as endangered under the *National Parks and Wildlife Act 1972*. Guidelines for whale watching and interacting with cetaceans are provided for in the *National Parks and Wildlife (Protected Animals—Marine Mammals) Regulations 2010* under the *National Parks and Wildlife Act 1972*. South Australia has declared a whale sanctuary and marine park at the head of the Great Australian Bight. In the *Great Australian Bight Marine Park (Commonwealth & State Waters) – A Description of Values and Uses,* blue whales are recognised as a migratory species that use the area.

Tasmania

The Tasmanian *Threatened Species Protection Act 1995* lists the blue whale as endangered. The Department of Primary Industries, Parks Water and Environment and the Tasmanian Parks and Wildlife Service provides whale watching guidelines that conform with the *Australian National Guidelines for Whale and Dolphin Watching 2005*.

Victoria

In Victoria, blue whales are listed as threatened under the *Flora and Fauna Guarantee Act 1988*. Under the *Wildlife Act 1975* it is an offence to kill, injure, take or interfere with a whale.

Western Australia

Blue whales are listed in Western Australia as 'fauna that is rare or is likely to become extinct' under Schedule 1, Division 1 in the *Wildlife Conservation (Specifically Protected Fauna) Notice 2010(2)* of the *Wildlife Conservation Act 1950*. Under state policy they are ranked as endangered based on using the International Union for Conservation of Nature (IUCN) criteria.

3. Governance

3.1. Interested and responsible agencies for the Plan

Listed below are key interested parties that may be involved in the development, implementation and review of the Plan for the Blue Whale. These include organisations likely to be affected by implementation of the actions proposed in this plan.

Australian Government

- Australian Fisheries Management Authority
- Australian Marine Mammal Centre
- Australian Maritime Safety Authority
- Department of Agriculture
- Department of Defence
- Department of Foreign Affairs and Trade
- Department of Infrastructure and Regional Development
- Department of Industry and Science
- Department of the Environment
- Director of National Parks
- Great Barrier Reef Marine Park Authority
- National Offshore Petroleum Safety and Environmental Management Authority

Industry, non-government organisations, research centres and community groups

- Commercial fishers and associations
- Commercial shipping
- Conservation groups
- Energy distribution networks
- Indigenous land councils and communities
- Local communities and community groups
- Nature-based tourism industry
- Oil and gas exploration and production industry
- Recreational fishers and associations
- Universities and other research organisations
- Whale-watching industry and associations
- Fisheries agencies
- Museums

State and territory governments

- Department of Parks and Wildlife, WA
- Department of Environment, Water and Natural Resources, SA
- Department of Primary Industries, Parks, Water and Environment, TAS
- Department of Environment and Heritage Protection, QLD
- Department of National Parks, Recreation, Sport and Racing, QLD
- Department of Environment and Primary Industries, VIC
- Department of Land Resource Management, NT
- Office of Environment and Heritage, NSW

4. Science

4.1. The Biology, Status and Environmental Parameters

General biology

Taxonomy

The order *Cetacea* comprises all whales, dolphins and porpoises, and contains the suborders *Mysticeti* (baleen whales) and *Odontoceti* (toothed whales, dolphins and porpoises). Blue whales are Mysticetes, and the distinguishing feature for this suborder is the presence of baleen plates used for filter feeding. Within *Mysticeti*, blue whales belong to the family *Balaenopteridae* (rorquals). Rorquals are characterised by throat pleats that allow the throat to expand when engulfing their prey.

There are four currently recognised subspecies of blue whales. Two are referred to as 'true' blue whales; the northern hemisphere subspecies, *Balaenoptera musculus musculus,* and the southern hemisphere subspecies, *Balaenoptera musculus intermedia*. The third subspecies is the 'pygmy' blue whale *Balaenoptera musculus brevicauda* known mainly from the southern Indian Ocean. *Balaenoptera musculus indica* (Blyth 1859) or the Northern Indian Ocean blue whale subspecies was recently recognised. A Chilean subspecies has also been suggested[15,25,94].

The two recognised Southern Hemisphere subspecies to which this Plan applies are the pygmy blue whale (*B. m. brevicauda*) and the Antarctic blue whale (*B. m. intermedia*), which are characterised by differences in morphology[15,18,51,54,55,57,88], distribution[15,18,51], vocal behaviour[64,76] and genetics[63].

Physical description

Blue whales are recognisable by a number of characteristics. They are the largest animal known to exist and are long-lived. The Antarctic subspecies can reach over 30m long and weigh up to 180 tonnes[18]. The longest recorded blue whale was a female from the Antarctic of 33.6m, and the longest pygmy blue whale was 24.4m[51]. They have mottled grey to almost black pigmentation which can be used to identify individuals from photographs (i.e. photo-identification)[99]. Compared to other cetaceans, they have a relatively small dorsal fin positioned far back on the body and this may remain underwater during surfacing. As with other baleen whales, females are generally larger than males. There is as yet no confirmed set of features that make the subspecies distinguishable at sea.

Reproduction

Blue whales reach sexual maturity at approximately 10 years old. They calve every two to three years, with gestation taking at least 10 months. Calves are 6–7m long at birth and 2.7 to 3.6 tonnes in weight, and are weaned at 7 months, by which time they are approximately 16m long[117].

Foraging

Blue whales have the highest known prey requirements of any predator, consuming up to two tonnes of krill per day[93]. Blue whale feeding grounds are therefore required to be areas of high primary productivity that can support sufficient densities of krill, such as oceanographic upwelling or frontal systems.

Pygmy blue whales

Australia has two known seasonal feeding aggregations of pygmy blue whales supported by upwelling systems located at the Perth Canyon off Western Australia and the Bonney Upwelling system and adjacent waters off South Australia and Victoria[44,45,92]. Blue whales predominately occur in these regions from November to May[44,45,71,7,92].

The Perth Canyon is a seasonally important area where pygmy blue whales feed on krill at depths of 200–300 metre in the canyon from January to May (with feeding peaking in the area from March to May). The number of blue whales in the Perth Canyon at any one time varies throughout the season, as well as between years depending on prevailing environmental conditions that in-turn determine the presence of their prey. Pygmy blue whales in the Perth Canyon predominantly feed on the krill *Euphausia recurva*[92].

The Western area of the Great Australian Bight is considered a possible foraging area and a likely transit route for whales travelling between the Perth Canyon and Bonney upwelling.

The Bonney Upwelling describes an oceanographic process that regularly occurs along the continental slope from the Eastern Great Australian Bight to Western Bass Straight. Like the Perth Canyon, the distribution of blue whales at the Bonney Upwelling system and adjacent waters changes within a season, depending on the local prevalence of environmental conditions that are favourable to krill[45].

Research to date has found that Pygmy blue whales occupy the western area of the Bonney Upwelling system in the Eastern Great Australian Bight and adjacent to the Kangaroo Island canyons from November and December. The first aerial survey of this area in 2003–04 found up to 30 blue whales feeding in this area[44], but subsequent surveys have shown that relative abundance in this area is highly variable both between and within seasons.

Pygmy blue whales then move south-east to the Bonney Upwelling system off eastern South Australia and Victoria (e.g. between Robe, SA and Cape Otway, Vic). This occurs predominately between January to April, although the within-season distribution trends in Bass Strait are unknown[45]. Distribution and timing of blue whales in the Bonney Upwelling can vary and during November and December 2012, large numbers of blue whales were sighted in the eastern area of the Bonney Upwelling, just west of Bass Strait. Pygmy blue whales in the Bonney Upwelling feed on the krill *Nyctiphanes australis*[44].

Outside of the recognised feeding areas, possible foraging areas for pygmy blue whales 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.*). 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. Anecdotal feeding areas include offshore of Eden and Merimbula, NSW (especially during October)[20].

Antarctic Blue Whales

Antarctic blue whales have a circumpolar, but potentially patchy, distribution off Antarctica during the summer feeding season. In the Antarctic, they prey on the krill *Euphasia superba*[19] and possibly *E. crystallorophias*. There is limited understanding of the movements of Antarctic blue whales around Antarctica or between Antarctica and breeding areas.

Distribution, migration and behaviour

Blue whales have a cosmopolitan distribution. As with other baleen whales, they generally migrate between (low-latitude) breeding grounds where both mating and calving take place during the winter, and (high-latitude) feeding grounds during the summer. During the southern hemisphere summer, Antarctic blue whales are usually found south of 60° South, while pygmy blue whales are usually found north of 55° South.

Breeding Areas

Pygmy blue whales

Pygmy Blue whales are thought to migrate from Australian feeding areas to low latitude breeding ground(s) that include Indonesia based on sightings in Indonesia in the austral winter[19]. Satellite tracked pygmy blue whales have been recorded moving from the Perth Canyon up the Western Australian coast and into the Banda Sea and Molucca Sea off Indonesia by Australian scientists[38]. It is possible that there may be more than one breeding habitat for these blue whales. Females with small calves are recorded seasonally moving through Geographe Bay in Western Australia from September to December[19], but the migratory origin and destination of these whales is largely unknown.

Antarctic Blue Whales

Antarctic blue whale winter migratory destinations include lower latitudes of the Pacific and Indian Oceans based on acoustic recordings[106]. Interestingly, Antarctic blue whales have been detected acoustically in the Australian Antarctic Territory[103] and the Western Antarctic Peninsula[102] 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[106], at the Perth Canyon from May to October (with a few occurrences recorded in March)[71], and off Tasmania predominately from May to December[42], which suggests these areas may be breeding grounds and/or migratory corridors, and/or winter feeding grounds.

