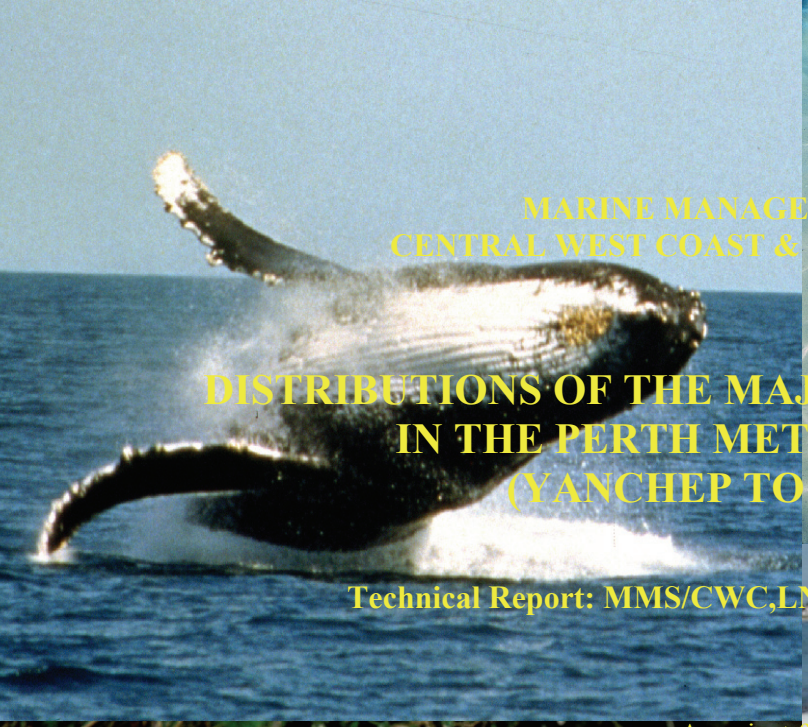
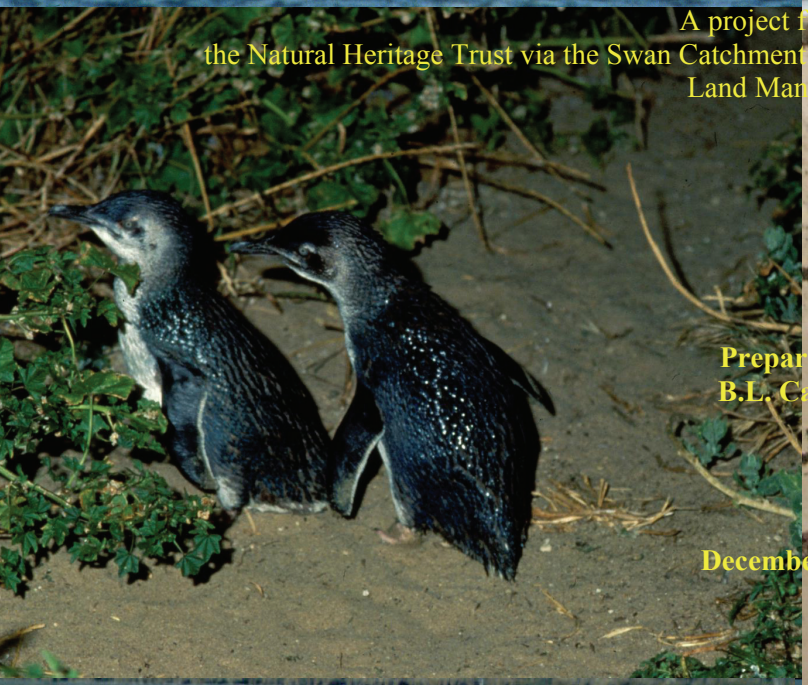



MARINE MANAGEMENT SUPPORT:
CENTRAL WEST COAST & LEEUWIN-NATURALISTE

DISTRIBUTIONS OF THE MAJOR MARINE FAUNA FOUND IN THE PERTH METROPOLITAN AREA (YANCHEP TO MANDURAH)

Technical Report: MMS/CWC,LNE/MMP,SEMP,SIMP - 79/2004

A project funded by
the Natural Heritage Trust via the Swan Catchment Council and the Department of Conservation and Land Management

Prepared by
B.L. Cannell

December 2004


Marine Conservation Branch
Department of Conservation and Land Management
47 Henry St
Fremantle, Western Australia, 6160

Natural Heritage Trust
Helping Communities Helping Australia
An Australian Government Initiative

Government of Western Australia
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Conserving the nature of WA

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Copies of this report may be obtained from:

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SUMMARY

This report supplements the previously poorly documented knowledge on the spatial and temporal distributions of the major marine fauna of the Perth metropolitan area and highlights their important biological features. The marine fauna investigated were cetaceans (humpback, southern right and blue whales and dolphins), Australian sea lions, seabirds (including little penguins) and migratory waders. These six major fauna groups in the Perth metropolitan area potentially come into direct conflict with human activities. Therefore information on the distribution of all these fauna will facilitate understanding the interactions between them and human activities.

The report also documents the current and potential threats to the marine fauna groups and a prioritisation of these threats was undertaken to highlight priority areas for management. Key findings for each fauna group are as follows:

WHALES

Humpback whales, *Megaptera novaeangliae*

- The Western Australian population is estimated to consist of approximately 6000 animals.
- They are the most commonly encountered whales on the west coast.
- In April-August, humpback whales migrate north from their Antarctic feeding grounds to their Kimberley breeding grounds.
- Whales have been sighted as far as 250 nautical miles offshore during their northern migration, while their southern migration route is closer inshore.
- The southern migration occurs from September–November.
- Cows and their calves migrate south two to four weeks after the others and are more likely to be closer to shore, often within five nautical miles.
- Very little research has been undertaken to determine whale migration paths south of Rottnest.
- All age classes use certain areas during the migration for milling/resting and can remain in the region for hours to days at a time.

Southern right whales, *Eubalaena australis*

- There is one Australia-wide population consisting of approximately 1000 whales.
- Only a small proportion of whales visiting southern Australia are observed in the Perth metropolitan area and limited research on southern right whales has been undertaken in this area.
- Females move close to the coast to give birth.
- In Western Australia the main calving area is along the south coast in small isolated bays/beaches.
- The northern migration occurs between May and August, but precise pathways are not known.
- The southern migration occurs between September and November.
- The whales travel very close to the coast within a kilometre of the coastline.
- The cows and calves show a preference for shallow water, sometimes only 4-5 m deep.
- Cows with young calves remain in milling/resting areas for extended periods, perhaps up to a month.
- Other adults are occasionally observed in the milling/resting areas but do not stay for extended periods of time.

Blue whales ('True' blue, *Balaenoptera musculus musculus* and Pygmy blue, *B. musculus brevicauda*)

- Pygmy blue whales are the most commonly observed blue whales in the Perth metropolitan area.
- Approximately 6000 pygmy blue whales and < 1000 'true' blue whales are found in the Southern Hemisphere.
- Studies of blue whale movements in the Perth metropolitan area have been concentrated in the Perth canyon and an offshore area slightly north of it.

- In March/April, whales have been found travelling north from the Perth Canyon along the 115° longitude.
- The migration south occurs from late September – November.
- Cows and calves are found amongst the group.
- Blue whales are found south of Rottnest Island and in the Perth canyon, however seasonal patterns are not known.
- Blue whales are found in the Perth Canyon from November to June, with peak numbers occurring in March/April. The Perth Canyon is an important feeding area for blue whales.

The major threats to whales in the Perth metropolitan area are described as follows:
- whales can collide with a range of watercraft, from recreational watercraft to large commercial ships. Southern right whales are more at risk of being disturbed or hit by vessels because they remain very close to the coast;
- swimming and diving with whales and uncontrolled recreational whale watching can significantly disturb whales;
- whales can become entangled in buoy-lines on pots set for rock-lobster, crab and octopus; long-lines set for tuna and other fish; set-nets; discarded fishing line, rope and twine; and fish nets lost at sea; and
- acoustic disturbance (eg. propeller noise) can affect whales in several ways, including: affecting communication between whales; causing them to spend less time on the surface; causing temporary or permanent hearing problems; and causing abandonment of important habitats.

BOTTLENOSE DOLPHINS, *Tursiops* sp.

- Bottlenose dolphins are found all year round in the Perth metropolitan area.
- They are distributed along the entire coast but may be more abundant in sheltered areas such as embayments.
- Most research has concentrated on dolphins within Cockburn Sound and Owen Anchorage.
- In Cockburn Sound, dolphins most intensively use the shallow sandy bottom Kwinana Shelf and deep basin.
- Mother-calf pairs make up approximately 20% of the population of dolphins in Cockburn Sound. This is higher than other studied populations in the world whose age-sex structure is known.
- Dolphins have high site fidelity, remaining in the same general location year round.

The major threats to dolphins in the Perth metropolitan area include:
- boat strikes, which can cause a range of injuries including propeller wounds to dorsal fins, head and body, and death;
- entanglements in fishing line and fishing nets, which may affect locomotion, the ability to catch food, increase the risk to predation and cause physical injury;
- reduction in food availability through overfishing and destruction of fish habitat;
- provisioning dolphins may lead to dolphins becoming beggars. Provisioning dolphins and habituation to begging can negatively impact the dolphins, such as affecting their social behaviour, increasing their risk of becoming sick, increasing risk of boat injury and line entanglement;
- ecotourism, which can have a range of negative effects such as injury from collisions, habitat displacement, interference with a range of social behaviours and acoustic disturbance.

AUSTRALIAN SEA LIONS, *Neophoca cinerea*

- Australian sea lions are the rarest species of sea lion in the world.
- They occur only in Western and Southern Australia.
- There are approximately 1000 sea lions in the central west coast population.

- Near Perth, sea lions haul out on Seal, Carnac, Penguin, Dyer and Little islands and Burns Rock. The sea lions observed in the Perth metropolitan area are almost exclusively sub adult and adult males.
- Breeding occurs every 17–18 months in Western Australia.
- Sea lions mate and pup on islands of the Cervantes/Jurien region.
- There is no information on where sea lions feed in the Perth metropolitan area or how far they travel to obtain food.

The major threats to sea lions in the Perth metropolitan area include:
- entanglements in fishing nets, fishing line, ropes, hooks, plastic bait bands, lobster pots and plastic bags which may cause lethal wounds, may inhibit feeding or may cause drowning;
- collision or disturbance by watercraft such as boats, jet skis, wind and kite surfers and surf skis;
- hand feeding from boats which may increase their risk of being hit by boats, make them ill or result in aggressive behaviour;
- disturbance by humans at their haul out sites and associated competition for available beach space; and
- reduction in food supply by competition from recreational and commercial fisheries.

LITTLE PENGUINS, *Eudyptula minor*
- Penguin Island is home to the largest colony of little penguins in Western Australia. The Perth metropolitan area represents the northern and western most breeding limit of little penguins in Australia.
- The colony on Penguin Island has the highest conservation status of all major little penguin colonies in Australia.
- Breeding in the Perth metropolitan area occurs between April and December.
- Both parents look after the eggs and chicks.
- Adults feed on several types of small fish including sandy sprat (*Hyperlophus vittatus)*, pilchard (*Sardinops neopilchardus*) and garfish (*Hyporhamphus melanochir*).
- Adults mainly feed on sandy sprat when they are feeding chicks.
- Parents must feed close enough to the colony to be able to return each evening with food for the chicks.
- During breeding, the penguins generally feed in Warnbro Sound and Comet Bay, remaining between the coast and the Murray Reef System.

The major threats to little penguins in the Perth metropolitan area include:
- entanglements;
- collisions or disturbance by watercraft;
- reduction in food supply by human activities depleting or damaging fish nursery areas and by competition from recreational and commercial fisheries which may cause low breeding success or death; and
- trampling by humans at nesting colonies which may injure penguins, destroy their nests or cause the adults to abandon their nests and eggs.

SEABIRDS
- The main seabird species found in the Perth metropolitan area are bridled terns, caspian terns, fairy terns, roseate terns, crested terns, little pied cormorants, pied cormorants, pied oystercatchers, wedge-tailed shearwaters, little shearwaters, pelicans and ospreys.
- Seabirds use a number of islands in the Perth metropolitan area for breeding and roosting.

The major threats to seabirds in the Perth metropolitan area include:

- human disturbance at seabird colonies, which can lead to increased mortality of eggs and chicks, reduced body mass or slower growth of chicks, disruption of nest-site selection, increased predation and population decline;
- boating activity, causing disturbance to roosting, nesting and foraging behaviour; and
- habitat loss or change, which can reduce sites available for roosting or breeding.

MIGRATORY WADERS

- At least 12 species of migratory waders are regularly found in the Perth metropolitan area.
- They come from their breeding grounds as far away as the Arctic, China and Japan.
- They usually arrive in spring and leave in autumn.
- Waders feed on worms, snails, insects and small crustaceans.
- The mudflats, reefs, rocky platforms, protected sandy beaches and sandbars in the Perth metropolitan area are important habitats for migratory waders.
- The Swan Estuary Marine Park and the beach north of the Milyu reserve provide the only remaining significant feeding and/or resting areas (mainly during periods of high tide) in the Swan Estuary.

The major threats to waders in the Perth metropolitan area include:

- watercraft activity, causing disturbance to roosting and foraging. Collisions with watercraft can cause injury or death;
- habitat loss through development, which can reduce sites available for roosting or breeding; and
- humans walking along the foreshore, causing disturbance to roosting and foraging.

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* * *

1. INTRODUCTION

1.1 BACKGROUND

Increasing populations in coastal regions are placing more demands on the land-ocean margins and their ecosystems (Burger 2000). It is now appreciated worldwide that ecological viability of marine systems can only be maintained if an ecosystem approach is taken in management, integrating data on marine fauna, particularly top predators, with oceanographic, jurisdictional and human-use information for the entire system (Borboroglu *et al.* 2004; Campagna & Croxall 2004; Haig *et al.* 1998). Unfortunately, very little is known about the diversity of marine life, making it difficult to determine areas that should be protected. Currently, less than one percent of coastal zones worldwide are protected and the need to gather information on marine fauna and flora has been highlighted by the collaboration between more than 50 countries (including Australia) and over 300 scientists in the Census of Marine Life (CoML). The goal of this ten year programme, instigated in 2000, is to "assess and explain the diversity, distribution and abundance of life in the ocean and explain how it changes over time" (http://www.coml.org/aboutcoml.htm). The CoML will identify biodiversity hotspots worldwide that will help earmark the location of new marine protected areas (Randerson 2003).

On a more local level, an estimated 86% of the population within Australia lives near the coast and an even greater percentage regularly visits it. This places an enormous environmental pressure on the coastal system (Lowe 2004.). Industrial and urban development, recreation, and commercial and recreational industries can impact the coastal environment, and potentially threaten the short and long term viability of the fauna that use this environment. To adequately manage the marine fauna it is therefore imperative to identify spatial and temporal habitats important for each fauna group. The Marine Conservation Branch (MCB) of the Department of Conservation and Land Management (CALM) has obtained funding, through the Swan Catchment Council, from the Natural Heritage Trust to:

- identify the distribution of the major marine fauna that are likely to come in direct conflict with humans in the Perth metropolitan area from Yanchep to Mandurah, namely whales, dolphins, sea lions, seabirds, little penguins and migratory waders;
- identify current and potential threats from human activity to each fauna group in this region; and
- develop priorities for management strategies in the areas of Fundamental Research, Applied Research and Monitoring using a strategic framework based on the relative significance of each fauna group/species, the pressures on each group/species and the adequacy of existing knowledge (Simpson *et al.* 2002).

Data for this study were collected from written resources and direct communication with people whom have expert knowledge of the distribution of marine wildlife in the Perth metropolitan area.

1.2 PURPOSE

The purpose of this report is to:

- provide information, for each of the six selected fauna groups on their conservation status, general ecology, occurrence and potential and current threats in the Perth metropolitan area;
- provide information, in the form of maps, of the spatial and temporal distribution of each of the fauna groups in the Perth metropolitan area;
- document the sources of the marine wildlife information used;
- document the methods used to produce the information layers;

- document the metadata for the GIS information layers, and;
- document the storage location of the GIS information layers.