Migratory pathways

Pygmy blue whales

Pygmy blue whales feeding off Australia use the west coast of Australia as part of their migratory route to and from breeding destinations[72]. The pygmy blue whales tend to pass along the shelf edge at depths between 500m to 1000m during their migration. Recent tagging studies have provided important new information potentially indicating the general migration pattern and breeding grounds of pygmy blue that feed off the western coast of Australia[34]. Assuming these movements are representative of the animals that feed off the western Australian area as a whole, pygmy blue whales migrate north from the Perth Canyon / Naturaliste Plateau region in March / April reaching Indonesia by June where they remain until at least September. Southern migration from Indonesia may occur from September and finish by December in the subtropical frontal zone after which the animals may make their way slowly northwards towards the Perth Canyon by March / April.

There are annual acoustic detections of Indo-Australian pygmy blue whales at Scott Reef. Detections of presumably south-bound whales occurs over late October to December[70].

Blue whales are also sighted travelling southwards through Geographe Bay in Western Australia from September to December[19], but the migratory origin of these whales is largely unknown. It is likely that they pass south of Cape Naturaliste and fan out to feed across southern Australia down to the subtropical convergence (i.e. the confluence of subtropical and subantarctic waters at approximately 40–45° South).

It is thought that pygmy blue whales are likely to migrate along the southern coast of Australia through the western area of the Great Australian Bight and between the two main feeding areas but further research is required to define the migratory paths for pygmy blue whales across this region.

The migratory routes for pygmy blue whales off the east coast of Australia are not known. Strandings of blue whales have occurred on the east coast, though it is not clear whether stranded whales were associated with the Indo-Australian or Tasman-Pacific populations. An acoustic noise logger in Bass Strait has picked up acoustic detections from pygmy blue whales in May–June, indicative of animals heading east but too late in the season for them to be heading up the Western Australian coast. Detection of these vocalisations could also be indicative of individuals that have forgone low-latitude migration, seeking alternative wintering grounds in temperate waters. There have also been regular acoustic detections of Tasman-Pacific type blue whale calls along the east coast of Australia, and elevated levels of underwater noise in frequency bands of Tasman-Pacific vocalisations, which suggests that this population of blue whales may utilise the Tasman Sea year round[73].

Antarctic Blue Whales

Acoustic recordings of Antarctic blue whales off Western Australia and Tasmania suggest these areas may form part of their migratory route between Antarctica and more northern wintering grounds[42, 71,106].

Southern Hemisphere Distribution

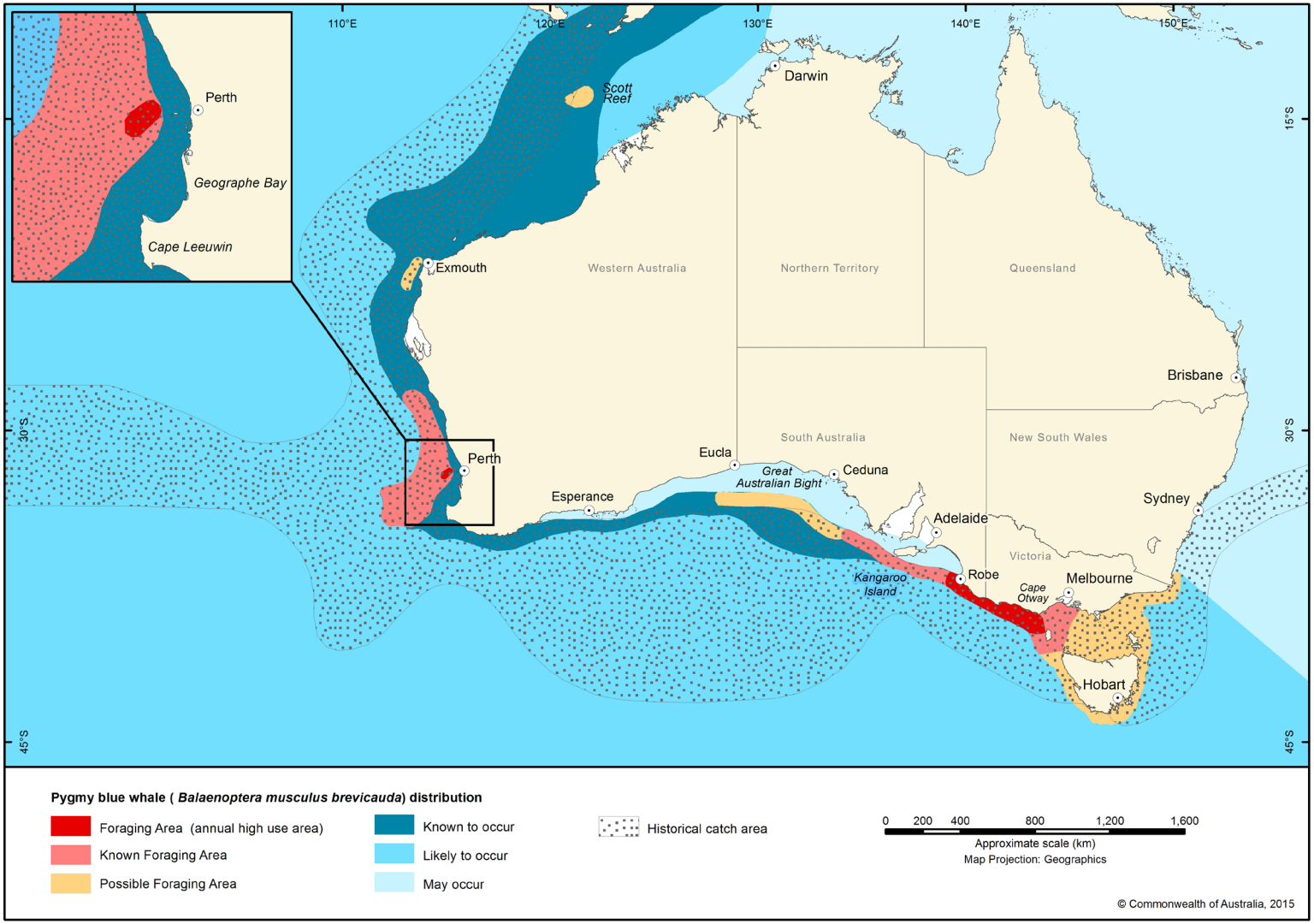
Blue whale catches in the 20th century during the feeding season were recorded almost continuously from around Tasmania, then westward to the south of the Bonney Upwelling and Great Australian Bight past Cape Leeuwin, then across the southern Indian Ocean to south of Madagascar and the Crozet Islands in the sub-Antarctic[19]. This continuous strip of catches includes high primary productive areas, such as the Southern Tropical Convergence[82] and the Crozet Islands[90,100,111] where Indo-Australian pygmy blue whale and Antarctic blue whale acoustic calls have been recorded[97], and the Madagascar Plateau[65] where blue whales of unknown population identity have recently been recorded[13].

Contemporary acoustic recordings from 2004 and 2006 have detected the unique call of Australian blue whales during February, March and April off the Crozet Islands[97] and south of Australia in the sub-Antarctic (54^0 South, 142^0 East)[42] respectively. Similar recordings in 2007 off the Crozet Islands did not detect any Indo-Australian pygmy blue whale calls throughout the year, however, simultaneous recordings at the Northwest and Southeast Amsterdam Islands detected Indo-Australian pygmy blue whales from February through to May. These areas may be important habitat for blue whales that also use Australian waters, thus highlighting some of the inherent challenges in studying a population that inhabits such a vast area.

There is increasing evidence that blue whales may not all follow precisely-timed annual migrations, rather, the timing of migrations may be staggered throughout the year, and/or some whales may not migrate every year. For example, Antarctic blue whales have been recorded year-round off the Western Antarctic Peninsula, eastern Antarctica[102], and off the Crozet Islands in the sub-Antarctic[97]. Recent research has indicated that there is population of blue whales residing in the Southwest Pacific and Tasman Sea between Australia and New Zealand year round[73,81].

At least a proportion of blue whales in the northern Indian Ocean are suspected to migrate longitudinally rather than latitudinally[2]. This longitudinal movement is between seasonally important areas of high primary productive, which suggest that blue whales do not necessarily fast during the breeding season, especially when combined with evidence from other localities[9,91]. Mounting evidence suggests that blue whales select wintering habitat that supports significant biological productivity.

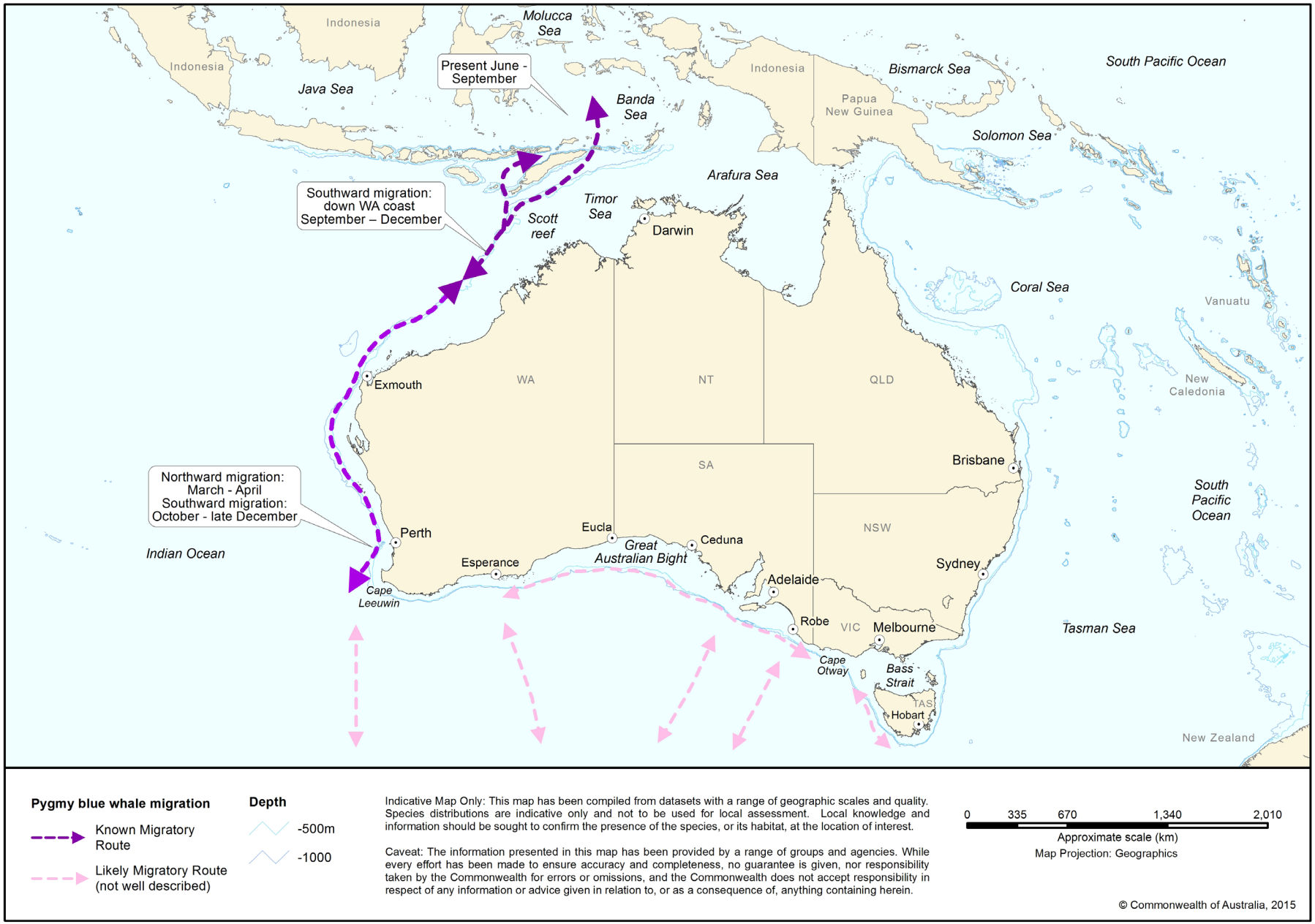
Figure 1. Pygmy blue whale distribution around Australia



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 2. Pygmy blue whale migration routes



Conservation Values Atlas

The Conservation Values Atlas is an interactive web-based tool developed to support implementation of Marine Bioregional Plans. The Atlas incorporates a range of national data on Australia's marine environment as well as specific information on the location and area of important marine habitats, ecological features, known breeding and feeding areas for protected species (blue whales) and other conservation values in the marine regions

www.environment.gov.au/topics/marine/marine-bioregional-plans/conservation-values-atlas

Population structure

Blue whales are a highly mobile species. The only clear barriers to movement are large continental land masses, however it is also generally thought that movement between the Northern and Southern Hemispheres is limited by warm water at the equator and opposite breeding seasons[30,80]. Although there has been little research to confirm population differentiation between hemispheres, acoustic evidence from the eastern tropical Pacific does indicate little overlap between blue whales in each hemisphere in the Pacific Ocean[108].

Pygmy blue whales

Genetic analysis has shown that pygmy blue whales which feed off the Perth Canyon, WA and the Bonney Upwelling, SA and Vic constitute the same population[5], i.e. they migrate to the same breeding ground and/or have high levels of gene flow between multiple breeding grounds. The genetic identity of blue whales travelling through Geographe Bay in Western Australia is unknown, but it is thought that they are the same population on the return from migrating to low latitude wintering grounds. Preliminary genetic data does not exclude whales in Geographe Bay from belonging to the same Australian population that uses the Perth Canyon and Bonney Upwelling (Moller et al, Report to AMMC). Finally, acoustic recordings identify calls in the Perth Canyon as being the same call types as in Geographe Bay, further suggesting that they are from the same population. However, this has not yet been genetically confirmed as the number of available samples for genetic analysis from this area is still small[4]. The genetic makeup of blue whales which use the East Coast of Australia is not known.

Antarctic Blue Whales

Genetic evidence has shown that Antarctic blue whales may consist of more than one genetic population, which is possibly driven by female site fidelity to particular regions of Antarctica[105]. However this requires further clarification.

Abundance and population trends

Abundance and population trends of blue whale populations using Australian waters are described below in the context of current population structure knowledge.

Pygmy blue whale

Blue whales from the two known Australian feeding aggregations belong to the same population[5], and therefore population abundance should be estimated together for these feeding aggregations. Abundance estimates based on photo-identification mark-recapture from 1999/2000 to 2004/2005 season for blue whales in the Perth Canyon are between 532 and 1,754[52] individuals, which generally agree with acoustic abundance estimates of 662 to 1,559 calling blue whales migrating south in 2004 past Exmouth in Western Australia[72] and a 1992/1993 season cruise which estimated 671 (95% interval 289–1,557) individuals offshore of southern Western Australia (35–45° South, 115–125° East)[56].

However, it is unknown what proportion of the total population these estimates encompass. This is a complex issue as there is the potential for between-year differences in habitat use due to, for example, differences in primary productivity between years which may bias estimates that are based on only one season of data. The degree of connectivity between different habitats is also poorly understood. While there is no evidence of genetic differentiation between the Bonney Upwelling and the Perth Canyon [5], there is the possibility of site fidelity of individuals to different feeding grounds. It is also unknown to what extent blue whales using the Australian feeding aggregations also use feeding habitat outside these areas, such as the Sub-tropical Convergence.

There is little knowledge of the pre-exploitation abundance of Australian pygmy blue whales, making it difficult to assess population recovery. Pygmy blue whales in the sub-Antarctic are estimated to have reduced from 7,598 at the start of the 1960/1961 season to 3,996 at the end of the 1971/1972 season[118], however this is based on out-of-date methodology and the population identity of these sub-Antarctic blue whales is unknown. Preliminary estimates of the number of pygmy blues caught are 13,022[16], though this encompasses all catches from South Africa to New Zealand and the northern Indian Ocean for which the extent of connectivity is unknown.

The estimate of the numbers of whales using the WA coast needs to be considered in context of the larger population pool of pygmy blue whales and the currently unknown movements of animals across the full geographic extent of the population within Australian waters. Little is known about the foraging, migration patterns and population structure of blue whales off the East Coast of Australia.

Antarctic blue whale

The Antarctic blue whale subspecies occurs off the Australian Antarctic Territory[19] and off at least Western Australia[106]. This was the most heavily exploited subspecies, with numbers estimated to have depleted from a pre-exploitation size of 239,000 (95% interval 202,000–311,000) to a minimum of 360 (95% interval 150–840) in 1973[17]. The most recent abundance estimate comes from the circumpolar survey that took place over 1992/1993 – 2003/2004 is 2,280 (95% interval 1,160–4,500) with an average estimated increase of 8.2% per year (95% interval 1.6–14.8)[14].

4.2. Biologically Important Areas for blue whale

It is not currently possible to define habitat critical to the survival of blue whales. Due to our limited knowledge about the distribution and abundance of these subspecies, little is currently known about the location and characteristics of these habitats. To date, the best information relates to biologically important areas where foraging occurs. These foraging areas can be considered important to the survival of blue whales as they seasonally support highly productive ecosystem processes on which significant aggregations of whales rely.

Through the development of marine bioregional plans, Biologically Important Areas (BIAs) have been identified for blue whales. BIAs are not defined under the EPBC Act, but they are areas that are particularly important for the conservation of protected species and where aggregations of individuals display biologically-important behaviour such as calving, foraging, resting or migration. BIAs have been identified using expert scientific knowledge about species' distribution abundance and behaviour.

This Plan builds on the descriptions of BIAs and upon the work of the marine bioregional plans to summarise the most current information available.

Foraging Areas

Unique areas where oceanographic processes allow sufficiently high krill densities to develop are essential to satisfy the large prey requirements of blue whales. The Eastern Great Australian Bight/Kangaroo Island canyons, SA and the area between Robe, SA and Cape Otway, VIC (both part of the Bonney Upwelling system), and the Perth Canyon, WA form the known feeding aggregation habitats for pygmy blue whales in Australia. Historical catch data and limited satellite tagging data suggest that the Southern Tropical Convergence may also constitute important feeding habitat for these whales.

Waters off Antarctica (including off the Australian Antarctic Territory) form the known feeding aggregation habitat for Antarctic blue whales.

Migratory Pathways

Migratory pathways are required for movement between breeding and feeding grounds. Pygmy blue whales feeding off Australia use at least the west coast of Australia as a migratory route[72] and have been sighted travelling west along the south-western tip of Australia, and some Antarctic blue whales likely use at least Cape Leeuwin, at least occasionally, as part of their migratory route to breeding grounds[106].

Anthropogenic disturbances along migratory routes may have unanticipated consequences as overcoming such disturbances depends on whether blue whales have the ability to adapt their migratory routes. The capability of changing migratory patterns has been suggested for north-east Pacific blue whales[21]. However, it is unknown whether the ability to adapt migratory routes is individual, species, subspecies, or population specific.

4.3. Attributes to be Monitored

Monitoring of abundance is required to determine population trends and recovery so that they can be evaluated against interim and long-term recovery objectives. Other attributes may need to be monitored in the future if new threats evolve or existing threats increase.

Pygmy blue whale population

Long-term monitoring of the abundance and population trends of pygmy blue whales needs to be initiated. The degree of connectivity (e.g. genetic) between populations needs to be assessed to determine the level of mixing both within Australian populations and between the Australian populations and other Southern Hemisphere populations. Furthermore, habitat usage patterns should be measured to determine whether there is structure (e.g. individual preferences) across the distribution range of a population, as this variation may affect abundance and population trend estimates.

Antarctic blue whale population

The abundance of the Antarctic blue whale population has been monitored off Antarctica, including off the Australian Antarctic Territory, through the International Decade of Cetacean Research (IDCR) and the Southern Ocean Whale and Ecosystem Research (SOWER) cruises conducted by the IWC from 1978/79 to 2009/10 seasons[14].

Continued research is required as the most recent abundance estimate is now nearly 20 years out of date, and there is substantial uncertainty regarding the annual rate of increase of this population.