1.3 METHODS

1.3.1 The study area

The study area for this project extends from Yanchep to Mandurah and includes the Marmion Marine Park, the Swan Estuary Marine Park, the Shoalwater Islands Marine Park, and the Rottnest Island Marine Reserve (Appendix II, Fig. 1). The study area comprises the marine component of the Swan Catchment Council.

2.2 Information sources

Conservation status, general ecology and data layers on spatial and temporal distributions of whales, dolphins, sea lions, little penguins, seabirds and migratory waders were collected from a range of sources both internal and external to CALM.

2.3 Research prioritisation

Marine research and monitoring priorities in the Perth metropolitan area were identified using a generic framework that utilizes a combination of relative significance of each ecosystem value/attribute (V), pressures on the attribute (P) and the adequacy of the existing knowledge (K) (Simpson *et al.* 2002). This framework prioritises marine research and monitoring activities using three simple formulae.

1. Fundamental research (FR) priorities were determined using the formula:
   FR=[V*(12-K)]

2. Applied research (AR) priorities were determined using the formula:
   AR=[V*P*(12-K)]

3. Monitoring (M) priorities were determined using the formula:
   M=V*P

Where V, K and P have values of 1 (low), 2 (medium) and 3 (high) and where:

- V is the value (or significance/importance) of an ecosystem attribute (e.g. seagrass meadow, target fish species etc) and is expressed in conservation (ie. biodiversity significance and ecological importance) and social/economic (ie. recreational, aesthetic, heritage, economic etc) terms;

- K is the adequacy of existing knowledge for conservation and management and is assessed in terms of the adequacy of inventory data (ie. quantitative description), baseline data (ie. spatio-temporal datasets to quantify natural variation), process information (ie. an understanding of key maintenance (growth and reproduction) and linkages to threatening processes) and predictive capacity (ie. to better understand cause-effect linkages and set ecologically sustainable management targets where some change from the 'natural' state is considered acceptable); and

- P represents the pressures (or threats) and are defined as anthropogenic (ie. natural influences are not considered as threats) activities that impact on the ecosystem structure and function. Pressures are assessed in relation to the trophic status of the natural attribute affected (ie. threats to lower trophic levels are considered more 'serious' than those to higher levels of the food web), spatial scale (ie. widespread threats are more 'serious' than localised threats), temporal scale (ie. chronic threats are more 'serious' than 'one-off' threats), probability of the threat occurring and the socio-economic consequences.

Full details of the prioritising framework may be found in Simpson *et al.* (2002).

For the marine fauna investigated in this report, fundamental research priorities were identified using this framework (Appendix IVa). The major threatening processes were also identified to determine priorities for applied research (Appendix IVb) and monitoring (Appendix IVc). The prioritisation process was undertaken in-house.

1.4 METADATA

The simplest definition of metadata is 'data about data'. It describes the content, quality, currency and availability of the data. A 'metadata' description of a particular data set will typically include detailed information on data collection methods, processing history, content, quality, accuracy, geographic extent and contact (source) information pertaining to the data. This information is important so potential users of existing data can identify the access constraints placed on the original data and assess its suitability for other purposes.

The metadata associated with the marine wildlife distribution data presented in the series of maps produced in this project are included as Appendix V.

1.5 DATA MANAGEMENT

1.5.1 Report

Hard copies of this report will be held at the following locations:

1. MCB, Department of Conservation and Land Management, 47 Henry Street, Fremantle, Western Australia, 6160. Ph: (08) 9336 0100, Fax: (08) 9430 5408.

2. Woodvale Library, Science and Information Division, Ocean Reef Road, Woodvale, Western Australia, 6026. Ph: (08) 9405 5100, Fax: (08) 9306 1641.

3. Archives, Woodvale Library, Science and Information Division, Ocean Reef Road, Woodvale, Western Australia, 6026. Ph: (08) 9405 5100, Fax: (08) 9306 1641.

The MCB holds digital copies of biological inventory Marine Management Support (MMS) or Marine Reserve Implementation (MRI) reports at the following locations:

1. The MCB Server: Sharedata on 'Calm-frem-1' [T:\144-Marine Conservation Branch\Shared Data\Current_MCB_reports\MMS\MMS_7904].

2. MCB Server full backup DAT tape: [T:\144-Marine Conservation Branch\Shared Data\Current_MCB_reports\MMS\MMS_7904].

3. CD-ROM held at MCB.

4. CD-ROM with the archived hard copy of the report held at the Woodvale Library, Science and Information Division, Ocean Reef Road, Woodvale, Western Australia, 6026. Ph: (08) 9405 5100, Fax: (08) 9306 1641.

5. MCB homepage on the Department of Conservation and Land Management Intranet CALMweb: http://www.calmweb.calm.wa.gov.au/drb/ncd/mcb/rep_pap.htm.

1.5.2 GIS layers

The data presented in the form of GIS layers will be stored digitally in the Marine Information System (MIS) on the MCB Server and the MCB Server full backup DAT tape. File names for the GIS layers are as follows:

1. whales-humpback_s_20040420_II_gda94.shp
2. whales-right-_s_20040503_II_gda94.shp
3. whales-blue_s_20040407_II_gda94.shp
4. whales-minke_s_20040302_II_gda94.shp
5. dolphins-survey-bd_s_20031201_II_gda94.shp
6. dolphins-survey-hf_s_20031201_II_gda94.shp
7. dolphins-survey-transect-hf_s_20031201_II_gda94.shp
8. dolphins-survey-hf_s_20030704_II_gda94.shp
9. dolphinpods-survey-kw_s__1997_II_gda94.shp
10. sealions_s_20040531_II_gda94.shp
11. birds-penguin_s_20040420_II_gda94.shp
12. birds-penguin_s_20031203_II_gda94.shp
13. birds-sea-survey_s_20040604_II_gda94.shp
14. birds-wader-survey_s_20040608_II_gda94.shp
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2. WHALES

Western Australia has the most comprehensive list of cetacean fauna of all the states (Bannister *et al.* 1996). The main whale species that utilize the Perth metropolitan waters are:

- Humpback whales *Megaptera novaeangliae*
- Southern right whales *Eubalaena australis*
- Pygmy blue whales *Balaenoptera musculus brevicauda*
- Minke whales *B. acutorostrata*

A number of other species have also been observed in the Perth metropolitan region, particularly around the Perth Canyon located west of Rottnest. Whale species sighted in the canyon include pygmy blue whales, humpback whales, southern right whales, true blue whales (*B. musculus*), fin whales (*B. physalus*), sperm whales (*Physeter macrocephalus*) and rare sightings of beaked whales (Burton pers. comm.; Jenner & Jenner pers. comm.; Johnson 2002; McCauley *et al.* 2003). Thus the canyon appears to be an extremely important area for a number of species, and it appears to be an area used for feeding. More recently, Killer Whales (*Orcinus orca*) have been sighted off the west end of Rottnest (Coughran pers. comm.).

2.1 CONSERVATION STATUS

All cetaceans are protected in Australian waters. Commonwealth laws apply within the 200 nautical mile Exclusive Economic Zone, and State laws apply within three nautical miles of the coast. Under the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act 1999), an Australian Whale Sanctuary has been established in all Australian Commonwealth waters. In these waters it is an offence to kill, trade, take, keep, interfere with or treat a cetacean (see Appendix IIIb for further clarification). Interference has been defined as harassing, chasing, herding, tagging, marking or branding a cetacean. Harassment is identified by any significant change in the behaviour including a significant deviation from a migratory path or substantial change in respiration or swimming pattern (EPBC Act 1999).

All the whale species found in the Perth metropolitan waters are listed in various categories of a number of conservation acts (Table 1).

The Natural Heritage Trust 2 (NHT2) has formed a Bilateral Agreement between the Western Australian State Government and the Commonwealth Government. That agreement specifies priorities for the delivery of marine and coastal natural resource management, through the Coastcare funding stream of NHT2. CALM has responded to the Coastcare priorities of the bilateral agreement through the development of a set of biodiversity conservation management priorities, resulting in a set of priorities for each NHT2 region and a set that addresses Statewide issues. As part of this process a risk assessment was undertaken. Blue whales, humpback whales and southern right whales in the Perth metropolitan area were assessed as having a high conservation value and medium relative threat (Department of Conservation and Land Management 2003) (Appendix I). In Simpson and Holley (2003), blue whales in Western Australia were also acknowledged as a species 'in distress' and requires an emergency response.

Humpback whales were acknowledged as a species:

- where 'sub-populations', groups or individuals are 'at risk' from commercial tourism;
- where 'sub-populations', groups or individuals are 'at risk' from recreational interaction; and
- 'in distress' and requires an emergency response.

Southern right whales were acknowledged as a species:

- possibly where 'sub-populations', groups or individuals are 'at risk' from commercial tourism; and
- 'in distress' and requires an emergency response

Table 1. List of state, commonwealth and/or international statutes protecting each species.
(See Appendix III for details of each category)

Species	Status
Humpback whale	Vulnerable (EPBC 1999) Migratory (EPBC 1999) Schedule 1 (WAWCA 1950) Vulnerable A1 ad (IUCN 2004) Appendix I CITES (UNEP 2003) Appendix 1 Bonn Convention*
Southern Right whale	Endangered (EPBC 1999) Migratory (EPBC 1999) Schedule 1 (WAWCA 1950) Lower risk cd (IUCN 2004) Appendix I CITES (UNEP 2003) Appendix 1 Bonn Convention
Pygmy Blue whale	Endangered (EPBC 1999) Schedule 1 (WAWCA 1950) Data deficient (IUCN 2004)
Minke whale	Appendix I CITES (UNEP 2003)
Blue whale	Endangered (EPBC 1999) Schedule 1 (WAWCA 1950) Endangered A1 abd (IUCN 2004) Appendix I CITES (UNEP 2003) Appendix 1 Bonn Convention
Fin whale	Vulnerable (EPBC 1999) Schedule 1 (WAWCA 1950) Appendix I CITES (UNEP 2003)
Beaked whales	Data deficient (IUCN 2004) Appendix I CITES (UNEP 2003)
Sperm whales	Vulnerable A1 bd (IUCN 2004) Appendix I CITES (UNEP 2003)
Killer whales	Appendix I CITES (UNEP 2003)

*Bonn Convention- the Convention on the Conservation of Migratory Species of Wild Animals

2.2 GENERAL ECOLOGY

2.2.1 Humpback whales

In the Southern Hemisphere there are at least six separate populations of humpback whales. The Western Australian population is estimated between 8,200-13,600 animals (Bannister & Hedley 2001) and they are the most commonly encountered whales on the west coast. They spend the summer feeding in Antarctic waters on krill (*Euphausia superba*) and there is some evidence that they feed on fish and plankton swarms in warmer waters (Bannister *et al.* 1996). They migrate north to breed and

calf in tropical waters during winter (Bannister *et al.* 1996). The Western Australian population breeds along the entire coast but the main calving areas are in the Kimberleys (Jenner *et al.* 2001; Jenner & Jenner 1995).

Humpback whales perform a variety of surface behaviours such as flipper and tail slaps, lobtailing, spyhopping and breaching. These behaviours appear to often be associated with courtship/breeding (Bannister *et al.* 1996).

2.2.2 Southern right whales

Southern right whales feed in Antarctic waters during summer, mainly on krill and smaller plankton such as copepods and pelagic larval crustacea (Bannister *et al.* 1996; Burnell & McCulloch 2001). They migrate northwards to warmer waters in winter (Bannister *et al.* 1997). The whales seen in Western Australia are thought to belong to one Australia-wide population, although individuals appear to have high site fidelity to particular regions (Burnell & McCulloch 2001 and references within). The Australian population has an estimated abundance of around 1000 whales (Bannister *et al.* 1996; Burnell & McCulloch 2001) and although it is thought to be increasing, it is far from secure and still remains at only a small fraction of the pre-exploitation level (Burnell & McCulloch 2001). The whales observed in the Perth metropolitan area represent only a small proportion of animals visiting southern Australia with approximately 10-20 animals seen in the Perth metropolitan area each year (Burton pers. comm.; Coughran pers. comm.).

The females move close to the coast to give birth in small isolated bays/beaches. The main calving area in Western Australia is along the southern coast (Bannister 1986), however limited observations of cows with young calves in the Perth metropolitan region indicate that a small proportion of females give birth along the coast near Perth. The locations of calving areas in this region are yet to be confirmed (Burton pers. comm.).

The whales display various surface behaviours such as fluking, tail slaps, flipper slaps, rolling, belly up for extended periods and breaching (Bannister *et al.* 1996)

2.2.3 Blue whales

The blue whale is the largest of all whales. Pygmy blue whales are commonly observed in the Perth metropolitan area. The presence of 'true' blue whales off Perth has been confirmed using acoustic techniques (Burton pers. comm.; McCauley *et al.* 2003). Both species spend the summer months feeding primarily in Antarctica and cold temperate waters mainly on krill, copepods and amphipods (Bannister *et al.* 1996; Rafic 1999), although there are also reports of these feeding in warmer waters (Bannister *et al.* 1996; Rafic 1999 and references within). They migrate to breeding grounds in warmer waters, but no specific breeding grounds have as yet been identified. In the Southern Hemisphere, there are thought to be < 1,000 'true' blue whales and approximately 6,000 pygmy blue whales (Bannister *et al.* 1996).

2.2.4 Minke whales

Minke whales feed in cold waters mainly on krill and migrate to warmer waters for breeding. However their migration routes and breeding grounds have not been identified. They are very difficult to observe at sea as they are noted to evade ships and hardly break the surface with an inconspicuous blow (Bannister *et al.* 1996; Jenner & Jenner pers. comm.). There are an estimated 90,000 animals in the area IV population, which extends from 70-130ºE (Bannister *et al.* 1996). It is likely that a tropical sub-species, rerferred to as "dwarf minke"and similar to that described off Eastern Australia, occurs from NW Cape northwards. It is believed that dwarf minke whales may not migrate to polar regions.

2.3 OCCURRENCE

2.3.1 Humpback whales

In Western Australia, the movements of humpback whales have been studied from Bunbury southwards and from Jurien northwards (Jenner *et al.* 2001), but limited research has been undertaken in the Perth metropolitan area (Burton pers. comm.; Coughran pers. comm.; Jenner & Jenner pers. comm.; McCauley pers. comm.). In 1989, commercial whale watching began during the southern migration in the area between Fremantle, Rottnest and Hillary's Boat Harbour. During each trip whale location information, photo identification, pod structure, and general activity of the whales have been recorded. A long term data base with this information has been established and maintained by Chris Burton (Burton pers. comm.).

Southern migration

Humpback whales are seen migrating southwards in the Perth metropolitan area from September to November (Appendix II, Fig. 2). Adolescents, adult males and non-breeding females begin their southern migration before the cows and their calves, who typically follow 2-4 weeks later (Chittleborough 1965). North of Rottnest, the outer limit of the southern migration is not clearly defined but is known to be somewhere within the 200 m bathymetry (Jenner *et al.* 2001). It is believed the cows and calves are more likely to be closer to shore, even within 5 nautical miles (Jenner & Jenner pers. comm.). A migratory bottleneck occurs between the west end of Rottnest and the 200m contour, 10 nautical miles off the island, as southbound pods move between Perth and Geographe Bay (Jenner & Jenner pers. comm.). In some years, naval vessels have detected humpback whales much further offshore at times when whale watch operators were encountering fewer whales in the usual areas closer to shore. This is possibly linked with the Leeuwin Current (McCauley pers. comm.). South of Rottnest some whales travel in a southerly direction towards Geographe Bay whilst others travel more south-westerly, however, the precise pathways and other associated data such as group structure are not known (Jenner & Jenner pers. comm.). It is likely that cow/calf pairs remain in shallower waters than adult or adolescent pods.

Milling/resting area

A milling/resting area is located north of Rottnest (Appendix II, Fig. 2). All age classes use this area throughout the southern migration period and individual whales can remain in the region for hours to days at a time (Burton pers. comm.; Coughran pers. comm.; Jenner & Jenner pers. comm.). Cows with calves may use this area for longer periods (Burton pers. comm.), however more research is needed to obtain detailed information.

Northern migration

The northern migration is even less clearly defined than the southern migration (Burton pers. comm.; Coughran pers. comm.; Jenner & Jenner pers. comm.; McCauley pers. comm.). The whales migrate northwards from April to August (Burton pers. comm.; Coughran pers. comm.; Jenner & Jenner pers. comm.) and the route tends to be more offshore than the southern migration route, with whales sighted as far as 250 nautical miles offshore (Jenner & Jenner pers. comm.) (Appendix II, Fig. 2). The whales' feeding grounds in Antarctica from November to April may determine where they close with the WA coast (Jenner *et al.* 2001). For example, if the whales were feeding in an area south of Esperance, they are more likely to meet the coast near Esperance whereas whales feeding further west may not close the coast until Geraldton or Shark Bay (Jenner *et al.* 2001).

2.3.2 Southern right whales

In Western Australia, research on southern right whale movements has been concentrated along the southern coast. Limited research has been undertaken in the Perth metropolitan area (Burton pers.

comm.; Coughran pers. comm.). For example, during the commercial whale watching season, observations and locations of southern right whales in the area between Fremantle, Rottnest and Hillary's Boat Harbour have been noted (Burton pers. comm.). Also, southern right whales locations have been noted during aerial surveys undertaken primarily to locate blue whales (Burton pers. comm.; McCauley *et al.* 2003).

Southern migration

Southern right whales are observed migrating south in the Perth metropolitan area from September to November (Appendix II, Fig. 3). They remain close to the coast and can often be seen moving along passages through the reefs to get to the outer breaks (Burton pers. comm.; Coughran pers. comm.). The females with calves have a preference for shallow water, with minimum depth requirements of 4-5 m (Burton pers. comm.). They can be found within all the coastal bays in the region, but are unlikely to move under the Causeway in Cockburn Sound (Coughran pers. comm.).

Milling/resting area

A milling/resting area for southern right whales is found extending approximately from Hillary's Boat Harbour south to the mouth of the Swan River and west to Rottnest (Appendix II, Fig. 3). Cows with young calves will remain within this area for extended periods of time, perhaps a month or more, but more research is required to determine this accurately. Elsewhere in Australia, cows and calves have been observed to reside in particular areas for three times longer than non-calving whales (Burnell & Bryden 1997; Burnell & McCulloch 2001). Other adults are occasionally observed in the milling/resting area here but do not stay for extended periods of time.

Northern migration

There is no information available for the routes travelled by southern right whales as they head towards Western Australia from their southern summer feeding grounds. Some animals have been seen close to the coast in the Perth metropolitan area heading north between May and August (Coughran pers. comm.).

2.3.3 Blue whales

For the Perth metropolitan area, studies of blue whale movements have been concentrated in the Perth canyon and an offshore area slightly north of it (Burton pers. comm.; McCauley *et al.* 2003). There are also some locational data for blue whales between between Fremantle, Rottnest and Hillary's Boat Harbour that have been taken during the commercial whale watching season (Burton pers. comm.). The level of information on blue whale migration routes is poor.

Southern migration

The whales migrate south between late September and November and are thought to remain within the 100 m bathymetry line (Appendix II, Fig. 4). Cows with calves are present in the group during the southern migration but the location of calving areas in Western Australia is not known (Burton pers. comm.; Coughran pers. comm.; Jenner & Jenner pers. comm.; McCauley pers. comm.). The calves seen in the Perth metropolitan area are presumed born in that same year (Burton pers. comm.). A migratory bottleneck occurs just north of Rottnest as the whales head in a westward direction. South of Rottnest it is not known where the whales travel and the only information available south of the Perth Canyon is that whales are found within the 1000 m contour (Burton pers. comm.; Coughran pers. comm.; Jenner & Jenner pers. comm.; McCauley pers. comm.).

Perth canyon

This is an important feeding area for the whales (Appendix II, Fig. 4) although very few calves have been sighted here. The whales are mainly found close to the canyon walls. These are areas of high productivity and therefore abundant food. Acoustic research has found the whales here from November to June, with peak numbers of whales in Feb/March (Burton pers. comm.; Jenner & Jenner pers. comm.; McCauley pers. comm.; McCauley *et al.* 2003).

Travelling corridor

North of the Perth Canyon the whales are thought to mainly travel in a fairly narrow corridor centered around the 115° longitude line (Appendix II, Fig. 4). The whales travel both northwards and southwards in this area (Burton pers. comm.; Jenner & Jenner pers. comm.; McCauley pers. comm.; McCauley *et al.* 2003).

Northern migration

Blue whales are found within the 1,000 m depth contour south of the Perth Canyon. They mainly travel northwards from the Perth Canyon in March and April (Burton pers. comm.; Coughran pers. comm.; Jenner & Jenner pers. comm.; McCauley pers. comm.; McCauley *et al.* 2003) (Appendix II, Fig. 4). However very little research has been undertaken to determine the northern migratory routes of the blue whales and therefore more accurate information is not available.

2.3.4 Minke whales

In the Perth metropolitan area minke whales are mainly observed in areas north and west of Rottnest usually in waters < 200 m deep (Coughran pers. comm.; Jenner & Jenner pers. comm.) (Appendix II, Fig. 5). Anecdotal observations suggest they migrate south between the 30 m and 100 m depth contours but seasonal patterns are not known (Jenner & Jenner pers. comm.). It has also not been established whether these whales are true minkes or dwarf minkes.

2.4 CURRENT THREATS

The current major threats to whales in the Perth metropolitan area are:

- boat strikes;
- entanglements; and
- human disturbance:
  - whale watching; and
  - acoustic disturbance.

2.4.1 Boat strikes

Boat strikes from small recreational craft, large cargo ships, fishing boats and fast, highly maneuverable naval vessels pose a risk to all cetaceans. Studies indicate that the most lethal injuries occur particularly with strikes by ships > 80m in length (Laist *et al.* 2001). Ship speed also affects injury scale, with 89% of lethal or most severe injuries occurring at boat speeds of 14kn or faster, and 11% at speeds from 10-14kn (Laist *et al.* 2001). Areas of greater risk could be those preferred by nursing or juvenile right whales and humpbacks (Laist *et al.* 2001). Boat strikes on cetaceans in Australian waters are not well documented. The probability of boat strikes are greater where shipping and recreational boating are concentrated in habitats such calving and nursing sites, and along migration routes (Bannister *et al.* 1996). The boat traffic between Hillarys to Rottnest and Fremantle to Rottnest is increasing, as is the number of whales found along the coast, thus the probability of boat strikes with whales is also increasing (Coughran pers. comm.).

Southern right whales are more at risk from being struck by boats due to their close proximity to the coast, the presence of cow-calf pairs, and their surface skim feeding (Burnell & McCulloch 2001). Indeed there are anecdotal claims within Australia of southern right whales being struck and wounded by pleasure craft (Burnell & McCulloch 2001).

2.4.2 Entanglement

Small whales become entangled in set-net fisheries in Australia, and buoy-lines on pots set for rock-lobster, crab and octopus and long-lines set for tuna and other fish occasionally entangle large species such as southern right, humpback and sperm whales (Bannister *et al.* 1996;Shaugnessy *et al.* 2003). However, the actual rate of incidence is unknown and is poorly documented (Bannister *et al.* 1996). The propensity for southern right whales to move close to the shore and travel between coastal locations increases their risk of becoming entangled in lines and nets used in nearshore fisheries (Burnell & McCulloch 2001). Since 1990, three southern right whales and 28 humpback whales have been found entangled in Western Australia, mostly in lobster fishing gear (Coughran pers. comm.). It is believed that this under estimates the number of cetaceans caught in gear however due to poor reporting and the fact that most deaths occur at sea (Coughran pers. comm.). The threat of entanglement is increased in migratory bottleneck areas and other high density areas such as resting or calving grounds e.g. the area just off the west end of Rottnest during the southern migration of humpbacks (Jenner & Jenner pers. comm.) and during June when there is a crossover of the lobster season with the northerly whale migration (Jenner & Jenner pers. comm.; McCauley pers. comm.).

The deep-sea crab fishery, which fishes outside the 150 m depth contour, is of potential concern. Pots typically have a substantial length of slack in their ropes with up 100 m to 200 m of line lying on the surface. In the 2003/2004 summer, deep-sea crab pots were set in the Perth Canyon. As this is a major feeding ground for many cetaceans there is a potential for entanglements. The humpback whales travelling on their offshore northerly migration may also encounter these pots. It is possible that the large diameter of these pot lines may be a mitigating factor in entanglement likelihood.

Large amounts of fish netting lost at sea (ghost nets) as well as smaller pieces of netting, fishing line, rope and twine that are abandoned or discarded at sea also pose threats to whales (Bannister *et al.* 1996; Shaugnessy *et al.* 2003). Associated entanglements affect locomotion, the ability to catch food, increase the risk to predation and may cause physical injury by constant abrasion and individual strands cutting deeply into subdermal tissues (Bannister *et al.* 1996).

2.4.3 Human disturbance

Whale watching

Whale watching from both commercial and recreational vessels can cause significant disturbance, particularly if the vessels show (Bannister *et al.* 1996):

- a persistent intrusive approach;
- fast maneuvering under power; and
- congestion of vessels when few animals are available for viewing.

Noise production from vessels, vessel type, and the station keeping capacity of the vessel and skill of the skipper also factor in the disturbance to the whales. Whales showed the greatest response when the noises changed suddenly, increased rapidly or when the vessels required repeated maneuvering to remain at a specific site (McCauley & Cato 2003; McCauley *et al.* 1996).

Possible consequences from disturbance caused by whale watching include abandonment of preferred habitats for less secure locations for calving and nursing, increased risk of collision with coastal shipping, breakdown in social or maternal behaviours, interruption of foraging, noise trauma and

increased exposure to natural predators (Bannister *et al.* 1996; Burnell & McCulloch 2001; Marsh *et al.* 2003). There is concern for the cumulative effects locally and on migratory paths (Marsh *et al.* 2003). The risk of such consequences would appear to be very high in particular for southern right whales due to their propensity to remain close to the shore and for cow-calves to stay resident in certain areas for extended periods of time (Burnell & McCulloch 2001).

Currently, there is good cooperation between the Perth based whale watching industry and government (Burton pers. comm.; Coughran pers. comm.). However, the Department of Conservation and Land Management can only maintain their profile on the water adjacent to Hillarys, Rottnest and Fremantle, so the behaviour of recreational boat operators outside these areas cannot be checked using conventional vessel-based surveillance (Coughran pers. comm.).

Swimmers and divers can also disturb cetaceans (Bannister *et al.* 1996).

Acoustic disturbance

Whales use acoustic signals for location of prey, information about their environment and communication. They use passive listening to gather information such as local sea state, wind strength and approaching storms (McCauley & Cato 2003). Man-made sound may affect whales in various ways, including (McCauley & Cato 2003):

- adverse effects on prey species, such as causing them to leave regions subjected to seismic survey;
- masking of signals of interest;
- behavioural responses;
- temporary shifts in hearing ability;
- permanent shifts in hearing ability; and
- damage to hearing and other organs.

Acoustic interference from ships and boats can lead to a variety of responses from cetaceans including changes in vocalization patterns, propensity to approach the vessel, deep diving, reduced time on the surface, and orientation of mother between calf and vessel (Truelove 1997). Communication between humpbacks has been shown to be adversely affected by vessel noise as it can mask their communication (McCauley *et al.* 1996). Repeated acoustic disturbance may result in the abandonment of important habitats (Bannister *et al.* 1996).

Many vessels involved in offshore seismic surveys use air guns that release compressed gas into the water. Humpback whales have shown a number of responses to such vessels and airguns, dependent on whether they were migrating or sedentary in key habitats. These responses include (McCauley *et al.* 2000):

- avoidance of vessels by up to 7-12 km in a key habitat;
- increased time spent at the surface whilst the air guns are operating, presumably to reduce the air gun sound they receive;
- male humpbacks appear to be attracted to the noise of the air guns possibly as the sound is similar to that of a female whale breaching;
- a startle response and an investigative response, both which result in whales coming to the surface; and
- course and speed changes so as to pass around the vessel.

The effects of seismic surveys may be greatest in areas of breeding and calving (McCauley *et al.* 2000).

There have been very few studies on the impacts of sonar on marine mammals. It has been shown to affect cetaceans by causing them to swim away from the area, altering their dive cycles or calling

patterns (Truelove 1997). Low frequency active sonar has also been shown to cause male humpbacks to sing longer songs, which may affect demographic parameters (Miller *et al.* 2000).

The thresholds for acoustic disturbance of southern right whales are unknown as there is no detailed audiogram for the species (Burnell & McCulloch 2001). Therefore impacts of various noises on this species cannot be determined.

2.5 POTENTIAL THREATS

The major potential threats to whales in the Perth metropolitan area are:

- pollution:
  - oil spills;
  - chemical contaminants;
  - plastic debris; and
  - water quality;
- industrial activity;
- reduction in food resources; and
- commercial whaling.

2.5.1 Pollution

Oil spills

Major spills are likely to occur following the wreck or collision of a bulk cargo. In 1991the Bureau of Transport and Communications Economics estimated an 84% risk of a major spill in Australian waters in the next 20 years (Bannister *et al.* 1996). Most input of oils however comes from small-scale spills and routine discharges from industrial plants and shipping (Bannister *et al.* 1996).

Oil can contaminate the skin, mucous membranes and the baleen. It can block the digestive tract and cause acute poisoning (Bannister *et al.* 1996). The impact of cumulative chronic petroleum pollution is unknown, but is likely to be significant (Bannister *et al.* 1996).

Oil spills within feeding or calving habitats are of greatest concern as they pose the greatest threat to the population (Burnell & McCulloch 2001).

Chemical contaminants

Baleen whales feed at the lower end of the food chain and therefore tend to have lower concentrations of organochlorines such as DDT and polychlorinated biphenyls and very low levels of heavy metals, since these materials are not concentrated in their prey (Bannister *et al.* 1996).

Plastic debris

Whales can ingest plastic materials accidentally whilst feeding, and calves and juveniles can play with such objects and therefore risk ingesting them (Bannister *et al.* 1996; Burnell & McCulloch 2001). Such ingestion can cause lethal blockages, ulceration of the digestive tract and a lowered feeding activity (Bannister *et al.* 1996).

Water quality

Water quality is more likely to affect southern right whales due to their inshore habits. Contamination of the coastal areas utilized by this species is of increasing concern as the population expands (Burnell & McCulloch 2001).

The Sepia Depression is a north-south natural underwater channel found to the west of Garden Island, Rockingham and Warnbro Sound (D'Adamo *et al.* 2000). Secondary treated effluent from the Woodman Point wastewater treatment plant and primary treated effluent from the Point Peron wastewater treatment plant are discharged into the Sepia Depression via the Sepia Depression ocean outfall (previously known as the Cape Peron ocean outfall). This outfall is the largest single point source of nutrients into the region. Northerly to north-westerly winds can drive water from Cockburn Sound and the Sepia Depresssion ocean outfall into Shoalwater Bay and Warnbro Sound, thus potentially bringing a suite of chemical contaminants, nutrients and biological organisms (D'Adamo *et al.* 2000). The extended reef system running parallel to the coast and extending from near Geraldton to Mandurah reduces water exchange between the embayments and the open sea. Thus contaminated water can remain in the embayments for extended periods (D'Adamo *et al.* 2000).

2.5.2 Industrial activity

Any industrial activity on the coast will harbor a suite of potential threats already mentioned including: increased underwater noise, pollution (e.g. bio-wastes, increased nutrient loading), oil spills, increased vessel traffic and therefore probability of collisions and increased competition for preferred or critical habitat (Burnell & McCulloch 2001).

The impact of any of the above threats is dependent on where the impact occurs, how repetitive or widespread it is, and how many individuals are affected. Effects on pregnant or lactating females have the potential to affect the reproductive success of the whole population (Burnell & McCulloch 2001)

2.5.3 Reduction in food resources

Large scale pelagic commercial fisheries targetting squid, fish and euphausiids pose a threat to all the oceanic cetaceans which are entirely or substantially dependent, either directly or indirectly, on these resources (Bannister *et al.* 1996).