In 2008, the Australian Government proposed a Southern Ocean Research Partnership (SORP) to the IWC and SORP was established in 2009, to conduct non-lethal, multi-national scientific research of cetaceans in the Southern Ocean. Two SORP research projects have been established to conduct further research on Antarctic blue whales: The Antarctic Blue Whale Project, and Acoustic Trends of Blue and Fin Whales[23,24,59].

The Antarctic Blue Whale Project aims to estimate the abundance, improve understanding of population structure and linkages between breeding and feeding grounds, and characterise the behaviour of Antarctic blue whales. The project has a strong focus on developing novel non-lethal methodologies to enable efficient and robust monitoring of Antarctic blue whales. An initial voyage trialling these methods was conducted in 2013[35] and methods to obtain a circumpolar abundance estimate have been rigorously explored with robust and efficient methods identified[89].

The Acoustic Trends SORP project aims to better determine the distribution and potentially the abundance trends through conducting long-term passive acoustic monitoring around the Antarctic [23,24,59]. Additionally, further understanding of Antarctic blue whale usage in waters off Australia may reveal the need to monitor Antarctic blue whales around Australia as well as in the Antarctic.

5. Threats

The relevance of the various threats to the two blue whale subspecies varies depending on the habitats they occupy and their population size. A precautionary approach must be used when identifying threats at a population level based on the detection and severity of acute effects on individuals, which are often the easiest to observe[43]. For example, a blue whale may continue feeding despite anthropogenic disturbance in the area if other suitable feeding areas are limited. Therefore the need to feed can override the need to move away from a possible threat such as anthropogenic noise.

5.1. Description of Threats

5A Whaling

The impacts of commercial whaling on blue whales have been well documented. While currently banned under the IWC moratorium on commercial whaling and due to classification by the IWC of all blue whale populations as a "Protected Stock", the potential for commercial whaling to recommence still exists.

An additional area of concern is the potential expansion of lethal special permit (or scientific) whaling undertaken under Article VIII of the International Convention for the Regulation of Whaling. That provision allows member states to issue special permits to kill, take and treat whales for purposes of scientific research. Since 1986, special permits have been issued for minke, fin, sei, sperm, Bryde's and humpback whale species as part of scientific whaling research programs undertaken by IWC members, including Iceland, Japan, Norway and the Republic of Korea. Part of Japan's lethal whaling program has taken place in the area covered by the Southern Ocean Sanctuary, and an area where Antarctic blue whales occur. To date, blue whales have not been caught under Special Permit whaling. While it does not appear likely in the near future, there is no guarantee that blue whales will remain exempt from future whaling operations.

5B Climate Variability and Change

Climate change is expected to cause changes in migratory timing and destinations, population range, breeding schedule, reproductive success and survival of baleen whales, including blue whale species and subspecies[62,66,95,101]. For example, it is predicted that cetaceans limited to warmer areas such as pygmy blue whales will experience a southward shift in distribution as ocean temperature increases[66]. There is evidence of these changes already occurring in other marine mammal species[96, 113], but such changes are difficult to detect for whales due to the complexity of ecological systems and the lack of, yet need for detailed long-term records.

Blue whales may also be affected by climate change through changes in distribution and abundance of their prey[83]. A decline in Antarctic krill abundance has already been recorded and a southward contraction in their distribution due to climate change has been predicted[3,116]. Additionally, the impact of naturally occurring temperature changes can be used as a proxy to investigate and assess the likely impact of anthropogenically caused climate change in the marine environment[37]. Warm El Niño and cold La Niña (ENSO events), which are natural oceanographic events characterised by regular short-term sea surface temperature changes in the tropical eastern Pacific Ocean, have affected krill abundance and consequently the abundance of blue whales and other baleen whales off California[12].

The krill *Nyctiphanes australis*, prey species of blue whales using the Bonney Upwelling, has also been shown to vary its abundance in response to ENSO events including a complete lack of them in Bass Strait near Tasmania during a temporary, natural La Niña event[35,48]. There is evidence that upwelling intensity off southern Australia (including the Bonney Upwelling) has increased over recent decades, with links to increased warming and the ENSO cycle.

Ocean acidification

Anthropogenic fossil fuel combustion and deforestation has led to an increase in atmospheric carbon dioxide levels[33]. This results in increased absorption of carbon dioxide into the ocean and, through chemical reactions of the carbon dioxide, a decrease in pH of sea water[33]. Laboratory experiments have shown that ocean acidification can be detrimental to Antarctic krill embryo development[58], which would consequently affect krill predators such as blue whales.

5C Noise Interference

Anthropogenic underwater noise covers a large range of frequencies, and the way in which a species is impacted by these sounds will depend on the proximity to the source, hearing sensitivity of the whale, intensity of source and its frequency spectrum, and the behavioural state of the whale[49,84,104]. The effects of elevated noise levels on marine mammals is known to include: avoidance of an area, tissue rupture, hearing loss, disruption of echolocation, masking (the inability of a whale to detect sounds important to it), habitat abandonment, aggression, calf abandonment, and behavioural disturbance. It is the high intensity signals with high peak pressures received at very short range that can cause acute impacts such as injury and death. The impact of anthropogenic noise that is received further away from the source but that occurs continuously can include hearing impairment (e.g. permanent and temporary threshold shifts) masking of communication, displacement, and other significant behavioural changes (including to vocal behaviour).

The purpose of different vocalisations in baleen whales, including blue whales, is still uncertain. It is difficult to link individual callers with their sex and behaviours to determine the role of specific calls, though suggested purposes include foraging, communication and association with breeding activities[86].

Blue whales produce powerful (188 dB re: 1 µPa @ 1 m), low frequency (10–500 Hz) sounds compared to other animals, including other cetaceans[29, 74]. They also have relatively stable call characteristics over time[76]. They have experienced a decrease in their tonal frequency globally over years but the reasons for this are currently unknown[41,75]. Sound travels faster through water than air and low frequencies are able to travel further than high frequencies. Therefore blue whales are able to communicate over hundreds of kilometres in some environments[107]. Blue whale calls vary across geographic regions[76], and within at least the eastern North Pacific it has been shown that call types vary depending on the caller's sex, behaviour and pod size[86, 87].

There has been no blue whale audiogram produced to indicate their hearing range and sensitivity at different frequencies. This is largely because such characteristics are difficult to measure in cetacean species not kept in captivity. However, ear morphology in *Mysticetes* (baleen whales) show they are specialised for hearing low frequencies compared to *Odontocetes* (toothed whales), and that they are likely capable of hearing outside their vocal range[60]. Given this lack of defined sensitivity for blue whales it is difficult to accurately assess whether a particular type of man-made sound would affect blue whales.

Masking by anthropogenic noise can become a concern for a particular cetacean species when the frequency band of the noise overlaps with the species' vocal frequency range or hearing range. The importance of sound to marine mammals means anthropogenic noise can create changes in their behaviour, vocalisations and physiology[84]. Many different anthropogenic noise sources have been shown to affect cetaceans and these are summarised below with specific reference to blue whales[49,84].

Seismic surveys

Seismic systems use sound to actively image geological structures below the seafloor. Marine seismic surveys are a method of locating and describing marine oil and gas deposits. This is often undertaken by using air gun arrays towed off ships to release air downward under pressure, producing powerful (up to 260 dB re: 1 µPa @ 1 m) and predominately low frequency (5 to 300 Hz) sound waves typically repeated in ~10 s intervals[49]. Impulsive sounds such as these present a greater risk than most continuous sounds because of the high peak levels and frequent repetition. Note that while the level of the anthropogenic sound is usually reported at 1m from the source as is standard, it is the level of the sound when received by the individual that is relevant for the whale (but this value is more difficult to determine). At lower received levels other responses may occur such as displacement and other behavioural responses[32].

The risk of physical impacts is minimised by implementation of the practical measures outlined in the *EPBC Act Policy Statement 2.1—interaction between offshore seismic exploration and whales*. While the seismic guidelines advise that seismic surveys should be undertaken outside of biologically important areas at biologically important times, it is not known at what distance from a seismic source, behavioural impacts may occur or the extent of any behavioural impact.

Acute and chronic industrial noise

Acute noise comes from activities such as pile driving, use of explosives, blasting, some forms of dredging and sonar. Sources of chronic industrial noise includes drilling, tender vessels, laying pipelines etc (a continuous, loud noise in the marine environment). The construction, operation and decommissioning of coastal and offshore oil and gas platforms or floating processing facilities, marinas and ports, and marine renewable energy facilities create large amounts of varied underwater noises from a wide range of activities. They also create additional shipping traffic especially around marinas and ports, and additional helicopter activity around oil and gas platforms to transport personnel. Such developments are subject to the EPBC Act in Australia. Most of these infrastructure projects require pile-driving during construction, which involves driving piles (beams or posts) into the seafloor to support the foundations of the structure. This creates strong (e.g. dependent on hammer energy; 237 dB re: 1 µPa @ 1 m for 1000 kJ hammer) and predominately low frequency (<1000 Hz) intermittent noise[49]. Oil and gas developments also include other activities that contribute to anthropogenic noise, including trenching and pipe-laying during construction, drilling, power generation and pumping during operation, and explosions. Avoidance of drilling rigs has been shown for other baleen whales[98].

Marine renewable energy facilities are a relatively recent industrial development that is growing worldwide. These include offshore wind farms, wave power sites and tidal power sites. There are currently no offshore wind farms in Australian waters, though their development is possible in the future[67,78].

Sonar is used to locate and characterise objects underwater. Passive sonar is when submarines, ships or animals are located by listening for them. This form of sonar does not add any anthropogenic noise to the environment. However active sonar involves the production of sound and using the sound echo to detect objects. Active sonar is used over a range of frequencies. Low frequencies can travel further (e.g. hundreds of kilometres) but have low resolution, medium frequencies are used for moderate ranges (e.g. < 10 km), and high frequencies which have high resolution[49].