2.5.4. Commercial whaling

Whaling potentially occurs by International Whaling Commission member countries (i.e. taking whales for scientific research) and by non-member countries involved in pirate whaling. Even relatively small catches of 'true' blue whales, humpback whales and southern right whales would significantly affect the already markedly reduced populations of these species (Bannister *et al.* 1996).

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3. DOLPHINS

The bottlenose dolphin (*Tursiops* sp. *–both T. truncates and T. aduncus*) is found all year round and is the most abundant delphinid in the Perth metropolitan area. However, a number of other species are observed in the study area, particularly in the Perth Canyon west off Rottnest but also occasionally closer to shore (Burton pers. comm.; Finn pers. comm.; Jenner & Jenner pers. comm.; McCauley pers. comm.). These species include:

- Risso's dolphins *Grampus griseus* , found from November-June, but may possibly be present all year round;
- Spinner dolphins *Stenella longirostris* , sighted January – April but are possibly present all year round;
- Common dolphins *Delphinus delphis*, observed January-April; and
- Striped dolphins, *S. coeruleoalba,* observed January – April.

3.1 CONSERVATION STATUS

All cetaceans are protected in Australian waters. Commonwealth laws apply within the 200 nautical mile Exclusive Economic Zone, and State laws apply within three nautical miles of the coast. In Commonwealth waters, it is an offence to kill, trade, take, keep, interfere with or treat a cetacean (see Appendix IIIb for further clarification). Interference has been defined as harassing, chasing, herding, tagging, marking or branding a cetacean. Harassment is identified by any significant change in the behaviour including substantial change in respiration or swimming pattern (EPBC Act 1999).

Bottlenose dolphins are listed in Appendix II of CITES and are a listed marine species in the EPBC Act 1999 (Appendix III). However it is difficult to assess their conservation status due to the paucity of information about the species, its taxonomy and the impacts of human activities (Hale 1997; Connor *et al.* 2000).

The Natural Heritage Trust 2 (NHT2) has formed a Bilateral Agreement between the Western Australian State Government and the Commonwealth Government. That agreement specifies priorities for the delivery of marine and coastal natural resource management, through the Coastcare funding stream of NHT2. CALM has responded to the Coastcare priorities of the bilateral agreement through the development of a set of biodiversity conservation management priorities, resulting in a set of priorities for each NHT2 region and a set that addresses Statewide issues. As part of this process a risk assessment was undertaken. Cockburn Sound dolphins were assessed as having a high relative conservation value and high relative threat in the Perth metropolitan area, second only to little penguins (Department of Conservation and Land Management 2003) Appendix I. They have also been classified as (Simpson & Holley 2003):

- a species where 'sub-populations', groups or individuals are 'at risk' from commercial tourism interaction;
- a species where 'sub-populations', groups or individuals are 'at risk' from recreational interaction; and
- a species that is 'in distress' and requires an emergency response.

3.2 GENERAL ECOLOGY

Female bottlenose dolphins do not become reproductively active until 12 – 14 years of age in the wild (Mann *et al.* 2000). Breeding and calving occur year round with peaks in the warm water months (November to March) (Mann *et al.* 2000). In Cockburn Sound (and likely in the entire Perth metropolitan area, since water temperatures will be the same throughout this region and births are linked to water temperature), the peak of births occurs in January/February and a secondary smaller peak in winter (Donaldson 1996). Dolphins wean at about 3-5 years of age (Mann *et al.* 2000) and they have sex-specific patterns of social development following weaning. Subadult females spend much of their time with mother-calf groups socializing with infants. Young subadult males spend time with mother-calf groups for 1-2 years after weaning. During later subadult years they spend increasing time with other males of a similar age. Much of their behaviour is socialising, possibly practicing fighting and mating skills. In the Perth metropolitan area, as in Shark Bay, young males develop alliances with other males (cooperative stable associations which help them to obtain mates), and as they get older they solidify these alliances with just one or two other males (Donaldson & Kobryn 2004). The females develop a loose network of female associates (Donaldson & Kobryn 2004).

In the Perth metropolitan area, the coast is quite open with few habitat barriers, so there is likely a single population of dolphins with gene flow along the coast. Observations suggest that dolphins in the northern metropolitan areas exhibit migratory patterns that may extend over distances from tens to hundreds of kilometres and include periods of seasonal residency in certain areas. However in more enclosed areas such as the Swan River and Cockburn Sound, the resident dolphins associate more with other individuals within their area, and less with outside individuals, so they may be considered a separate 'community' (Donaldson & Finn in prep.). Dolphins in and around Cockburn Sound are long-term, year round residents (Finn & Donaldson 2004).

Within each population group size and composition is fluid and can vary on a daily or hourly basis with age, sex, activity and physical parameters.

3.3 OCCURRENCE

Bottlenose dolphins are distributed along the entire inshore coast of Western Australia, however they may be more abundant in more sheltered areas such as embayments.

3.3.1 Comet Bay

Very little information is available for dolphins in this area. Approximately 70 dolphins use the Peel/Harvey area. The dolphins move through the inlet out to the ocean into Comet Bay via the Peel-Harvey Inlet, possibly daily. The dolphins appear to leave the Peel-Harvey Inlet and head towards Roberts Point (southern end of Comet Bay) in the afternoon. They have been seen heading north of the inlet. Dolphins are occasionally seen riding in waves made by the reef near Roberts Point or by the sandbar in the south eastern corner of Comet Bay (Kirby pers. comm.).

Dolphins follow alongside the commercial trawlers as they move out from marina to the open ocean, but do not follow the boats whilst they are trawling (as they do in Shark Bay) (Butler pers. comm.).

3.3.2 Warnbro Sound

Dolphins are often seen between Third Rock and the Sisters, within 200 m of reef (Edwards pers. comm.). It is thought that fewer dolphins have been observed in Warnbro Sound since Tern Island became joined with the mainland (Goodale pers. comm.). Some animals do appear to range between

Warnbro and Cockburn sounds, however there are no systematic data available for the dolphins in this area.

3.3.3 Cockburn Sound/Owen Anchorage

Around 200 bottlenose dolphins have been photo-identified within Cockburn Sound and Owen Anchorage. They have been studied since 1994 by researchers from Murdoch University's School of Veterinary and Biomedical Sciences and School of Biological Sciences (Donaldson & Kobryn 2004). Dolphins are found in all the main habitat types present in the sound i.e. seagrass beds, the silty deep basin, the shallow sandy bottom Kwinana Shelf (hereafter called Shelf), the east shore and the Shelf edge (the interface between the deep basin and shallow shelf) (Watterson 2001). The Shelf and deep basin appear to be the most intensively used habitat areas (Donaldson & Kobryn 2004; Donaldson & Finn in prep.; Watterson 2001), (Appendix II, Fig. 6.) with the shelf edge the most intensively utilised habitat. The dolphins spend proportionally more time feeding on the Shelf (Kwinana Shelf) than in other habitat types in Cockburn Sound. (Finn & Donaldson in prep.-a) and this has been shown to be consistent over time (Donaldson & Finn in prep.). Major foraging sites within the Shelf are found on the western margin where the Shelf meets the deeper basin and along the shipping channel on the eastern side of the shelf (Finn in prep.) particularly in areas of reef and remnant seagrass meadow (Calver & Finn 2001) After the Shelf, the Deep Basin is the next most used habitat for foraging by the dolphins. Often groups of 10-15 dolphins are observed feeding together (Donaldson unpubl. data). The dolphins are often observed to forage on pilchards (*Sardinops neopilchardus*) and other baitfish, and squid (*Sepioteuthis* sp.) (Donaldson unpubl. data). However, the abundance and distribution of fishes in the sound has likely changed dramatically over the past few decades due to commercial and recreational fishing and depletion of sea-grasses, and there are no data on historic feeding preferences of dolphins prior to these changes (Donaldson pers. comm.).

Mother-calf pairs make up about 20% of the population of dolphins in Cockburn Sound and this is higher compared to other studied populations whose age-sex structure in known elsewhere in the world (Donaldson 1995). Therefore, Cockburn Sound may be significant as a dolphin nursery area, with habitats that are in some way important for nursing mothers or their calves (Calver & Finn 2001; Donaldson 1995). The Shelf is the critical feeding area for mothers and calves (Donaldson & Kobryn 2004; Finn & Donaldson in prep.-a; Watterson 2001).

The dolphins each appear to have a home range of approx. 80 km^2, and have a high site fidelity, remaining in the same general location year-round and likely throughout their lifetime (Finn & Donaldson 2004). Many dolphins in Cockburn Sound do range to the north or south of the Sound, however for approx. 80 animals, the Sound composes their entire home range (Calver & Finn 2001; Donaldson & Finn in prep.). The home ranges of females with calves < 2 years old shifts noticeably, moving in closer to the eastern shoreline on Kwinana Shelf (Donaldson 1995), (Calver & Finn 2001; Donaldson & Kobryn 2004). Seasonal shifts in ranging and habitat use within home ranges occur, possibly in relation to shifts in the availability of prey species and reproductive state.

3.3.4 Swan River

Approximately 40 dolphins have been observed within the Swan River, mostly in the lower and middle reaches, and 20-25 dolphins utilise the area on a daily, or near daily, basis. They appear to follow consistent pathways and to prefer edge habitats (Appendix II, Fig 6). They have been observed to frequently forage in the northern end of the Port, Blackwell Reach, Mosman Bay, Lucky Bay, Port Dundas, and Milyu. The dolphins have most often been observed to rest in the deep Melville waters. They tend to spend a tidal cycle in the river, move out and then return (Finn unpubl. data).

3.3.5 Fremantle to Yanchep

The dolphins inhabiting this area were studied over 27 months from 1991-1993 (Waples 1997). They were observed all year round along the entire coast between Fremantle and Yanchep, but remained within 6 km off shore (Appendix II, Fig 7). Dolphins were most often seen over a sandy bottom, but were also found near reefs and in areas containing both rocky and sandy substrate. Dolphins were observed travelling, foraging, socializing, milling and resting throughout this area (i.e. engaged in all activities). The dolphins were found in groups ranging from one to approximately 60 individuals, with an average of around nine individuals. Mean group size was the greatest in summer and smallest in the spring. The structure of groups was inconsistent and changed frequently, although some associations between individuals were repeated.

Dolphins were not typically sighted throughout the study area, but tended to either be found north or south of Mindarie Keys. The size of the range of individual dolphins varied and in this dolphin community it appears that some maintain a smaller consistent range whilst others travel more extensively along the coast (Waples 1997). A review of the photo-id catalogues for this area and Cockburn Sound did not find any animals common to both study areas indicating the possibility of population structuring based on social and ecological isolation (Finn pers. comm.).

3.4 CURRENT THREATS

The current threats to bottlenose dolphins in the Perth metropolitan area are:

- direct killing;
- boat strikes;
- entanglements;
- reduction in food resources due to:
  - commercial and recreational fisheries;
  - reduction of feeding grounds; and
  - destruction of prey fish habitat.
- direct human disturbance:
  - provisioning (illegal hand-feeding from boats and jetties);
  - ecotourism (marine mammal observation and interaction);
  - boating activity:
    - acoustic disturbance; and
    - negative effects on behaviour.

3.4.1 Direct killing

There is documented evidence that some fishers deliberately kill dolphins in the Perth metropolitan area perhaps due to direct competition with fish sources (Finn & Donaldson 2004). Inshore species such as bottlenose and common dolphins appear to be most at risk of all cetaceans as they approach boats and bow-ride (Bannister *et al.* 1996). Of 28 reported deaths from 1985-1993 where cause could be determined, 13 had implications of human influence. Twenty eight percent of total deaths were net entanglements, and 18% were intentional killing (Bannister *et al.* 1996).

3.4.2 Boat strikes

Boats strikes cause a range of injuries including propellor wounds to dorsal fins (Wells & Scott 1997) head and body (Samuels *et al.* 2003), and death.

In inshore areas, small dolphins are particularly vulnerable to fast, high powered launches and personal watercraft (PWC). As dependent calves are the most vulnerable demographic unit, the effects of boat strikes on a population are exacerbated in habitats utilized for calving and as nursery areas. Cetaceans may perceive a boat's approach but may be unable to manoeuvre in time to avoid getting

struck. Risk of this obviously increases with speed of the water vessel and with time the dolphins spend in close proximity to vessels (i.e. if being hand-fed).

Approaching boat traffic has also been shown to affect surfacing intervals of dolphins. Inexperienced mothers and females without dependent calves had shorter interbreath intervals, increasing their probability of being struck by a vessel (Nowacek *et al.* 2001). High-speed, wave piercing hydrofoil ferries pose a particular hazard to individual cetaceans in their path (Bannister *et al.* 1996). Dolphins who have become beggars have a higher risk of being struck by a boat.

In the Swan River, dolphins extensively forage in the personal watercraft (PWC) area at Milyu and there are also "bottleneck" areas for dolphins in the unlimited speed sections of the river such as around Point Walter. Thus the risk of injury to the dolphins in these areas is high (Finn pers. comm.).

3.4.3 Entanglements

Dolphins get caught in drift gillnets, fixed gillnets, trawl nets and purse-seine nets (Bannister *et al.* 1996; Hale 1997; Majluf *et al.* 2002). Entanglements in such pieces affect locomotion, the ability to catch food, increase the risk to predation and may cause physical injury by constant abrasion and individual strands cutting deeply into subdermal tissues (Bannister *et al.* 1996). The incidental take of inshore bottlenose dolphins is currently poor understood (Bannister *et al.* 1996), but is thought to be potentially serious and has been listed as being one of the greatest concerns (Shaugnessy *et al.* 2003). Another hazard arises from the large amount of fish netting lost at sea (ghost nets) as well as smaller pieces of netting that are abandoned or discarded at sea.

Recreational fishing line has been implicated in bottlenose dolphin entanglements, particularly of subadults (Mann *et al.* 1995; Wells *et al.* 1998). Discarded fishing line poses a risk similar to that of ghost nets (Wells *et al.* 1998). In Cockburn Sound, fishing line entanglement have been observed to cause around one death (mostly calves) each year over the past decade (Donaldson unpubl. data). This is likely an underestimate of mortality as most dolphins will die at sea and not be recovered. With numbers of recreational boaters and fishers expected to increase significantly in coming decades (Department of Transport 1999), the incidence of entanglements will also increase. In small subpopulations/communities of dolphins, even a slight increase in death rates due to human-related causes may over a few generations threaten the subpopulation/community with extinction (Finn & Donaldson 2004)

3.4.4 Reduction in food availability

Most stocks of commercial and recreational fish species in Australian waters have declined through overfishing and the destruction of fish habitat (Hale 1997). Dolphins restricted to narrow and specific habitats can be at particular risk from competition with commercial and recreational fishing (Bannister *et al.* 1996) and the food requirements of cetaceans are often not taken into account when annual catches of particular fish stocks are set (Bannister *et al.* 1996).

Commercial and recreational fisheries.

The viability of the dolphins in Cockburn Sound is dependent on the maintenance of current levels of prey availability (Calver & Finn 2001; Finn in prep.). Females with dependent calves are particularly vulnerable to reductions in prey availability, due to their extremely high energy requirements during lactation (Mann et al. 2000).

Five commercial fisheries operate in Cockburn Sound:

1. the beach baitfish net fishery targets small pelagic fish such as sandy sprat (*Hyperlophus vittatus*), blue sprat (*Spratelloides robustus*), anchovy (*Engraulis australis)*, and pilchards;

2. the fish net fishery takes a range of fin fish by gill net, beach seine and haul net. The main species targeted are garfish (*Hippocampus melanochir*) and Australian herring (*Arripis georgianus*);
3. the pot and long line fishery targets garfish, herring and pink snapper;
4. the crab fishery; and
5. the mussel fishery.

Cockburn Sound is one of the most popular areas for recreational fishing in Western Australia and approximately 56% of the combined recreational and commercial catch of the key finfish species in Cockburn Sound were taken by the recreational fishery in 2002 (Department of Fisheries 2003).

The extent to which commercial and recreational fisheries currently compete with dolphins for prey resources is not known. Recreational fishing effort within Cockburn Sound is predicted to increase by up to 30% over the next two decades and the implications of such a substantial increase in fishing effort is unclear. The effective ecological removal of the predatory fish favoured by recreational fishers may have important consequences for the structure of fish communities within Cockburn Sound. Increased recreational fishing effort may also lead to declines in species such as garfish or herring that are utilised by dolphins, particularly at times of the year when forage fish such as pilchard and anchovy are not available.

Dolphins in Cockburn Sound spend over 50% of their time feeding and searching for food, which is higher than has been reported for any other population (Donaldson 1995); this may indicate that dolphins in the sound are experiencing some feeding pressure.

Reduction of feeding grounds

In Cockburn Sound, the dolphins' critical feeding habitat is now the Shelf rather than remnant seagrass beds (Donaldson & Kobryn 2004; Finn & Donaldson in prep.-a). Land reclamation or industry development and associated increased vessel activity on the Shelf would result in reduction of key feeding habitat and also increased disturbance of the remaining Shelf habitat. As this area is also the most popular 'nursery' area for mothers and calves, a reduction of the Shelf habitat is likely to have serious negative consequences for the Cockburn Sound dolphins.

Destruction of fish habitat

Seagrass beds are important nursery areas for juvenile fish and feeding grounds for adult fish. For example, within the Shoalwater Islands Marine Park, over half of the 75 finfish species that have been recorded in nearshallow waters have an affiliation with seagrass (Department of Conservation and Land Management in prep.). Thus any impact affecting the remaining seagrass beds in the Perth metropolitan area will also affect the prey availability for the dolphins. The seagrass ecosystems are affected by direct degradation, e.g. limesand mining and scouring from mooring chains, as well as high sediment and nutrient loads (Blaber & Blaber 1980; Department of Environmental Protection 1996). The extent of seagrass habitats between Fremantle and Becher Point has declined in all but one area (Becher Point east) since the 1970s (Department of Environmental Protection 1996).

3.4.5 Human disturbance

Provisioning

Feeding of dolphins by humans has been classed as "harassment" by the United States Marine Mammal Commission, and has been banned in the U.S. since 1994. In Australia, it is banned in Commonwealth waters, Victoria, Queensland and Western Australia (except at Monkey Mia and Bunbury) (Bannister *et al.* 1996). At Monkey Mia, 12 of 17 calves born to provisioned females since 1975 have died. This mortality rate is much higher than that known for non-provisioned dolphins and

is believed to be directly linked to the dolphins being provisioned (Wilson 1994). Other hazards posed by feeding dolphins include (Wilson 1994):

- prolonged exposure to polluted near-shore waters;
- exposure to human pathogens;
- distraction of animals from potential threats, especially shark attacks;
- possible increased incidence of sharks due to concentration of fish offal; and
- acceptance of poor-quality food items (or non-food items) from boats, causing illness.

The number of dolphins begging from boats has increased dramatically in and around Cockburn Sound recently, with nearly 20% of the resident dolphins now showing begging behaviour (Finn and Donaldson 2004). There are several serious threats to dolphins and humans when dolphins become beggars. These include(Donaldson & Finn in prep.; Finn & Donaldson 2004, in prep.-b; Samuels *et al.* 2003):

- the risk to calves if they are learning boat-begging as a foraging tactic, instead of practicing their hunting skills;
- the breakdown of long-term social associations, leading to a likely decrease in reproductive success for adult males who lose their alliance partners and therefore their competitive ability;
- the increased chance of dolphins being injured deliberately by humans if they approach boats (a few spearing/stabbing deaths have been recorded in the past in Cockburn Sound);
- the increased chance of injury from boat propellers (21% of beggars in Cockburn Sound have signs consistent with propeller injury. None of the 'non-begging' individuals have scars indicative of propeller injury);
- the increased risk of line entanglement (one beggar became emaciated following an infection in his mouth after getting a hook lodged in his mouth, and several calves washed up over the last few years have been entangled in fishing line. In one case the line had cut off the calf's tongue and cut down to the jawbone); and
- wild dolphins, particularly adult males, have been reported to become aggressive and bite/shove people, and one wild (sociable) adult male dolphin killed a man in Brazil who was wading/swimming with him.

In the event of juveniles becoming boat beggers, deleterious effects to the population would be likely due to their probable increase in mortality, reduced acquisition of hunting skills, and decreased reproductive success (Donaldson & Finn in prep.).

Ecotourism

Swim-with-dolphin tours and dolphin watching pose various potential threats to dolphins. These include injury from collisions, habitat displacement, interference with behaviours such as foraging, socializing, mating and calving, and acoustic effects (Constantine 2001; Marsh *et al.* 2003; Weir *et al.* undated). The cumulative effects of human disturbance is of concern (Marsh *et al.* 2003).

For swim-with-dolphin tours, dolphins have been shown to rarely interact with swimmers, to actively avoid them (Weir *et al.* undated), and to increase their rate of avoidance of swimmers over time (Constantine 2001). Deep diving, rapid swimming, tail slapping (often a sign of aggression), splitting into smaller groups, change in course and decoy animals from a group are all typical evasion behaviours observed by dolphins (Weir *et al.* undated). The approach method by a tour operator has been shown to affect the type of response, and avoidance was more likely if (Constantine 2001; Weir *et al.* undated):

- swimmers were placed in the path of the dolphins' travel;
- swimmers entered the water from a stationary boat the dolphins were milling around; or
- swimmers swam towards the dolphins.

Juveniles are more likely to interact with swimmers than adults. Both positive and negative interactions between dolphins and humans can have long term effects by altering time spent foraging, socializing and resting (Constantine 2001). The energy used by a dolphin to respond to a disturbance is part of its overall energy budget available for self-maintenance and reproduction. Therefore as the number and sources of disturbance increase, so too does the percentage of the population affected, resulting in an ultimate loss of fitness for the population as a whole (Finn pers. comm.; Weir *et al.* undated).

In Western Australia, three swim-with-dolphin tour operators exist, one of which is in Cockburn Sound. It is believed possible that some of the dolphins in this area have been habituated to humans (Samuels *et al.* 2003).

In Cockburn Sound, passive (i.e. boats approaching and following dolphins at a close distance) and contact interactions with recreational craft commonly occur (Calver & Finn 2001).

Boating activity

Boating activity can affect dolphins in a number of different ways. All watercraft traffic can result in "harassment" of the dolphins as defined under the U.S. Marine Mammal Protection Act of 1972 (Nowacek *et al.* 2001). In the Perth metropolitan area, and Cockburn Sound in particular, the negative effects of boating activity will be exacerbated due to:

- the increasing number of recreational boat users;
- the attraction of people to the begging behaviour of dolphins;
- the lack of enforcement and knowledge of regulations by the public for interactions;
- people actively seeking out interactions with dolphins; and
- the large number of (vulnerable) mother-calf pairs in Cockburn Sound.

Acoustic disturbance

Sound is important for dolphin orientation and behaviour (Marsh *et al.* 2003 and refs within). They use signals for location of prey, information about their environment and communication. They use passive listening to gather information such as local sea state, wind strength and approaching storms (McCauley & Cato 2003). Dolphins are less sensitive to lower frequencies, but are probably more sensitive to sounds above 300 Hz (Wursig & Greene 2002) and their range extends up to approximately 150 kHz (McCauley & Cato 2003) and refs within). Man-made sound may affect dolphins in various ways, including (McCauley & Cato 2003):

- adverse effects on prey species;
- masking of signals of interest (leading to reduced detection of predators and prey, with associated risks to survival);
- behavioural responses;
- temporary shifts in hearing ability;
- permanent shifts in hearing ability; and
- damage to hearing and other organs.

For example, a study on the noises associated with an aviation fuel receiving facility (AFRF) in western Hong Kong found that the sounds in the waters east of the AFRF could disrupt communication and the passive listening during dolphin/porpoise foraging for acoustically active fishes (Wursig & Greene 2002). Recent research has also shown that dolphins may alter the frequency for communication with each other in the presence of boats, as boat noise occurs at similar frequency to dolphin communication (Newby 2004). The effects of this change of frequency for communication have not been identified as yet.

Affect on behaviour

Boats can disturb dolphin feeding, resting and socializing activities (Hale 1997). Approaching vessels can alter group cohesion, swimming courses and speed, habitat use, and surface, respiration and dive

cycles (Allen & Read 2000; Hale *et al.* 1998; Marsh *et al.* 2003; Nowacek *et al.* 2001; Van Parijs & Corkeron 2001). The frequency of these changes can be significantly higher in shallow water (Hale *et al.* 1998; Nowacek *et al.* 2001). Approaches by erratic craft such as PWC have been shown to result in more changes of heading and interanimal distance. PWC are not acoustically detectable at the same distances as other types of watercraft. Thus dolphins cannot respond as quickly to their approach, and the lack of predictability of PWC results in greater disturbance and possible danger potential to the dolphins. Given that PWC can be used in shallow waters, which are typically used by dolphins for feeding and calf rearing, then a dolphin's ability to sustain itself, avoid boat traffic or a mother's ability to safely rear her calf could be compromised (Nowacek *et al.* 2001). Separation of a mother and calf, even by a few tens of metres can increase the predation risk of an inshore calf (Van Parijs & Corkeron 2001 and references within).

3.5 POTENTIAL THREATS

The major potential threats to the bottlenose dolphins in the Perth metropolitan area are:

- expansion of port development;
- pollution:
  - oil spills;
  - chemical contaminants;
  - water quality; and
  - plastic pollution.
- loss of appropriate habitat; and
- construction operations.

3.5.1 Expansion of port development

The Kwinana Shelf is the key feeding habitat for dolphins in Cockburn Sound, and females with younger infants shift their ranges to spend more time on the shelf (Donaldson 1995; Donaldson & Kobryn 2004; Finn & Donaldson in prep.-a). Proposed coastal developments in the southern half of the Kwinana shelf would remove a considerable portion of this feeding habitat and would increase disturbance from vessel traffic in the remaining habitat. The dolphins in Cockburn Sound are resident and remain in their maternal ranges (Donaldson & Finn in prep.) and therefore will not move to new home ranges no matter how disturbed their ranges become.

3.5.2 Pollution

Oil spills

The potential for oil spills to impact dolphins exists within the Perth metropolitan area. Crude and petroleum oils can coat body surfaces, block orifices, contaminate mucous membranes, block the digestive tract, and cause acute and chronic poisoning (Bannister *et al.* 1996).

Chemical contaminants

Heavy metals

A study of coastal waters in Perth from 1991-1994 (Department of Environmental Protection 1996) showed that heavy metal loads into Cockburn Sound were generally lower than in the 1970s and 1980s, but that some large point discharges occurred. For example, copper loads into Cockburn Sound were found to have increased from 1992 to 1993 and zinc loads increased from 1991 to 1995. Subsequent surveys of sediments from various sites in Cockburn Sound in 1999 indicated that levels of chromium, copper and zinc have increased, but remain below Interim Sediment Quality Guidelines

for the protection of marine ecosystems (DAL 2001). Water samples taken in 2003 indicated that the concentrations of heavy metals in Cockburn Sound were similar to that of open ocean and uncontaminated coastal waters (Department of Environment in press). Even so, there is the potential for heavy contamination from unlicensed inputs or accidental spills from toxic substances (Environmental Protection Authority 2005).

In Warnbro Sound, concentrations of most heavy metals are relatively low (Department of Environmental Protection 1996). The levels of chromium and copper in the sediments were found to have increased from 1994 to 1999, but were below Interim Sediment Quality Guidelines for the protection of marine ecosystems (DAL 2001). In both the 1994 and 1999 sediment surveys arsenic was found to be elevated in sediments of the Warnbro Sound Basin (Department of Environmental Protection 1996; DAL 2001), and was generally greater than the criterion for the maintenance of ecosystem integrity at an EQO2 Class II level[1] (Department of Environmental Protection 1996). The principal source was thought to be the storm water drains. Arsenic is carcinogenic to animals and is toxic in other ways (Newman 1985). In the Sepia Depression, discharge is mainly through the wastewater outfall. Annual loads of copper, zinc, cadmium, chromium, lead and mercury have decreased since the Woodman Point wastewater treatment plant was upgraded in 2002. The levels are predicted to remain relatively constant until 2019 (Water Corporation of Western Australia 2003), although the maximum toxicant load allowable in 2019 has been capped at 3½ times the typical load in 2004 (Environmental Protection Authority 2004).

Reduced survivorship of first calves, reduced male fertility and susceptibility to disease have been linked to loads of chemical pollutants and heavy metals (Hale 1997 and references within). Coastal odontocetes in Australia were found to have the highest levels of hepatic mercury and lead compared to elsewhere in the Southern Hemisphere (Evans 2003).

Increased loads of pesticides and polychlorinated biphenyls (PCBs)

DDT was the most common organochlorine (OC) pesticide detected in sediments during the Southern Metropolitan Coastal Waters Study 1991-1994 (Department of Environmental Protection 1996). The majority of detection sites in Cockburn Sound were linked with marinas, harbours and industrial and municipal outfalls (Department of Environmental Protection 1996). PCBs were found in sediments at the Jervoise Bay Marina and in the southern basin of Warnbro Sound (Department of Environmental Protection 1996). In 2003, water samples from sites in Cockburn Sound and Warnbro Sound were tested for 49 different organic compounds (Department of Environment in press). Whilst the concentrations of all the compounds were below the Limit of Reporting, the Limit of Reporting for four of the chemicals was above the national guidelines set for 99% species protection (Department of Environment in press). For 36 of the compounds, there are no national guidelines for 90%, 95% or 99% species protection (Department of Environment in press).

High concentrations of OCs impose serious threats and possible toxic effects on dolphins (Kim *et al.* 1996). They are passed from a mother to the fetus and then to the calf via lactation, and therefore their concentrations decrease in females after maturity. In males however, levels of OCs increase with age (Kim *et al.* 1996). In a study on various pollutants in marine mammals in the Southern Hemisphere, bottlenose dolphins were found to have the highest concentration of PCBs. Their coastal habitat and proximity to point sources of pollution was hypothesized to be the major factor (Evans 2003).

Butyltin (BT) levels

Butyltin compounds include tributyltin (TBT) and its degradation products mono- (MBT) and dibutyltin (DBT). TBT has been used for several decades as an antifoulant on boat hulls and aquaculture nets, but is now no longer used on vessels < 25 m in length. Butyltin compounds bind to

[1] EQO2 Class II represents a high level of protection which requires that any contaminant discharges or human-made changes which do occur may be readily absorbed or withstood by the waterbody without any detectable effects on the biota or the functioning of the ecosystem. Department of Environmental Protection (1996). Southern Metropolitan Coastal Waters Study (1991-1994). Final Report No. 17. Department of Environmental Protection, Perth, Western Australia, p 288

cell receptors and exert acute toxic effects. They are potent inhibitors of energy production in cells (Kannan *et al.* 1997 and references within). TBT and DBT have well documented immunosuppressing potential in fish and mammals (Kannan *et al.* 1998 and references within). BTs bioaccumulate up the food chain and therefore is serious in higher trophic marine organisms (Kim *et al.* 1996). In dolphins, BTs accumulate in the liver and kidney and levels of BTs have been found to increase with age until maturity, thereafter stabilizing (Kannan *et al.* 1997; Kim *et al.* 1996). BTs do not appear to transfer from the body via gestation or lactation as no significant difference in BT levels between sexes has been found (Kannan *et al.* 1997; Kim *et al.* 1996).

Higher concentrations of BTs have been found in dolphins collected from large scale mortality events along the U.S. Atlantic and Gulf coasts compared to offshore cetaceans and those from Japanese coastal waters. Dolphins from such large-scale mortalities have also exhibited bacterial and viral infections (Kannan *et al.* 1997) and the elevated levels of BTs are thought to have contributed to the dolphins' immune dysfunction (Kannan *et al.* 1998; Kannan *et al.* 1997).