Commercial and general sonar is usually active, high frequency sonar to detect the sea floor or fish. Worldwide, military use low to mid frequency sonar to detect submarines and ships from a distance, or high frequencies to detect mines on the sea floor. Their long-range detection sonar is often high-powered (>235 dB re: 1 µPa @ 1 m[49]). Only mid to high frequency sonars are used in Australian waters, including by the Royal Australian Navy or any visiting Navy[28]. The Royal Australian Navy in consultation with the Department of the Environment has adopted mitigation procedures for the use of military sonar to avoid potential impacts on marine mammals. Activities involving the use of military sonar are subject to thorough defence environmental assessment procedures.

Shipping noise

Ships create noise from machinery, their physical movement through water and sonar. The sound produced is unique for each vessel. Generally large commercial ships produce frequencies mostly between 10 to 50 Hz, and small boats between 1 to 5 kHz[49]. Ships generally produce louder noise as they increase in size and speed[49]. Shipping noise is expected to be more predominant along shipping lanes or near marinas and ports. A study off California has shown that blue whales increase calling due to shipping noise, indicating that it is likely to affect their communication[77].

In Australia, shipping noise associated with the port in Fremantle, Western Australia impacts on the known blue whale habitat in the Perth Canyon. The Victorian port of Portland is also associated with industrial activity and is on a major shipping route that runs through the Bonney Upwelling. Additionally, there are an increasing numbers of ports in north-western Australia and existing ports in south-western Australia (Albany and Esperance).

Aircraft noise

Airplanes and helicopters used for scenic tours, passenger transport, military and private use create sound in the air that enters the water. Off Portland helicopter-based whale watching has targeted blue whales in the Bonney Upwelling, and was managed by whale watching regulations (see 5E Vessel Disturbance). The power of the sound entering the water depends on how far the sound has travelled through the air, and the angle of the sound waves and the sea state which determine the amount of sound reflected (i.e. not entering the water). This makes it difficult to determine the sound exposure of submerged whales, however a few studies on aircraft noise have shown it can cause at least short-term behavioural changes in baleen whales such as shorter surfacing durations[84]. Aircraft noise is likely to have a considerably lower impact that the other sources of noise identified here.

5D Habitat Modification

Habitat modification in this context refers to physical modification of habitat, and has the potential to spatially displace individuals. This includes the construction of ports and marinas, oil and gas rigs and platforms, marine aquaculture facilities, and marine renewable energy facilities. In Australia, such developments are subject to assessment under the EPBC Act and relevant state and territory legislation where the facilities occur in state waters or on land.

Commercial fisheries and aquaculture equipment

Marine aquaculture involves farming 'shellfish' such as oysters and mussels, or 'finfish' such as salmon and bluefin tuna. The former takes place in inshore areas, and does not require nets, cages or supplemental feeding, and the latter takes place in inshore or offshore areas, requires nets or cages to contain the finfish and supplemental feeding. Baleen whales could potentially be affected from offshore aquaculture by displacement.

Baleen whales can become entangled in nets, lines and ropes that are used for commercial fishing or aquaculture. Entanglement has the potential to cause physical injury that can result in loss of reproductive fitness, and mortality of individuals from drowning, impaired foraging and associated starvation, or infection or physical trauma[22]. There was an unconfirmed report of a blue whale entangled in a lobster pot off Portland in 2009.

Marine debris

Marine debris or litter known to harm cetaceans includes discarded or lost fishing gear that can cause entanglement, or plastics such as plastic bags or bottles that can cause problems by ingestion or as entanglement in small cetaceans[22,31,46]. Plastics often float and can travel large distances in the ocean currents, and as they are not generally biodegradable they can remain in the environment for long time periods. Marine debris are found in areas where oceanographic features promote their concentration such as enclosed seas or inside gyres which can trap marine debris like the sub-tropical gyre of the South Pacific Ocean[22,31]. Ingestion of plastics by cetaceans can cause internal damage and the blocking of the digestive tract which can lead to starvation.

Entanglement and ingestion may result in the loss of reproductive fitness or mortality. It therefore has the potential for impeding the recovery of populations if these consequences are impacting a sufficiently large number of individuals.

Marine debris causing entanglement and ingestion was recognised as a key threatening process for vertebrate marine life (including blue whales) in 2003 under the EPBC Act. This lead to the development of the *Threat abatement plan for the impacts of marine debris on vertebrate marine life* to prevent, remove and mitigate the impacts of marine debris[26,27].

Infrastructure /coastal developments

Ports and marinas alter near-shore habitat and therefore are a threat to blue whales in near-shore areas, and oil and gas platforms and rigs can displace animals using offshore waters. The construction of such infrastructure can involve dredging and pile driving which can alter habitat and create underwater noise.

Marine-based renewable energy involves using naturally replenished offshore wind, waves and tidal power for energy. In Australia marine-based renewable energy facilities are a potential future threat to blue whales through potential displacement as there are sites in Australia with appropriate conditions for offshore wind farms, wave and tidal energy facilities[47,50,78]. Currently there are no offshore wind farms in Australia [78] but there are wave energy projects under consideration to operate in the Bonney Upwelling.

Acute and chronic chemical discharge

A wide variety of pollutants can enter the marine environment through processes including dumping, run-off from urban, agricultural or industrial sources, effluents, atmospheric transport and leakage. Marine pollution can have a variety of possible consequences for blue whales at an individual and population level, or indirectly through harming their prey or the ecosystem. In extreme cases, acute chemical discharge such as oil or condensate spills have shown to cause long-term, population-level declines due to toxicity and associated mortality[69]. The threat of toxic marine pollution to the environment is managed through a variety of initiatives. The threat of pollution entering the sea through dumping is managed by the *Environment Protection (Sea Dumping) Act 1981* and the *Environment Protection (Sea Dumping) Amendment Act 1986*. Land-based pollution sources are managed through Australia's National Programme of Action for the Protection of the Marine Environment from Land-Based Activities.

There has been growing concern regarding pollutants that undergo bioaccumulation, which is the accumulation of substances in an organism, and biomagnification, which is the increase in concentration of a substance in an organism up the food chain. Pollutants with these characteristics do not break down quickly in the environment. As marine predators, marine mammals have the potential to accumulate relatively high levels through biomagnification. Blue whales feed directly on krill, which occupy a low level on the food chain, and therefore biomagnification in general would not be expected to have a strong effect on blue whales since there are fewer levels in their food chain[85].

However, these pollutants remain a threat because of the long life history of blue whales and the characteristic of these pollutants to accumulate in fat such as whale blubber.

Persistent organic pollutants (POPs) is one example of pollutants that undergo bioaccumulation and biomagnification[36,53]. They predominately enter the marine environment through atmospheric transport, reaching as far as Antarctica[1,10,112]. They have been produced for a variety of industrial applications or as unintentional industry by-products, or as pesticides such as dichlorodiphenyltrichloroethane (DDT). They were controlled by bans or restrictions in some developed countries including Australia after their toxicity to humans and wildlife was realised in the 1960s and 1970s. Australia became a Party of the Stockholm Convention on Persistent Organic Pollutants in 2004. However the persistence of POPs and their ability to be transported over long distances makes them a continued threat to blue whales off Australia. POPs, including DDTs, have been found in blue whales using waters off Canada[40,79]. POPs have the potential to cause harm in blue whale calves during development, and may affect fertility of mature individuals[8,39].

Heavy metals are also persistent and are able to bioaccumulate and biomagnify. Heavy metal concentrations can increase in the environment through practices including mining and processing, burning fossil fuels, and the use of fertilisers or pesticides containing heavy metals. These can enter the marine environment through run-off, effluents, or atmospheric transport. The effects of heavy metals and its degree of toxicity in cetaceans is poorly understood, but there is evidence that heavy metals may pose a threat in baleen whales through immunosuppression[115].

5E Vessel Disturbance

Vessel disturbance can occur in the form of collisions or by disrupting the behaviour of animals. The type of vessels involved can range from large commercial vessels, to small recreational vessels including personal watercraft such as jet skis.

Vessel Collisions

Collisions will impede recovery of blue whale populations if a sufficient number of individuals in the population lose reproductive fitness or are killed. Although all forms of vessels can collide with whales, severe or lethal injuries are more likely to occur by larger or faster vessels[61,110]. Collisions with calves may be more likely because they spend more time at the surface, are slower, or may need to learn to avoid vessels[61].

The EPBC Act requires all collisions to be reported in Commonwealth waters (i.e. 3 to 200 nautical miles from coast), with similar reporting enacted in state and territory governments (i.e. within 3 nautical miles from the coast). In 2006, a Navy vessel struck and killed a blue whale in the Fremantle shipping lanes off Western Australia, close to the Perth Canyon and within the feeding season[6]. Subsequently, the Western Australian Government and the Navy developed and implemented a successful Navy protocol to reduce vessel collision in the shipping lanes associated with the Fremantle Port.

Since 2006 there have been two records of likely ship strikes of blue whales in Australia. In 2009 and 2010, there were blue whale strandings in Victoria near the Bonney Upwelling with suspected ship strike injuries visible[7,8]. There have been increases in recent years in recreational fishing of southern bluefin tuna (*Thunnus maccoyii*) at the continental shelf waters off Portland and other ports in south west Victoria during the blue whale feeding season, which increases the potential collisions with blue whales in this region. Blue whales in the Bonney Upwelling region regularly feed at the surface on krill aggregations and are likely to be more vulnerable to ship strike.

It is likely this risk will increase as shipping traffic grows, and the impact on an individual could have a significant, potentially population-scale effect, especially as the population numbers of blue whales in Australian waters is not known. The Australian Government is currently developing a national ship strike strategy and developed an online National Ship Strike Database to report any incidents[8].