High levels of TBT have been found in Cockburn Sound generally, with highest concentrations associated with large vessel operational areas. Frequent disturbance of the sediment in Cockburn Sound means that TBT in the sediment is bioavailabale. TBT has been found throughout sediments in Warnbro Sound, the northern half of Comet Bay, Cockburn Sound, Fremantle Harbour, the waters between Fremantle and Rottnest and surrounding the western half of Rottnest (Department of Environmental Protection 1996). Although levels of TBT in the sediment do not necessarily indicate levels of TBT in the water column, bioaccumulation up through the food chain means that dolphins could accumulate TBT if their prey forage in areas where it is still present in the sediment. In a recent study comparing the incidence of imposex in whelks (*Thais orbita*) between 1993 and 1998/99, the incidence of imposex remained high at Thompsons Bay, Fremantle Harbour, northern and southern Jervoise Bay, Challenger Beach Colpoys Point, Trigg and Cottesloe (Reitsema *et al.* 2003). Of the whelks examined from Yanchep, Hillary's Boat Harbour, Carnac Island, Penguin Island and several sites around Rottnest, 11-70% had an incidence of imposex (Reitsema *et al.* 2003).

Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs enter the coastal system via man-made processes such as urban runoff, boat/ship exhaust (particularly smaller boats due to poor exhaust systems), oil spills, industrial processes and from oil refineries (Marsili *et al.* 2001, Gagnon pers. comm.). PAHs in the aquatic environment are either quickly adsorbed on to the surface of organic and inorganic particles and settle out, or they remain in solution and are readily available to aquatic organisms (Marsili *et al.* 2001). PAHs are known to be carcinogenic, mutagenic and teratogenic (International Programme on Chemical Safety 1998). Hydrocarbon "biomarkers" have been found in fish sampled in Cockburn Sound (DAL 2001).

Water quality

The Sepia Depression is a north-south natural underwater channel found to the west of Garden Island, Rockingham and Warnbro Sound (D'Adamo *et al.* 2000). Secondary treated effluent from the Woodman Point wastewater treatment plant and primary treated effluent from the Point Peron wastewater treatment plant are discharged into the Sepia Depression via the Sepia Depression ocean outfall (previously known as the Cape Peron ocean outfall). This outfall is the largest single point source of nutrients into the region. Northerly to north-westerly winds can drive water from Cockburn Sound and the Sepia Depresssion ocean outfall into Shoalwater Bay and Warnbro Sound, thus potentially bringing a suite of chemical contaminants, nutrients and biological organisms (D'Adamo *et al.* 2000). The extended reef system running parallel to the coast and extending from near Geraldton to Mandurah reduces water exchange between the embayments and the open sea. Thus contaminated water can remain in the embayments for extended periods (D'Adamo *et al.* 2000).

In Cockburn Sound, water quality, as a function of chlorophyll a levels, is not that different from its poorest recorded state in the 1970s. This is despite the large decrease in nutrient inputs since then

(Department of Environmental Protection 1996; DAL 2001). Algal blooms can be toxic to marine animals and increased turbidity can affect growth and reproduction of seagrasses, in turn potentially affecting fish availability.

Plastic pollution

Apart from fishing line, dolphins can become entangled in, or ingest various plastic pollution such as bags, bait bands, cords and polystyrene. Following entanglement or ingestion, the animal may have a reduced ability to forage, have an increased risk to predation, may suffer abrasion and infection, fatal blockages or may drown (Bannister *et al.* 1996).

3.5.3 Loss of appropriate habitat

Identification of key habitats for dolphins must precede the development of effective conservation strategies (Bannister *et al.* 1996). The dedication of specific areas as protected habitat may be of limited benefit unless such areas are of particular importance for feeding, resting or reproduction. (Hale 1997).

In Cockburn Sound, the western and eastern edges of the Kwinana shelf and the northern end of the central basin are the major areas used by the dolphins for foraging. These areas are regarded as critical habitats and impacts in these areas are likely to impact the dolphins more than in other areas of the Sound (Finn pers. comm.).

3.5.4 Construction operations

Underwater blasting from construction can cause acoustic disturbance (Wykes *et al.* 1999), producing the same potential effects as detailed above in "Acoustic Disturbance"

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4. AUSTRALIAN SEA LIONS

The Australian sea lion, *Neophoca cinerea*, is endemic to Australia. It is the rarest of the five known species of sea lions. Breeding populations are small and therefore vulnerable to local extinction (Orsini 2004). There are an estimated 13,000 Australian sea lions in Australia, of which 2,700 to 3,400 individuals are found in Western Australia (Gales *et al.* 1994) and 1,000 of these are found specifically on the west coast. The population breeding in the mid-west coast of Western Australia appears to be stable, but the populations on the south coast appear to be declining (Gales 1999).

4.1 CONSERVATION STATUS

The Australian sea lion is listed as a species 'in need of special protection' in the Western Australian Wildlife Conservation Act 1950 as *past commercial exploitation reduced its numbers to low levels from which it has recovered only partially to date, and because it requires special protection against illegal destruction and disturbance to its habitat* (Department of Conservation and Land Management 1992). It is a listed marine species under the EPBC Act 1999, but this is currently under review to be upgraded to the "Vulnerable" status (Orsini 2004).

The Natural Heritage Trust 2 (NHT2) has formed a Bilateral Agreement between the Western Australian State Government and the Commonwealth Government. That agreement specifies priorities for the delivery of marine and coastal natural resource management, through the Coastcare funding stream of NHT2. CALM has responded to the Coastcare priorities of the bilateral agreement through the development of a set of biodiversity conservation management priorities, resulting in a set of priorities for each NHT2 region and a set that addresses Statewide issues. As part of this process a risk assessment was undertaken. The sea lions in the Perth metropolitan area were assessed as having a high conservation value and a medium relative threat (Department of Conservation and Land Management 2003) (Appendix I). They were further identified as such (Simpson & Holley 2003):

- the W.A. population is 'at risk;'
- 'sub-populations', groups or individuals are 'at risk' from commercial tourism;
- 'sub populations', groups or individuals are 'at risk' from recreational interaction;
- they pose a risk to public safety; and
- 'in distress' and requires an emergency response.

4.2 GENERAL ECOLOGY

Australian sea lions have a unique non-annual, non-seasonal 17-18 month breeding cycle, no synchrony between sites (Gales & Cheal 1992; Gales *et al.* 1994) and an extended mating season lasting four to five months (Gales 1999). Unlike the typical otariid mating strategy where a male has a harem of females, each sea lion bull attends only one female at a time until mating occurs after oestrus and thereafter pairs up with another pre-oestrous female (Department of Conservation and Land Management 1997; Gales 1999; Gales & Costa 1997 and references within). There are approximately 27 separate colonies of sea lions in Western Australia (Gales 1999) and the females have a high site fidelity, breeding at the same island colony each season (Gales *et al.* 1992). This has resulted in each colony being genetically distinct (Campbell 2003). Breeding does not occur on any of the islands in the Perth metropolitan area between Yanchep and Mandurah. However, males from the haulout sites within this area have been found at breeding sites in the Jurien Bay region (Gales *et al.* 1992).

Currently, there is limited information about the foraging behaviour and dietary preferences of sea lions. The information available suggests they are opportunistic feeders, feeding on a wide diversity of prey such as fish, cephalopods, sharks, seabirds and turtles (Gales & Cheal 1992; Gales & Costa 1997 and references within). Studies using time depth recorders on lactating female sea lions have shown that they are benthic feeders and spend their time at sea almost continuously diving (Costa & Gales 2003; Gales & Costa 1997 and references within). Studies on their metabolic rate at sea indicate that the females are expending a lot of energy whilst foraging, and are most likely pushed to their metabolic limit (Costa & Gales 2003).

4.3 OCCURRENCE

Males almost exclusively are observed in Perth, and can be found at haulout sites on Seal, Carnac, Penguin, Dyer and Little islands and Burns Rock (Gales *et al.* 1992) (Appendix II Fig. 8). These sites are used throughout the year by the sea lions. They are regularly sighted in waters around Garden Island (Wykes *et al.* 1999) and occasionally haulout for short periods on beaches at Garden Island, Rottnest Island and mainland Perth. Haulout sites are thought to be important for recovery following the energetically demanding foraging, the development and maintenance of social bonds, predator avoidance and the promotion of the moult (Orsini 2004 and references within).

4.4 CURRENT THREATS

The current major threats to sea lions in the Perth metropolitan area are:

- direct killing;
- boat strikes;
- entanglements:
  - fisheries related gear; and
  - other plastic pollution.
- drowning in lobster pots (pups and juveniles);
- reduction in food resources:
  - commercial and recreational fisheries; and
  - destruction of fish habitat.
- human disturbance:
  - at haul-out sites; and
  - provisioning.

It is important to note that the number of animals that die each year from direct killing, boat strikes, and entanglements is an underestimate as some animals will never be found, some carcasses will be too decomposed to verify cause of death (Mawson & Coughran 1999) and there may be a low report rate of entanglement by the fishing industry (Page *et al.* 2004). In Mawson and Coughran's (1999) study of the numbers of sick, injured and dead sea lions in Western Australia from 1980-1996, greater numbers of sea lions from the smaller west coast population were found dead compared to the south west coast. It is presumed that this is due to the proximity of sea lion habitats to major human population centres and their associated fishing and boating activities (Mawson & Coughran 1999). However, even low levels of sea lion loss drastically affect the sea lion population (Shaughnessy *et al.* 2003) due to its small population size (Gales *et al.* 1994), genetically distinct colonies (Campbell 2003) and low pup production (Gales *et al.* 1994). .

4.4.1 Direct killing

Direct killing of sea lions accounted for 38% of the 47 deaths of known cause in Mawson and Coughran's (1999) study. Methods of killing included:

- shooting;
- spearing or being shot by arrows; and
- being clubbed.

4.4.2 Boat strikes

Boat strikes of sea lions accounted for 17% of deaths of known cause in Mawson and Coughran's (1999) study. Boats strike at least one to two sea lions each year in the Perth metropolitan area (Edwards pers. comm.). The number of sea lions that die from boat strikes each year is expected to increase with increasing recreational boat usage, particularly that occurring close to haul out sites (Mawson & Coughran 1999).

4.4.3 Entanglements

Fisheries related gear

Sea lions have been found entangled in fishing nets (both trawling and monofilament), fishing lines, nylon ropes, hooks and plastic bait bands/straps. These entanglements involve both operational and discarded fishing gear (Page *et al.* 2004; Shaughnessy 1999). The material can get caught around a sea lion's neck, fore-flippers, mouth or teeth. The material can cut into the flesh and result in a lingering death (Page *et al.* 2004; Shaughnessy 1999). Entangled seals have lower survival rates and are more likely to spend more time at sea foraging due to the increased energy demands placed on them by the additional drag (Fowler *et al.* 1990). From 1980-1996, entanglements caused 23% of reported sea lion deaths on the west coast (Mawson & Coughran 1999).

In the Perth metropolitan area approximately 3-4 male sea lions are found entangled in gang hooks each month when the salmon are prevalent. This generally occurs in April-May and the sea lions found entangled are mainly from Carnac Island (Edwards pers. comm.). A survey of beach litter in the Marmion Marine Park in 2002 found 2.63 kg of discarded fishing line (Poynton *et al.* 2002) and as sea lions are observed consistently in the Park (Edwards pers. comm.), entanglements in such debris are likely. A large number of 5-10 cm long pieces of unravelled rope were also found in the survey. Whilst unlikely to cause entanglements, they could pose problems for the sea lions if ingested.

Other plastic pollution

Sea lions get entangled in other plastic pollution such as plastic bags, rubber bands from car tyre tubes, rubber rings used for connecting and sealing large diameter pipes, cords, six-pack yokes, binder twine and garment remnants (Page *et al.* 2004; Shaughnessy 1999 and references within).

4.4.4 Drowning in lobster pots or attached ropes

Pups and young sea lions can drown in rock lobster pots or attached ropes that are set near breeding islands and haul out sites (Campbell in press). This problem is more prevalent near the breeding islands in Jurien Bay than in the Perth metropolitan area (Edwards pers. comm.).

4.4.5 Reduction of food resources

Most stocks of commercial and recreational fish species in Australian waters have declined through overfishing and the destruction of fish habitat (Hale 1997).

Commercial and recreational fisheries

As there is very little information on the foraging behaviour and prey preferences of sea lions, it is difficult to determine if any competition for same prey species exists with commercial and recreational fisheries, or the extent of such competition (Campbell in press; Department of Conservation and Land Management 1997).

Recreational fishing is one of the most popular leisure activities in Western Australia (Sumner & Williamson 1999). Between Yanchep and Mandurah approximately 290,000 fishers are estimated to fish, generating an estimated 1.3million fishing days a year (Department of Fisheries 2003) and refs within. A survey of recreational boat based fishing on the west coast in 1997 showed that the overall catch of many species was of similar magnitude to the commercial catch (Department of Fisheries 2002). The sustainability of recreationally fished stocks in Western Australia is threatened by population growth, coastal development, improved fishing and fish storage technology, a low participation cost and access to areas previously protected from significant levels of fishing due to their remoteness (Department of Fisheries 2003). There is anecdotal evidence of a reduction of abundance of popular target reef fish species at least within the Shoalwater Islands Marine Park (Department of Conservation and Land Management in prep.)

Destruction of fish habitat

Seagrass beds are important nursery areas for juvenile fish and feeding grounds for adult fish. For example, within the Shoalwater Islands Marine Park, over half of the 75 finfish species that have been recorded in nearshallow waters have an affiliation with seagrass (Department of Conservation and Land Management in prep.). Thus any impact affecting the remaining seagrass beds in the Perth metropolitan waters is likely to affect the prey availability for the sea lions. The seagrass ecosystems are affected by direct degradation, e.g. lime sand mining and scouring from mooring chains, as well as high sediment and nutrient loads (Blaber & Blaber 1980; Department of Environmental Protection 1996). The extent of seagrass habitats between Fremantle and Becher Point has declined in all but one area (Becher Point east) since the 1970s (Department of Environmental Protection 1996).

4.4.6 Human disturbance

Haul out sites.

The islands in the Perth metropolitan area are highly utilised for recreation (Department of Conservation and Land Management 1997) therefore sea lions in the Perth metropolitan area are under considerable pressure from humans competing for available terrestrial habitat (Gales *et al.* 1992).

At Seal Island no beach access is allowed but at Carnac Island two tour operators are licensed for shore based viewing of sea lions. There is no accurate data for the number of people visiting Carnac Island annually. An estimated 13,000 people land on Carnac Island annually and an estimated 20,000-30,000 people in private boats and tours enter Eastern Bay, near Carnac Island annually (Orsini 2004). They can then make their own way onto the island. Penguin Island attracts approximately 80,000 people a year. There is no accurate data for the number of people estimated to visit Little Island, but it is a good site for anchoring boats, swimming and snorkeling (Department of Conservation and Land Management 1991). Interactions with sea lions in waters surrounding it are common (Department of Conservation and Land Management 1991). Burns Rock and Dyer Island are difficult to access and presumably have very low visitation (Orsini 2004). Licensing conditions for tour operators stipulate that people must remain at least 5 m away from a sea lion on land, and to swim no closer than 10 m to a sea lion (Department of Conservation and Land Management 1984). However there are no control mechanisms to manage or limit non-commercial visits to sea lion haul out sites (Department of Conservation and Land Management 1997) and in a recent study at Carnac Island, people were observed on a significant number of instances to be closer than 2.5 m from a sea lion (Orsini 2004).

Other notable digressions from viewing guidelines for sea lions during this study included (Orsini 2004):

- boats anchored on the beach close to the sea lions;
- walking between sea lions and water;
- young children running unsupervised near sea lions;
- surrounding sea lions at distances < 5 m;
- talking loudly near sea lions;
- playing ball games near sea lions;
- throwing sand, seaweed and other objects at sea lions; and
- pouring alcoholic beverage from a can over a sea lion.

At Carnac Island, it has been shown that humans compete with sea lions for space on the beach (Orsini 2004). The sea lions appear to prefer to lie on cool wet sand or seaweed near the waters' edge, or partly in the water, most likely to reduce overheating. Humans used the same space for recreational activities or to elicit responses from sea lions (Orsini 2004).

Sea lions on Carnac Island responded to human presence by (Orsini 2004):

- increasing vigilance behaviour, with juvenile/subadult males showing a greater response than adult males;
- retreating or leaving the beach; and
- displaying aggression to humans, including flaring whiskers, huffing and lunging.

The incidence of vigilance behaviour exhibited by the sealions has been shown not to decrease with increasing approach distance by humans, even when they were greater than 15 m away (Orsini 2004). The types and frequencies of responses were also similar irrespective of the approach distance by humans (Orsini 2004). Potential long term effects of continued human presence are increased stress and associated physiological responses such as increased cardiac output, reduction in haul-out times (thereby increasing sea lion energy expenditure and possible affecting breeding success), and abandonment of certain haul-out sites (Orsini 2004).

Provisioning

Hand feeding sea lions can result in the establishment of boat begging behaviour, which may in turn result in aggressive behaviour exhibited by the sea lions (Edwards pers. comm., Kirkwood *et al.* 2003). It also increases the risk of sea lions being struck by boats (Department of Conservation and Land Management 1997).

4.5 POTENTIAL THREATS

The major potential threats to sea lions in the Perth metropolitan area are:

- pollution:
  - oil spills;
  - chemical contaminants; and
  - water quality.
- diseases;
- other ecotourism; and
- seismic activity.

4.5.1 Pollution

Oil spills

In the Perth metropolitan area, sea lions can potentially be impacted by oil spills, especially if the haul out sites or foraging areas are close to major shipping lanes. The effect of oil spills depends on the amount of skin exposed or the amount ingested (Salazar 2003). In extreme cases, kidney failure, destruction of intestinal lining, neural disorders and bioaccumulation are likely (Overton *et al.* 1994). Oil spills have been shown to cause chemical burns on sea lion skin and reduced pup productivity in fur seals (Salazar 2003 and references within), and have been implicated with eye problems (Salazar 2003).

Chemical contaminants

Heavy metals

A study of coastal waters in Perth from 1991-1994 (Department of Environmental Protection 1996) showed that heavy metal loads into Cockburn Sound were generally lower than in the 1970s and 1980s, but that some large point discharges occurred. For example, copper loads into Cockburn Sound were found to increase from 1992 to 1993 and zinc loads increased from 1991 to 1995. Subsequent surveys of sediments from various sites in Cockburn Sound in 1999 indicated that levels of chromium, copper and zinc have increased, but were below Interim Sediment Quality Guidelines for the protection of marine ecosystems (DAL 2001). Water samples taken in 2003 indicated that the concentrations of heavy metals in Cockburn Sound were similar to that of open ocean and uncontaminated coastal waters (Department of Environment in press.). Even so, there is the potential for heavy contamination from unlicensed inputs or accidental spills from toxic substances (Environmental Protection Authority 2005).

In Warnbro Sound, concentrations of most heavy metals are relatively low (Department of Environmental Protection 1996). The levels of chromium and copper in the sediments were found to have increased from 1994 to 1999, but remain below Interim Sediment Quality Guidelines for the protection of marine ecosystems (DAL 2001). In both the 1994 and 1999 sediment surveys arsenic was found to be elevated in sediments of the Warnbro Sound Basin (Department of Environmental Protection 1996; DAL 2001), and was generally greater than the criterion for the maintenance of ecosystem integrity at a EQO2 Class II level[2] (Department of Environmental Protection 1996). The principal source was thought to be the storm water drains. Arsenic is carcinogenic to animals and is toxic in other ways (Newman 1985). In the Sepia Depression, discharge is mainly through the wastewater outfall. Annual loads of copper, zinc, cadmium, chromium, lead and mercury have decreased since the Woodman Point wastewater treatment plant was upgraded in 2002, and levels are predicted to remain relatively constant until 2019 (Water Corporation of Western Australia 2003).

An excess of heavy metals can cause negative effects to sea lions (Evans 2003), though the levels at which negative effects occur is not known.

Increased loads of pesticides and polychlorinated biphenyls (PCBs)

DDT was the most common organochlorine (OC) pesticide detected in sediments during the Southern Metropolitan Coastal Waters Study 1991-1994 (Department of Environmental Protection 1996). The majority of detection sites in Cockburn Sound were linked with marinas, harbours and industrial and municipal outfalls (Department of Environmental Protection 1996). It was found to be more widespread in Warnbro Sound and Comet Bay and probably entered via storm water drains and estuarine outflows (Department of Environmental Protection 1996). PCBs were found in sediments at the Jervoise Bay Marina and in the southern basin of Warnbro Sound (Department of Environmental

[2] EQO2 Class II represents a high level of protection which requires that any contaminant discharges or human-made changes which do occur may be readily absorbed or withstood by the waterbody without any detectable effects on the biota or the functioning of the ecosystem. Department of Environmental Protection (1996). Southern Metropolitan Coastal Waters Study (1991-1994). Final Report No. 17. Department of Environmental Protection, Perth, Western Australia, p 288

Protection 1996). In 2003, water samples from sites in Cockburn Sound and Warnbro Sound were tested for 49 different organic compounds (Department of Environment in press). Whilst the concentrations of all the compounds were below the Limit of Reporting, the Limit of Reporting for four of the chemicals was above the national guidelines set for 99% species protection (Department of Environment in press). For 36 of the compounds, there are no national guidelines for 90%, 95% or 99% species protection (Department of Environment in press).

In male pinnipeds, OC concentrations in blubber increase with age. In females however, the concentrations decrease after maturity and reproduction due to the transfer of OCs during lactation (Lee *et al.* 1996). PCBs magnify up though the food chain, such that the levels found in pinniped blubber is higher than in their blood and the fish they prey on (de Swart *et al.* 1996). PCBs appear to impair the immune function in pinnipeds (de Swart *et al.* 1996).

Butyltins (BT)

Butyltin compounds include tributyltin (TBT) and its degradation products monobutyltin (MBT) and dibutyltin (DBT). Tributyltin has been used for several decades as the active ingredient in certain marine anti-fouling paints, and has been banned on vessels under 25 m in length in WA since 1992. It is extremely toxic to marine life, and causes a sexual deformity (imposex) in marine snails. It has been found throughout sediments in Warnbro Sound, the northern half of Comet Bay, Cockburn Sound, Fremantle Harbour, the waters between Fremantle and Rottnest and surrounding the western half of Rottnest (Department of Environmental Protection 1996). In a recent study comparing the incidence of imposex in whelks (*Thais orbita*) between 1993 and 1998/99, the incidence of imposex remained high at Thompsons Bay, Fremantle Harbour, northern and southern Jervoise Bay, Challenger Beach Colpoys Point, Trigg and Cottesloe. Of the whelks examined from Yanchep, Hillary's Boat Harbour, Carnac Island, Penguin Island and several sites around Rottnest, 11-70% had an incidence of imposex (Reitsema *et al.* 2003).

Bioaccumulation up through the food chain means that the sea lions could accumulate TBT if their prey forage in areas where it is still present in the sediment. High levels of TBT have been associated with toxic effects on mammal immune systems (Kannan *et al.* 1997). It appears that pinnipeds can excrete about 25% of their total Butyltin load when they shed their hair each year (Kim *et al.* 1996).

Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs enter the coastal system via man-made processes such as urban runoff, boat/ship exhaust (particularly smaller boats due to poor exhaust systems), oil spills, industrial processes and from oil refineries (Marsili *et al.* 2001, Gagnon pers. comm.). PAHs in the aquatic environment are either quickly adsorbed on to the surface of organic and inorganic particles and settle out, or they remain in solution and are readily available to aquatic organisms (Marsili *et al.* 2001). PAHs are known to be carcinogenic, mutagenic and teratogenic (International Programme on Chemical Safety 1998). Hydrocarbon "biomarkers" have been found in fish sampled in Cockburn Sound (DAL 2001).

Water Quality

The Sepia Depression is a north-south natural underwater channel found to the west of Garden Island, Rockingham and Warnbro Sound (D'Adamo *et al.* 2000). Secondary treated effluent from the Woodman Point wastewater treatment plant and primary treated effluent from the Point Peron wastewater treatment plant are discharged into the Sepia Depression via the Sepia Depression ocean outfall (previously known as the Cape Peron ocean outfall). This outfall is the largest single point source of nutrients into the region. Northerly to north-westerly winds can drive water from Cockburn Sound and the Sepia Depresssion ocean outfall into Shoalwater Bay and Warnbro Sound, thus potentially bringing a suite of chemical contaminants, nutrients and biological organisms (D'Adamo *et al.* 2000). The extended reef system running parallel to the coast and extending from near Geraldton to Mandurah reduces water exchange between the embayments and the open sea. Thus contaminated water can remain in the embayments for extended periods (D'Adamo *et al.* 2000).

In Cockburn Sound, water quality, as a function of chlorophyll a levels, is not that different from its poorest recorded state in the 1970s. This is despite the large decrease in nutrient inputs since then (Department of Environmental Protection 1996; DAL 2001). Algal blooms can be toxic to marine animals and increased turbidity can affect growth and reproduction of seagrasses, in turn potentially affecting fish availability..

4.5.2 Diseases

Tuberculosis has been reported in Australian sea lions found dead along the Western Australian coast. Other diseases which have been reported to cause pinniped deaths, such as calicivirus, leptospirosis and hookworm disease have not been reported in Australian sea lions, although they are known to carry hookworms (Shaughnessy 1999).

4.5.3 Sesimic activity

Seismic activity is thought to only pose a threat to sea lions if it occurs in close proximity to them (Shaughnessy 1999).

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5. LITTLE PENGUINS

The largest colony of little penguins in Western Australia is located on Penguin Island situated in the Shoalwater Islands Marine Park. The Perth metropolitan area represents the northern most breeding limit of little penguins. The nearest colonies of any comparable size occur over 600 km away at Breaksea Island and Cheyne Island near Albany and on various islands in the Recherche Archipelago.

5.1 CONSERVATION STATUS

Little penguins are a listed marine species in the EPBC Act 1999 (Appendix III). The penguins from Penguin Island are a key performance indicator for the Shoalwater Islands Marine Park (Department of Conservation and Land Management in prep.). The Natural Heritage Trust 2 (NHT2) has formed a Bilateral Agreement between the Western Australian State Government and the Commonwealth Government. That agreement specifies priorities for the delivery of marine and coastal natural resource management, through the Coastcare funding stream of NHT2. CALM has responded to the Coastcare priorities of the bilateral agreement through the development of a set of biodiversity conservation management priorities, resulting in a set of priorities for each NHT2 region and a set that addresses Statewide issues. As part of this process a risk assessment was undertaken. The little penguins were assessed as having the highest relative threat and the highest conservation value of all marine fauna in the Perth metropolitan area (Department of Conservation and Land Management 2003) (Appendix I). The W.A. population of little penguins was identified to be 'at risk' and 'sub-populations', groups or individuals 'at risk' from recreational interaction (Simpson & Holley 2003). In 1996, the colony on Penguin Island was also given the highest conservation status of all colonies in Australia (Dann *et al.* 1996).

5.2 GENERAL ECOLOGY

Little penguins are the smallest of all penguin species. They appear to be highly faithful to their natal colony with little evidence of immigration or emigration (Wienecke 1993). Little penguins on Penguin Island have been found to return to a nest site within 5 m^2 of the nest site they had occupied during the previous year or where they were raised (Nicholson 1994). The penguins on Penguin Island are larger than penguins elsewhere in Australia. Some preliminary genetic studies of several colonies around Australian suggested the penguins on Penguin Island were genetically different to the others (Wienecke 1993).

On Penguin Island, the penguins' breeding season is unusually protracted, lasting from April to January (Cannell pers. obs.; Nicholson 1994; Wienecke 1993). Time of egg laying varies between years and appears to coincide with an abundance of food for hatchlings (Wienecke 1993), but can begin anywhere from April to August (Nicholson 1994; Wienecke 1993). The main peak of egg laying is generally in June however, with a smaller peak in September (Dunlop *et al.* 1988). Two eggs are usually laid and incubated for five weeks. Both parents share the incubation and chick rearing, which lasts for about eight weeks. After hatching, the parents guard the chicks for approximately 14 days, and the longer they are guarded for, the greater the chance of the chicks surviving to fledging (Chiaradia & Kerry 1999). Depending on the date of laying, some pairs will lay two clutches of eggs in a season (Wienecke 1993). Once the chicks fledge they leave and generally return to the island to breed when they are two to three years of age (Reilly & Cullen 1982; Wienecke 1993). During the breeding season, eggs and chicks may be abandoned, depending on the condition of the parents, food

availability and time of the year e.g. if the penguins are still incubating eggs or raising chicks when they should be moulting then they will abandon the breeding.

During the breeding season, peak numbers of penguins leave the island each day before dawn and they forage at sea all day. They usually begin to return to the island 45 minutes after dusk, with peak numbers arriving one to two hours after dusk (Klomp & Wooller 1991). Recent studies on the diving depths of the penguins have shown that they travel in the top one to two metres (Bethge *et al.* 1997; Cannell *et al.* in prep.) and forage at a range of depths, including the top 1-4 m (Cannell *et al.* in prep.; Ropert-Coudert *et al.* 2003). They can dive 150 times an hour (Cannell *et al.* in prep.) and must spend a portion of time after each dive or bout of dives at the surface, recovering depleted oxygen stores.

From diet samples taken from Penguin Island penguins in 1986, 1989, 1995, 1996 and 1997, it has been shown that the Penguin Island colony feed on a range of fish including pilchards (*Sardinops neopilchardus*), garfish (*Hyporhamphus melanochir*), anchovy (*Engraulis australis*), Blue sprat(*Spratelloides robustus*) and sandy sprat (*Hyperlophus vittatus*) (Connard 1995; Wienecke 1989; Wienecke *et al.* 1995). Pilchard predominate the penguins' diet in autumn and early winter (Connard 1995; Klomp & Wooller 1988a). Sandy sprat comprise a large proportion of the diet of adult penguins and this proportion increases to more than 80% of food during chick rearing (Bradley *et al.* 1997). Studies on the carbon to oxygen ratios of the otoliths from the sandy sprat in diet samples taken from penguins have shown that the sandy sprat originated from a nursery site at Becher Point (Lenanton *et al.* 2003).

After breeding, the adult penguins moult between November and January, replacing all their feathers. This is a critical process which the penguins must undergo every year. The moult takes two to three weeks and the penguins are confined to land during this time, as their new feathers are not waterproof.

5.3 OCCURRENCE

In the Perth metropolitan area, little penguins breed on Penguin Island, Garden Island, and Carnac Island (Appendix II Fig. 9). From a radio-tracking study in 1996/1997 the penguins from Penguin Island were found to (Bradley *et al.* 1997; Wooller *et al.* in review):

- travel south to Warnbro Sound and Comet Bay; occasionally moving further south, particularly during non-breeding;
- travel and forage between the coast and the Garden Island Ridge. To reach Comet Bay, the penguins must transit a corridor less than 2 km wide between Becher Point and the crest of the Garden Island Ridge offshore;
- generally remain within 15 km of Penguin Island during chick rearing; and
- be more likely to successfully raise chicks if they travelled shorter distances to feeding grounds.

(Appendix II Fig.9)

After moulting, the penguins generally leave the island and return at the prebreeding stage. There is little information on their locations during this time. There is anecdotal evidence of penguins observed west of Penguin Island. Penguins have also been found on beaches north of Penguin Island such as Woodman Point, Quinns Rocks and as far north as Geraldton. In 2004, two penguins were found on the beach at Quinns Rock. One of these had a flipper band and had been banded in 1993 on Penguin Island (Cannell pers. comm.).

5.4 CURRENT THREATS

The little penguin is in serious decline all around Australia, particularly in populations that are close to expanding urban areas (Boersma 1991; Dann 1992). The major current threats to the little penguins in the Perth metropolitan area are:

- reduction in food resources:
  - commercial fishing;
  - recreational fishing; and
  - destruction of fish habitat.
- entanglements;
- human disturbance;
- boating activity:
  - boat strikes; and
  - negative effects on behaviour.

5.4.1 Reduction in food resources

Most stocks of commercial and recreational fish species in Australian waters have declined through overfishing and the destruction of fish habitat (Hale 1997). Both commercial and recreational fishing affect fish numbers. Radio-tracking studies of penguins from Penguin and Phillip Islands have found that the penguins are reliant on a concentration of clupeoid fish within 15-20 km of their breeding site at the crucial time when they are raising young (Bradley *et al.* 1997; Collins *et al.* 1999; Weavers 1992; Wooller *et al.* in review).