Whale Watching

Although whale watching can provide educational, conservation and economic benefits, there are also potential negative side effects such as disturbance and physical injury to whales[39]. As blue whale numbers increase, there may be more incentive for increased commercial whale watching targeting blue whales. Generally the whales need to be close to the coast for commercial whale watching to be practical; therefore blue whales offshore, such as in the Perth Canyon, are less likely to be targeted. While whale watching blue whales currently occurs off Geographe Bay, the commercial viability of this operation is likely due to the presence of humpback whales that are present at the same time and more commonly sighted and targeted. Helicopter-based whale watching targeted blue whales off Portland between 2007–10.

Whale watching in Australia is regulated by the Environment Protection and Biodiversity Conservation Act Regulations and reflected in the *Australian National Guidelines for Whale and Dolphin Watching 2005* which have been developed to reduce impacts from whale watching on whales.

5F Overharvesting of prey

The abundance of krill is affected by many key factors including; fisheries, predator-prey nutrient cycling, and climate change.

Antarctic krill, the prey of the Antarctic blue whale subspecies, are the primary Southern Hemisphere species of krill harvested by the krill fishery. It is predicted that expanding the Antarctic krill fishery may cause a slower Antarctic blue whale population recovery from whaling[114]. The Commission established under the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) manages the krill fishery catch limits using a precautionary, ecosystem-level sustainable approach that aims to prevent or minimise negative impacts of the krill fishery on natural krill predators. Australia is a Member of the Commission, and krill fishery catch limits off the Australian Antarctic Territory are managed through the Commission. Continuation of CCAMLR's precautionary ecosystem-level approach in setting krill catch limits should minimise the threat of krill fisheries to Antarctic blue whales.

Antarctic krill abundance may have decreased in the Southern Ocean due to the decrease in predator abundance from whaling. This apparent paradoxical relationship may exist because baleen whales release iron stores in krill through their faeces and thereby increase ocean productivity[109]. This means that recovery of blue whale and other baleen whale stocks may cause a positive feedback loop by increasing krill stocks and consequently further increasing whale stocks. The re-assertion of iron nutrient cycling will also be beneficial for the whole ocean ecosystem.

5.2. Threat Prioritisation

The threats to blue whales identified in the previous section were assessed using a risk matrix which evaluates the likelihood of a threat causing an impact and the consequences of it at the population level. The resulting risk assessments in turn determines the priority for conservation and/or management action. Threat ratings were undertaken for Australian pygmy and Antarctic blue whales separately to account for potential differences in exposure to threats and resulting impacts. Threats may act differently on Antarctic blue and pygmy blue whales and different populations at different times of year, but the precautionary principle dictates that the threat category is determined by the group at highest risk.

Population-wide threats are generally considered to present the highest risk. Where mitigation/management measures for a threat exist, the threat is assessed assuming that these measures are being applied appropriately. For example, the seismic guidelines contain practical measures that minimise the likelihood of physical impacts to whales from seismic surveys. However, measures specific for behavioural impacts are not included in the seismic guidelines.

After consideration of ongoing mitigation, the threat is then classified within the risk matrix, including consideration of

1. Knowledge of the effectiveness of the mitigation/management measure;
2. The coverage of the mitigation/management measure; and
3. The scope of the mitigation/management measure.

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

- Likelihood:
  - Almost certain: expected to occur every year
  - Likely: expected to occur at least once every five years
  - Possible: might occur at some time
  - Unlikely: such events are known to have occurred on a worldwide basis but only a few times
  - Rare or Unknown: may occur only in exceptional circumstances; OR it is currently unknown how often the incidence will occur
- Consequences:
  - Not significant: no long-term effects on individual or populations
  - Minor: individuals are affected but no affect at population level
  - Moderate: population recovery stalls or reduces
  - Major: population declines
  - Catastrophic: population extinction

The level of risk and the associated priority for action are shown in Table 3 using the following criteria:

- Very high: immediate additional mitigation action required;
- High: additional mitigation action and an adaptive management plan required, the precautionary principle should be applied;
- Moderate: obtain additional information and develop additional mitigation action if required; and
- Low: monitor the threat occurrence and reassess threat level if likelihood or consequences change.

Table 3. Risk matrix template

Likelihood of occurrence	Consequences				
	No long term effect	Minor	Moderate	Major	Catastrophic
Almost certain	Low	Moderate	Very high	Very high	Very high
Likely	Low	Moderate	High	Very high	Very high
Possible	Low	Moderate	High	Very high	Very high
Unlikely	Low	Low	Moderate	High	Very high
Rare or Unknown	Low	Low	Moderate	High	Very high

The overall risk matrix for both subspecies is shown in Tables 4 and 5.

Table 4. Pygmy blue whale risk matrix

Likelihood of occurrence (relevant to species)	Consequences				
	No long term effect	Minor	Moderate	Major	Catastrophic
Almost certain		• Commercial fisheries or aquaculture equipment • Shipping noise* • Industrial noise*	• Seismic surveys*		
Likely		• Infrastructure/ coastal development			
Possible		• Marine debris • Aircraft noise • Whale watching • Acute Chemical Discharge (oil or condensate spill)	• Vessel collisions	• Climate variability and change	
Unlikely		• Chronic chemical pollution (toxins)		• Whaling Δ	
Rare or unknown			• Overharvesting of prey Δ		

* Given the behavioural impacts of noise on Pygmy blue whales are largely unknown, a precautionary approach has been taken regarding assignation of possible consequences.

Δ Threat occurs outside Australia.

Table 5. Antarctic blue whale risk matrix

Likelihood of occurrence (relevant to species)	Consequences				
	No long term effect	Minor	Moderate	Major	Catastrophic
Almost certain		• Commercial fisheries or aquaculture equipment			
Likely		• Shipping noise*			
Possible		• Marine debris	• Vessel collisions • Seismic surveys*	• Climate variability and change	
Unlikely	• Whale watching • Aircraft noise	• Chronic chemical pollution (toxins) • Industrial noise • Acute chemical discharge (oil or condensate spill) • Infrastructure/ coastal development		• Whaling Δ	
Rare or unknown			• Overharvesting of preyΔ		

* Given the behavioural impacts of noise on Antarctic blue whales are largely unknown, a precautionary approach has been taken regarding assignation of possible consequences.

Δ Threat occurs outside Australia.

6. Actions

6.1. Summary of Actions to be implemented

A summary of relevant actions identified as part of the plan is displayed below (Table 6). The threat prioritisation carried out as part of this plan identified the threats with highest priority for action. Only actions that address the most significant threats (rated as 'high' (yellow) and 'very high' priority (red)), and those that support the estimation of abundance and measuring population recovery and identification of important habitat have been included. It is expected that every action will progress or be completed during the lifetime of this plan. It is also recognised that during the lifetime of the Plan, the listed priorities below may change. This may be due to the development of new threats or change in risk, the discovery of additional population(s) using Australian waters, or due to an increased knowledge about the two subspecies and three populations. Where needed, the Australian Government will work together with relevant key stakeholders to modify actions under an adaptive management framework.

Table 6. Summary of actions with interim objectives and recovery targets

Actions Area	Population	Priority	Interim Objective	Threats Addressed	Recovery Targets
A: Assessing and addressing threats					
A.1: Maintain and improve existing legal and management protection	Australian pygmy whale	Very high	3	A, B, C, D, E, F	3–1
	Antarctic blue whale	Very high			
A.2: Assessing and addressing anthropogenic noise	Australian pygmy whale	Very high	2, 3, 4	C, D, E	2–1, 3–1, 4–1, 4–2
	Antarctic blue whale	High			
A.3: Understanding impacts of climate variability and change	Australian pygmy whale	High	2, 3, 4	B	2–1, 3–1, 4–1, 4–2
	Antarctic blue whale	High			
A.4: Minimising vessel collisions	Australian pygmy whale	High	2, 3, 4	E	2–1, 3–1, 4–1, 4–2
	Antarctic blue whale	High			
B: Enabling and Measuring Recovery					
B.1: Measuring and monitoring population recovery	Australian pygmy whale	Very high	1	A, B, C, D, E, F	1–1, 1–2,1–3
	Antarctic blue whale	Very high			
B.2: Investigating population structure	Australian pygmy whale	High	2	A, B, C, D, E, F	2–2
	Antarctic blue whale	High			
B.3: Describing spatial and temporal distribution and defining biologically important habitat	Australian pygmy whale	High	2	A, B, C, D, E, F	2–1
	Antarctic blue whale	High			

Previous and existing management actions

Australia has a long-standing commitment to the conservation and management of cetaceans. While this plan focuses on actions to be undertaken to improve the recovery of blue whales, it is important to recognise the context of existing international agreements and national mitigation/management measures that are important to blue whale recovery.

These include:

- International Whaling Commission (IWC) - ensuring that blue whales receive appropriate levels of protection outside Australian waters through involvement in the IWC and improving understanding and management of blue whale populations;
- Intergovernmental Panel on Climate Change (IPCC) - The IPCC is an intergovernmental body of which Australia is a member. The mission of the IPCC is to undertake a comprehensive scientific review of the current state of knowledge in climate change and assess its potential environmental and socio-economic impacts;
- Convention of the Conservation of Antarctic Marine Living Resources (CCAMLR)—CCAMLR established a Ecosystem Monitoring Program (CEMP) in 1989 to monitor and record fishing and krill harvesting in and around Antarctica. In particular, CCAMLR focuses on addressing increases in krill catches in the Southern Ocean and the potentially serious impact of this on marine life that is dependent upon krill as food, such as the blue whale;
- Australian Whale Sanctuary—maintaining the legislative protection afforded to blue whales by the Australian Whale Sanctuary;
- Commonwealth Marine Protected Reserves—take a spatially explicit approach to protecting biodiversity and enhancing resilience. Ten year Management Plans set out key conservation values that include biologically important areas for species listed under the EPBC Act, including blue whales, that must be taken into account when assessing impacts of potential activities and guides research priorities;
- Marine Bioregional Planning—aims to improve decisions made under the EPBC Act. Bioregional plans describe the marine environment and conservation values (protected species, protected places and key ecological features), sets out broad objectives for its biodiversity, identifies regional priorities, and outlines strategies and actions to achieve these. People planning to undertake activities within a marine region can use the information provided in marine bioregional plans and supporting information tools including the conservation values atlas (which maps biologically important areas for species) to determine how to mitigate the potential environmental impacts of their proposal and whether their proposal should be referred in accordance with the EPBC Act;
- EPBC Act Assessment Process and referrals—ensuring that proposals are adequately assessed and reviewed and that appropriate measures are in place to mitigate any potential impacts on blue whales from approved activities. Assessments for offshore petroleum and greenhouse gas activities including seismic surveys in the oil and gas sector are now managed by the National Offshore Petroleum Safety and Environmental Management Authority;
- State and territory legislative arrangements—regulating activities occurring in state or territory waters.

State and territory government partnerships also address the protection of blue whales by improving knowledge on blue whales observed within state and territory waters, and by maintaining and improving existing protection measures for blue whales. Some of these initiatives include:

- Marine protected areas in state waters;
- Raising community awareness;
- Creating whale watching regulations;
- Promoting data sharing;
- National guidance documents for cetacean incidents addressing disentanglement, strandings and euthanasia;
- Supporting the national disentanglement network;
- Undertaking necropsy of carcasses and reporting;
- Developing state based codes of practice for commercial fisheries (e.g. WA and VIC governments);
- Developing state based guidelines for seismic activities;
- Developing state based guidelines for reducing ship collisions; and
- Creation and/or updating of an oil spill response plan.

Existing research actions

Research on blue whales using Australian waters that was completed or is underway has focused on the following areas:

- Characterising historical population parameters such as distribution, abundance and life history characteristics by using historic whale catch data;
- Developing long-term, cost-effective and feasible population abundance and trends methods (e.g. based on distance sampling from ship or aerial surveys, mark-recapture from photo-identifications, cue counting from acoustics, or a combination of those);
- Assessing the distribution, habitat use and seasonality of the two subspecies using acoustic recordings, land-based observations, boat and aerial surveys and spatial modelling;
- Monitoring long-term regional occupancy through boat and aerial surveys, land-based observations and photo-identification catalogues for Bonney Upwelling, Perth Canyon and Geographe Bay areas;
- Assessing spatial connectivity (both national and international) through a recently developed Southern Hemisphere Blue Whale Photo Identification Catalogue;
- Assessing genetic identity and connectivity (both national and international) using genetic methods;
- Characterising foraging habitat and interactions with blue whales, including prey dynamics and influences of climate and ocean processes for feeding areas including the Bonney upwelling and Perth Canyon;
- Assessing migratory pathways and timing, and other long range movements through satellite tagging and acoustic recordings;
- Collecting information on stranded blue whales and undertaking necropsies where possible; and
- Conducting noise exposure experiments with baleen whales (e.g. humpbacks rather than blue whales) to assess changes in whale behaviour, migratory routes and habitat occupancy.

Assessing and addressing threats

The following sections summarise the key action areas including the targets and threats they are addressing.

Action Area A.1	Priority	
Maintain and improve existing legal and management protection	**Pygmy**	Very high
	Antarctic	Very high

Action
1. Continue or improve existing legislative management actions as identified in Section 2 of this Plan. 2. Maintain the currency of management advice and actions

Recovery Targets addressed	**Threats to be mitigated**
3–1	A, B, C, D, E, F

Description
Australia should maintain its position on promoting high levels of protection for blue whales domestically and in all relevant international agreements including the IWC, CITES, CMS, fisheries-related agreements, and the Antarctic Treaty Consultative Meetings (ATCM). All management advice should be informed by current information on their spatial and temporal distribution, Biologically Important Areas and current and developing threats.

Within the life of this plan
Measure of success: Australia continues to develop and implement appropriate domestic legislation to protect blue whales and actively promote the protection of blue whales outside of Australian waters through involvement in the IWC and other fora. *Risks:* Recent changes to domestic environmental assessment processes may result in a reduced level of communication between relevant management agencies. This can be mitigated by periodic meetings and maintaining the currency of policy guidance documents such as Policy Statement 2.1 for the interaction between offshore seismic exploration and whales. *Likelihood of success*: Moderate to high.

Action Area A.2	Priority	
Assessing and addressing anthropogenic noise	**Pygmy**	Very high
	Antarctic	High

Action

Improved management and understanding of what impacts anthropogenic noise may have on blue whales by:

1. Investigating the baseline acoustic behaviour of blue whales;
2. Assessing the effect of anthropogenic noise on blue whale behaviour;
3. Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area;
4. EPBC Act Policy Statement 2.1—Interaction between offshore seismic exploration and whales is applied to all seismic surveys; and
5. Ensuring behavioural impacts are considered when developing and updating policy documents on the management of cetaceans and anthropogenic noise.

Recovery Targets addressed	Threats to be mitigated
2–1, 3–1, 4–1, 4–2	C, D, E

Description

Little is known about noise impacts on blue whales, but it is recognised that mid and low frequency noise can travel through water over long distances and are within the hearing sensitivity range of blue whales. Noise has the potential to cause injury/death, permanent and temporary hearing impairment, masking, and changes in whale behaviour, habitat use, shifts in habitat occupancy and/or migratory pathways. These effects, either in isolation or in combination, can potentially impair population recovery or effect habitat occupancy. Acoustic noise can be generated by vessels, industrial and seismic noise. To address noise from shipping, vessel movements in blue whale aggregation areas need to be quantified, with particular emphasis on regions that are characterised by high shipping traffic.

Within the life of this plan

Measure of success: Improved understanding of the impacts of noise on blue whales and minimise the exposure of blue whales to anthropogenic noise.

Risks: The long-term impact of noise on blue whales may be difficult to assess. This is due to a limited understanding of the long-term effects of noise exposure and of when and to what extent blue whales are exposed to noise. This depends on the characteristic of the noise, environmental factors and the distance of the whales to the noise source. While an understanding of noise impacts may be improved during the time frame of this plan, it is likely to not be clarified in its full extent.

Likelihood of success: Moderate

Action Area A.3	Priority	
Understanding impacts of climate variability and change	**Pygmy**	High
	Antarctic	High

Action

Continue to meet Australia's international commitments to reduce greenhouse gas emissions and regulate the krill fishery in Antarctica.

Recovery Targets addressed	Threats to be mitigated
2–1, 3–1, 4–1, 4–2	B

Description

Climate change may cause changes in the migratory timing and destinations, habitat occupancy, breeding schedules, reproductive success and survival of blue whales. Rapid climate change and ocean acidification is also likely to have an impact on krill, the principle component of a blue whale's diet. Australia's broader policy actions will attempt to combat climate change and manage sustainably the Antarctic krill fishery.

Within the life of this plan

Measure of success: Australia continues its commitment to combat climate change and retains strong engagement within the CCAMLR to sustainably manage the krill fishery in Antarctica.

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

Likelihood of success: Moderate.

Action Area A.4	Priority	
Minimising vessel collisions	**Pygmy**	High
	Antarctic	High

Action

1. Develop a national vessel strike strategy that investigates the risk of vessel strike on blue whales and also identifies potential mitigation measures.
2. Ensure all vessel strike incidents are reported in the National Ship Strike Database.
3. Ensure the risk of vessel strikes on blue whales is considered when assessing actions that increase vessel traffic in areas where blue whales occur and, if required, appropriate mitigation measures are implemented.

Recovery Targets addressed	Threats to be mitigated
2–1, 3–1, 4–1, 4–2	E

Description

An increase in shipping activities in Australian waters suggests the probability of vessel strike involving blue whales may increase. Due to limited information on the abundance and population trend of blue whales in Australian waters and the overlay between shipping lanes and migratory routes and/or biologically important areas for blue whales it is considered a priority to determine the level of impact of vessel strike on this species, and apply mitigation measures as needed.

Within the life of this plan

Measure of success: Completion of a national vessel strike strategy and reporting of vessel strikes to the National Ship Strike Database.

Risks: The vessel strike strategy may not be implemented fully within the life of this Plan.

Likelihood of success: High.

Enabling and measuring recovery

Action Area B.1	Priority	
Measuring and monitoring population recovery	**Pygmy**	Very high
	Antarctic	Very high

Action

Develop and apply cost-effective methods to determine population abundance and trends for the pygmy and Antarctic blue whale subspecies.

Recovery Targets addressed	Threats to be mitigated
1–1, 1–2, 1–3	An improved understanding will allow for better mitigation of threats A, B, C, D, E, F

Description

There has been no precise abundance or trend estimation for blue whale population(s). The most recent and imprecise abundance and trend estimates for Antarctic blue whales are nearly 20 years old.

Within the life of this plan

Measure of success: The delivery of precise estimates of abundance and trend of blue whale populations.

Risks: Insufficient resources to fund the monitoring of blue whale populations.

Likelihood of success: Moderate.

Action Area B.2	Priority	
Describe the population structure of blue whales	**Pygmy**	High
	Antarctic	High

Action

Describe the population structure of Antarctic and pygmy blue whales.

Recovery Targets addressed	Threats to be mitigated
2–2	An improved understanding will allow for better mitigation of threats A, B, C, D, E, F

Description

Recent research has partly clarified the population structure of pygmy and Antarctic blue whales but uncertainties remain particularly in relation to the substructure within Antarctic blue whales. There is a multinational effort to address these uncertainties.

Within the life of this plan

Measure of success: Adequate description of the population structure of Antarctic and pygmy blue whales.

Risks: Insufficient resources to collect the samples and data required to address the uncertainties in population structure.

Likelihood of success: Moderate.

Action Area B.3	Priority	
Describe the spatial and temporal distribution of blue whales and further define Biologically Important Areas	**Pygmy**	High
	Antarctic	High

Action

1. Identify Biologically Important Areas especially feeding and breeding areas.
2. Identify migratory pathways between breeding and feeding grounds.
3. Assess timing and residency within Biologically Important Areas.

Recovery Targets addressed	Threats to be mitigated
2–1	An improved understanding will allow for better mitigation of threats A, B, C, D, E, F

Description

The effective conservation management of blue whales is informed by knowledge of the spatial and temporal distribution of blue whales and identification of their Biologically Important Areas. Blue whales range over very large areas and therefore investigating distribution and habitat use over large geographic scales will be important in identifying feeding and breeding areas.

Within the life of this plan

Measure of success: A robust description of the temporal and spatial distribution of blue whales including the delineation and characterisation of Biologically Important Areas.

Risks: Comprehensive research will be difficult given the wide distribution and relatively low numbers in most regions throughout their range. Given this, all of the research Actions proposed above may not be completed during the lifetime of this plan, especially those pertaining to Antarctic blue whales.

Likelihood of success: Moderate

Cumulative Impacts

For the conservation status of both subspecies to improve so that they no longer meet the criteria for threatened species listing under the EPBC Act, the cumulative impacts of the above listed threats should also be considered.

6.2. Implementation of the Conservation Management Plan

The recovery of the two blue whale subspecies using Australian waters is anticipated to take longer than the 10 year period of this plan. A plan should remain in place until blue whales have improved to a level that the conservation status of both subspecies no longer meets the criteria for threatened species listing under the EPBC Act. This would allow the species to be removed from the threatened species list.

The cost of this plan will be met through various direct and indirect funding providers. These include Commonwealth, state and territory governments, non-government organisations such as marine conservation groups and research organisations, and marine based industries. Key mechanisms and indicative costs to carry out some of the priority actions are outlined below. Costing of other specific actions will be determined at the time of the activity.

Table 7. Key mechanisms and indicative costing to carry out some of the priority actions for blue whales under the Conservation Management Plan for the Blue Whale

Actions	Mechanisms to achieve actions	PYGMY Indicative Cost	ANTARCTIC Indicative Cost
A: Assessing and addressing threats			
A1: Maintain and improve existing legal and management protection	• Continue or improve existing national and state legislative and management actions to minimise anthropogenic threats	Core government business	Core government business
A2: Assessing and addressing anthropogenic noise	• Seismic guidelines are reviewed and updated if necessary • Research assessing impacts on blue whales exposed to anthropogenic noise	Core government business Not less than $5 million Could include contributions from Marine based Industries	Core government business
A3:Understanding Impacts of climate variability and change	• Australian Government climate change adaptation initiatives • Ongoing Commonwealth and state monitoring programs • Ongoing research activity • Government grant programs for new research priorities	Core government business	Core government business
A4: Minimising vessel collisions	• Development and implementation of the Australian Government ship strike strategy to mitigate against vessel / cetacean collisions	Core government business plus $100,000	Core government business
B: Enabling and measuring recovery			
B1: Measuring and monitoring population recovery	• Ongoing Australian and state government monitoring programs • Ongoing research activity • Government grant programs for new research priorities	$500,000 Pilot to determine monitoring technique for population abundance	$3 million per dedicated whale research voyage to Antarctica
B2: Describe the population structure of blue whales	• Ongoing Commonwealth and state research activity. • Government grant programs for new research priorities.	$300,000	$200,000 contingent upon B1
B.3: Describe the spatial and temporal distribution of blue whales and further define Biologically Important Areas	• Ongoing Commonwealth and state research activity. • Government grant program for new research priorities.	$500,000 – $1 million	$500,000 – $1 million

6.3. Reporting Process

A comprehensive monitoring regime for this Conservation Management Plan includes two aspects:

1. Monitoring of the population; and
2. Monitoring of the progress of actions in the plan and detailing the adaptive management for the next plan.

Monitoring the population

Monitoring of the population will occur under Action Areas B1. The aim of this monitoring is to understand the current population abundance and at what rate, if any, each subspecies is recovering. This will determine whether the objectives of recovery, as defined in Section 1.2 of this Plan, are being met.

An important complement to this monitoring is the development of an adaptive management regime for the population. This for example can occur in cases where knowledge on blue whale populations becomes available during the life span of the Plan, potentially creating need for immediate change in management actions to achieve better conservation outcomes.

Monitoring progress towards the actions of the Conservation Management Plan

Monitoring of the plan itself will require tracking the progress of actions designed to improve management of the population and reduce threats. It is anticipated that a midterm (5 year) review of the plan will be conducted using a 'Measure of Success' for each Action Area. This review will identify:

1. Actions that have been completed;
2. Actions that are on track for completion; and
3. Actions that have not commenced.

A process for reporting and review is essential to determine how well the Plan is contributing towards its overall long-term objectives and, specifically, how well it is meeting the interim objectives and their targets within the time frame of the Plan.

Data management

Collection of data on the two known blue whale subspecies using Australian waters, and archiving of these data, is mainly performed by individual researchers and/or research organisations. The Department of the Environment summarises newly collected data on an annual basis in the Australia's Progress Report to the International Whaling Commission.

Data on blue whales usually falls into one of the following categories:

- Sightings;
- Photo-identification;
- Spatial distribution (GPS coordinates);
- Behavioural;
- Acoustic;
- Genetics;
- Satellite tagging;
- Archival tagging;
- Strandings;
- Necropsies;
- Vessel collision, entanglement and/or Injuries;
- Habitat modelling using environmental covariates; and
- Habitat and prey field characteristics.

A central database, the National Marine Mammal Data Portal for strandings, sightings, entanglement and shipstrike data has been developed by the Australian Marine Mammal Centre at the Australian Antarctic Division. It is a repository and existing catalogue for genetic information, archive samples, and collection of photo-IDs. It is recommended that publically funded research data is entered into this centralised database and it would be advantageous if all research from alternative funding source is also entered.

A Southern Hemisphere Blue Whale Photo-Identification Catalogue was recently developed for allowing researchers to upload and match catalogues between different regions for better understanding movements of blue whales and connectivity of populations in the southern hemisphere. An Indo-Pacific Blue Whale Research Consortium was also recently created to assist in collaborative research efforts and communication between research groups working on blue whales in the region.

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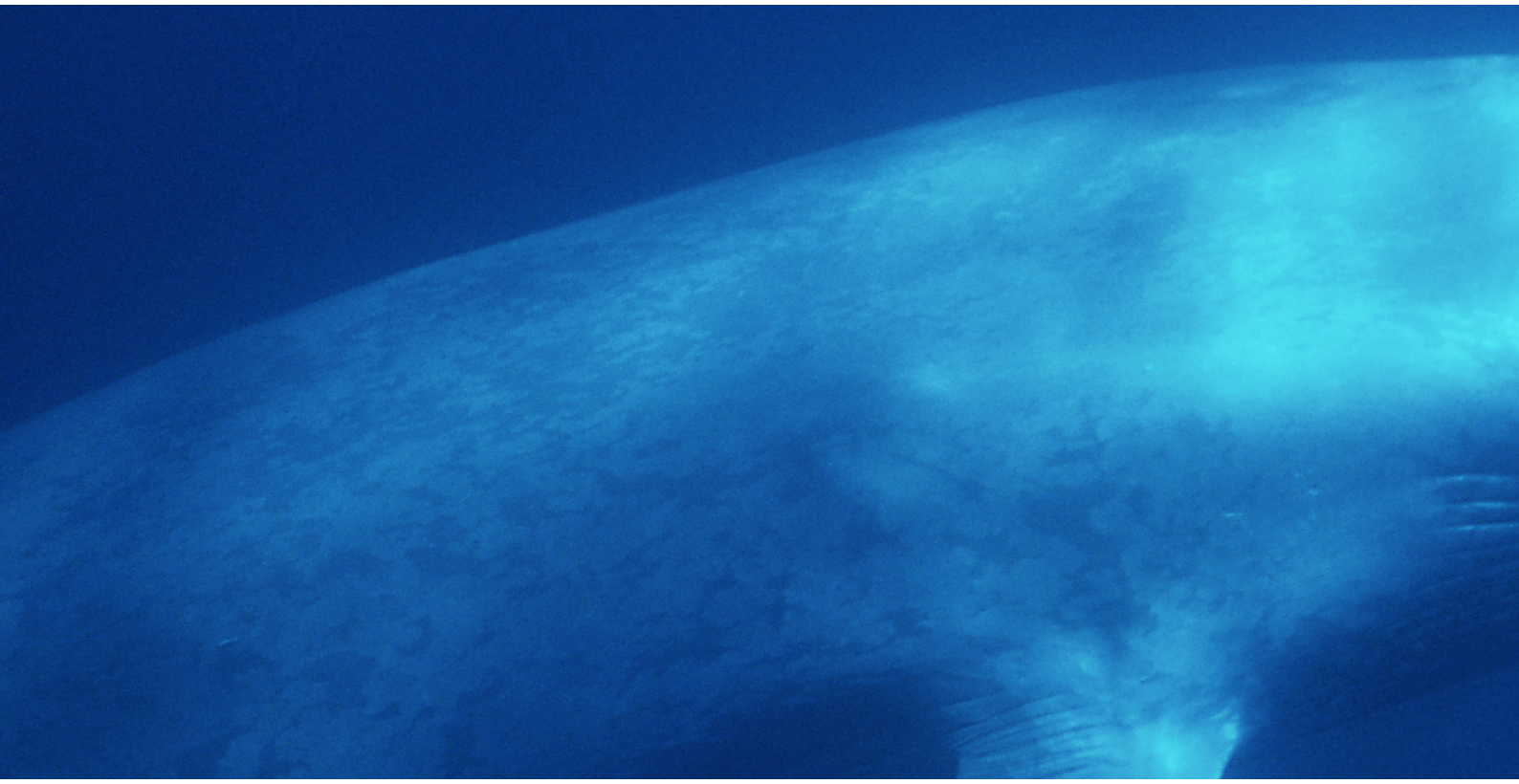

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