Commercial fishing

The distribution of sandy sprat is largely restricted to nearshore waters and the nursery areas are restricted to protected inshore marine areas and major estuaries. The total stock size of sandy sprat between Fremantle and Busselton is < 1,000 tonnes and is patchily distributed (Gaughan *et al.* 1996). Sandy sprats are caught commercially using shore based nets and most is caught from the Bunbury region (Department of Fisheries 2002), although there is currently one operator taking sandy sprat from Becher Point. This species is particularly vulnerable to overfishing (Gaughan *et al.* 1996).

Pilchard biomass is carefully monitored and the risk of population reduction from commercial fishing would appear to be minimal (Cannell 2001). However isolated incidents such as the mass pilchard mortality in 1995 and 1999, in conjunction with commercial fishing, could have serious consequences on the pilchard population size. Following the mass mortality in 1995, there was an increase in adult penguin mortality at Phillip Island, a delay in their breeding and a reduced breeding success, and in increase in first-year mortality (Dann *et al.* 2000). On Penguin Island, the number of eggs laid in 1995 in the nest boxes was the second highest ever recorded, but the percentage of chicks raised was the lowest. The lowest number of eggs ever recorded in the boxes occurred in 1999, and the subsequent percentage of chicks raised was below average (Cannell pers. comm.).

Recreational fishing

Recreational fishing is one of the most popular leisure activities in Western Australia (Sumner & Williamson 1999). Between Yanchep and Mandurah, approximately 290,000 people partake in recreational fishing, generating an estimated 1.3 million fishing days a year (Department of Fisheries 2003 and refs within). In 1996/97, an estimated 10,626 boats fished in the southern half of Warnbro Sound and Comet Bay (Williamson pers. comm.). It is difficult to estimate the effect recreational fishers are having on the populations of fish in the area. However, in a recent survey, the recreational catch of many of the main species caught was similar to that of the commercial catch (Department of Fisheries 2002). The catch of both skipjack trevally (*Pseudocaranx dentex*) and garfish from the southern Perth and Mandurah regions (which incorporate Warnbro Sound and Comet Bay), were

amongst the highest recorded (Sumner & Williamson 1999). These two species have been found in the diet of Little Penguins, and garfish composed significant proportions of the diet in 1986, 1989 and 1995. The fish caught by the recreational fishers are, on average, larger than those taken by penguins (Sumner & Williamson 1999), but the larger fish taken represent the mature breeding population. Consequently the number of smaller juveniles on which the penguins prey is likely to be affected. Competition between the fishers and the penguins undoubtedly exists and is likely to be increasing with the increasing number of recreational fishers. The sustainability of recreationally fished stocks in Western Australia is threatened by population growth, coastal development, improved fishing and fish storage technology, a low participation cost and access to areas previously protected from significant levels of fishing due to their remoteness (Department of Fisheries 2003).

Destruction of fish habitat

Seagrass beds are important nursery areas for juvenile fish and feeding grounds for adult fish. For example, within the Shoalwater Islands Marine Park, over half of the 75 finfish species that have been recorded in nearshore shallow waters have an affiliation with seagrass (Department of Conservation and Land Management in prep.). Seagrass beds have also been shown to influence the assemblages of fish in adjacent sandy surf-zone areas (Ayvazian & Hyndes 1995). The large wracks of detached macrophyte detritus that originate from the seagrass beds provide food, particularly for juvenile fish, and shelter from predators (Lenanton & Caputi 1989; Robertson & Lenanton 1984). Two penguin prey species, blue sprat and garfish were found in sandy surf-zones associated with seagrass beds (Ayvazian & Hyndes 1995).

The seagrass ecosystems are affected by direct degradation as well as high sediment and nutrient loads, which reduces seagrass productivity (Blaber & Blaber 1980). Boating activity in shallow areas can scar seagrass beds, increase sediments in suspension and cause bottom-shear stress that will erode seagrass beds (Marsh *et al.* 2003).

Extensive studies of the fish populations inshore and offshore in Comet Bay, Warnbro Sound and Cockburn Sound have shown that the largest sandy sprat nursery in this area exists in the seagrass beds in the southern section of Warnbro Sound at Becher Point (Valesini *et al.* 1998). This was shown to be the only seagrass habitat between Fremantle and Becher Point that had not reduced in extent since the 1970s (Department of Environmental Protection 1996). An area, including the seagrass bed, was earmarked for a marina in the Port Kennedy Development Agreement Bill 1992 and was excised from the Shoalwater Marine Park when it was formed in 1990. The construction of a marina is now no longer likely. However the latest proposal for the area includes a boat ramp and jetty close to the seagrass bed, which will increase the level of boating activity near it. Sediment inundation due to the construction of a boat launching facility has been implicated as a major cause of the substantial decrease in seagrass meadows at Cape Peron from 1972-1994 (Department of Environmental Protection 1996). Therefore the potential sediment inundation from the proposed boat ramp and the increased boating activity pose a similar threat to the seagrass beds at Becher Point. This would reduce the efficacy of the seagrass as a nursery area and therefore the number of fish that originate from it. As a nearby, plentiful supply of sandy sprat is essential for the little penguins (Bradley *et al.* 1997; Collins *et al.* 1999; Wooller *et al.* in review), their breeding success and ultimately their population size, are likely to be negatively impacted.

5.4.2 Entanglements

Penguin species, including little penguins, have been caught in fishing nets in areas where the penguins travel, feed and rest on the surface (Majluf *et al.* 2002; Norman 2000). Little penguins from Victoria were found to be caught in a bay net and a purse/beach seine net (Norman 2000). For little penguins in the Perth metropolitan area, the risk of entanglement in fish nets appears to be low. Currently there is one beach seine fisher in Warnbro Sound, and no off shore purse seining occurs within Warnbro Sound or Comet Bay. There are three boats that trawl within the Comet Bay area for

prawns and scallops and there is no reported bycatch of penguins. Rock lobster pots are concentrated on the west side of the Murray Reef system whilst the penguins tend to remain on the east side of the reef system. Therefore the probability of penguins getting caught in the pots is low. There are two crab boats licensed to fish in the open ocean of Comet Bay, and one in Warnbro Sound. The impact of these fishers on penguins is thought to be minimal.

Penguins do become entangled in fishing line (Dann 1990; Norman 2000). Usually their flippers, feet or bill is entangled and the bird cannot feed or it may drown (Dann 1990). Penguins have been found entangled by fishing line to bushes on Penguin Island. The penguins are usually starving or dehydrated by the time they are found and their chance of survival is low (Cannell pers. obs.; Mitchell pers. obs.).

5.4.3 Human disturbance

Penguin Island and its penguins are a major tourist attraction and an estimated 80,000 people visit it a year (Goodlich pers. comm.). This increase in human presence on Penguin Island exacerbates the vulnerability of the colony. Trampling, destruction of habitat and disturbance of flora and fauna are the more severe impacts of humans on Penguin Island. Since the construction of the walkways on Penguin Island, public access to many areas used by the penguins has been restricted but direct disturbance of the penguins' nesting sites is conditional on people remaining on the walkways.

Other activities such as swimming and picnicking on the beaches also affect the penguins (Wienecke *et al.* 1995). The occupancy of the nest boxes and the hatching and breeding success of the pairs within the nest boxes is reduced in those areas closest to human disturbance (Klomp *et al.* 1991). Penguins will abandon their nest sites if disturbed and king skinks may then opportunistically take unprotected eggs. Some protection is afforded to the penguins during the typical first peak of breeding as the ferry is not operational from June to September. This however does not stop people making their own way to the island. Also, the second peak of breeding occurs from September to November/December (Cannell pers. obs.; Wienecke *et al.* 1995), followed by the moult period. This also coincides with warmer weather and school/Christmas holidays, and the moult period represents the only time in the annual cycle that the penguins are restricted to land. The number of people visiting the island during November- January is very high. The presence of the CALM Ranger and CALM volunteers on the island aids in the reduction of disturbance by visitors. However there are anecdotal reports of tourists and bus operators removing penguins from accessible caves in order to take photographs (Goodale pers. comm.). Unfortunately, stressed penguins are not easily discerned. A study on Adelie penguins showed that their heart rates could double with no evidence of posture change (Culik *et al.* 1990).

5.4.4 Boating activity

The Rockingham population is growing rapidly, as is the recreational use of the waters around Penguin Island. In 1996 an estimated 10,000 recreational fishing boats were found to use the same areas in which little penguins travel and forage (Williamson pers. comm.). The increase in the recreational use of wind surfers, parasails, jet skis, motor boats and other watercraft in the same areas where the penguins travel, forage and even sleep, make interactions between the two increasingly unavoidable. These interactions range from interruption of foraging bouts to the injury and even death of birds struck by boats, propellers or skegs.

Boat strikes

Most penguins die at sea and the chances of recovering them are small (Wienecke 1993). However, penguins have been collected with propeller/fin wounds across the upper body and flippers (Goodlich pers. comm.; Mayes pers. comm.), and a post mortem on a penguin in 2003 found large contusions on the side of its body (Cannell pers. comm.) suggesting a collision with watercraft. Little penguins

spend a large portion of their time underwater in the top 1-4 m of the water column (Bethge *et al.* 1997; Cannell *et al.* in prep.). Therefore, the probability of a collision between watercraft and penguins is high and increases with increasing watercraft usage in areas used by little penguins. As penguins transit through a narrow corridor between Warnbro Sound and Comet Bay, a boat ramp at Port Kennedy would increase the number of watercraft using the same narrow corridor, thus increasing the likelihood of negative interactions with the penguins.

Negative effects on behaviour

Little penguins are rarely seen at sea, and have been observed to dive immediately at the slow approach of a boat (Cannell pers. obs.). Thus passing watercraft could compromise the recovery time spent by penguins at the surface. Repeated disturbance could result in loss of fitness.

The presence of watercraft may cause the penguins to shift away from the areas they are use for foraging or travelling, thus potentially increasing their energy expenditure. From radio-tracking studies, all penguins tracked from Penguin Island foraged and travelled in Warnbro Sound and Comet Bay during chick rearing. Therefore repeated disturbance in these areas could potentially affect the survivorship of the population on Penguin Island.

5.5 POTENTIAL THREATS

The potential threats to little penguins in the Perth metropolitan area are:

- pollution:
  - oil spills;
  - chemical contaminants;
  - water quality; and
  - plastic pollution;
- introduced predators.

5.5.1 Pollution

Oil spills

Oil spills have the potential to elicit major, even catastrophic, effects on penguin populations (Dann 1996). Not only do they have immediate and devastating effects on Little Penguins, but oiled and rehabilitated little penguins show a delay in egg-laying the following season and they have an overall reduced egg success. For at least two seasons after the oiling event, masses of their pre-fledglings are significantly lower, reducing their survival rate (Giese *et al.* 2000). Findings from various studies suggest there is a dose related immune suppression among all seabirds that ingest petrochemicals at sea, during preening on land, or prior to being presented for cleaning and rehabilitation (Briggs *et al.* 1997).

According to the Department of Transport, the risk of an oil spill affecting Penguin Island is extremely low. The large ships using bunker oil are well offshore. Those travelling northwards towards Fremantle pass approximately seven to eight nautical miles to the west of Penguin Island.

On Garden Island, many small refuelling spills, predominantly diesel fuel, occur at the wharves in Careening Bay. The potential occurrence of a large oil spill is low but significant. However, the Royal Australian Navy has well defined procedures in place for clean up operations (Cannell 2002).

Chemical contaminants

Heavy metals

A study of coastal waters in Perth from 1991-1994 (Department of Environmental Protection 1996) showed that heavy metal loads in Warnbro Sound were relatively low (Department of Environmental Protection 1996). In a more recent study, the levels of chromium and copper in the sediments were found to have increased from 1994 to 1999, but were below Interim Sediment Quality Guidelines for the protection of marine ecosystems (DAL 2001). In both the 1994 and 1999 sediment surveys, arsenic was found to be elevated in sediments of the Warnbro Sound Basin (Department of Environmental Protection 1996; DAL 2001), and was generally greater than the criterion for the maintenance of ecosystem integrity at an EQO2 Class II level[3] (Department of Environmental Protection 1996). The principal source was thought to be the storm water drains. Arsenic is carcinogenic to animals and is toxic in other ways (Newman 1985). A study of little penguins from Phillip Island, Lion Island, Bowen Island, the Taronga Zoo and eggs from Montague Island showed that arsenic accumulated in the fat, and levels of 3.7-8.3 $mg.kg^{-1}$ of wet weight of fat were higher than levels previously reported for other seabirds. It is unclear the implications such levels have on the health of the penguins (Gibbs 1995).

In Cockburn Sound concentrations of heavy metals were found to be generally lower than in the 1970s and 1980s, but some large point discharges have occurred (Department of Environmental Protection 1996). For example, copper loads into Cockburn Sound were found to increase from 1992 to 1993 and zinc loads increased from 1991 to 1995. The major contributors of these heavy metals into Cockburn Sound are heavy industry (Department of Environmental Protection 1996). Subsequent surveys of sediments from various sites in Cockburn Sound in 1999 indicated that levels of chromium, copper and zinc have increased, but remain below Interim Sediment Quality Guidelines for the protection of marine ecosystems (DAL 2001). Water samples taken in 2003 indicated that the concentrations of heavy metals in Cockburn Sound were similar to that of open ocean and uncontaminated coastal waters (Department of Environment in press). Even so, there is the potential for heavy contamination from unlicensed inputs or accidental spills from toxic substances (Environmental Protection Authority 2005).

In the Sepia Depression, discharge is mainly through the wastewater outfall. Annual loads of copper, zinc, cadmium, chromium, lead and mercury have decreased since the Woodman Point wastewater treatment plant was upgraded in 2002. The levels are predicted to remain relatively constant until 2019 (Water Corporation of Western Australia 2003), although the maximum toxicant load allowable in 2019 has been capped at 3½ times the typical load in 2004 (Environmental Protection Authority 2004). In seabirds, cadmium causes behavioural changes, suppressed egg production, thinning of eggshells and testicular damage (Furness 1996). In animals it is known to cause kidney toxicity and to be carcinogenic (Burger & Gochfeld 2002 and references within). Lead poisoning can cause drooped wings, loss of appetite, lethargy, weakness, tremors, neurobehavioural effects including impaired locomotion, balance and depth perception, and death (Burger & Gochfeld 2002 and references within). Mercury can cause various reproductive and neural effects (Burger & Gochfeld 2002 and references within). Presumably similar effects will occur in little penguins.

Increased loads of pesticides and polychlorinated biphenyls (PCBs)

DDT was the most common organochlorine (OC) pesticide detected in sediments during the Southern Metropolitan Coastal Waters Study 1991-1994 (Department of Environmental Protection 1996). The majority of detection sites in Cockburn Sound were linked with marinas, harbours and industrial and municipal outfalls (Department of Environmental Protection 1996). It was found to be more widespread in Warnbro Sound and Comet Bay and probably entered via storm water drains and estuarine outflows (Department of Environmental Protection 1996). PCBs were found in sediments at

[3] EQO2 Class II represents a high level of protection which requires that any contaminant discharges or human-made changes which do occur may be readily absorbed or withstood by the waterbody without any detectable effects on the biota or the functioning of the ecosystem. Department of Environmental Protection (1996). Southern Metropolitan Coastal Waters Study (1991-1994). Final Report No. 17. Department of Environmental Protection, Perth, Western Australia, p 288

the Jervoise Bay Marina and in the southern basin of Warnbro Sound (Department of Environmental Protection 1996). In 2003, water samples from sites in Cockburn Sound and Warnbro Sound were tested for 49 different organic compounds (Department of Environment in press). Whilst the concentrations of all the compounds were below the Limit of Reporting, the Limit of Reporting for four of the chemicals was above the national guidelines set for 99% species protection (Department of Environment in press). For 36 of the compounds, there are no national guidelines for 90%, 95% or 99% species protection (Department of Environment in press).

Increased levels of OCs and PCBs have been associated with increased rates of anomalies in seabird eggs, including live-deformed embryos (Yamashita *et al.* 1993). Other effects of PCBs found in seabirds include embryo mortality, growth retardation and liver damage (Gilbertson 1989). DDT is known to cause thinning of egg shells, particularly in birds of prey and those that eat fish (Commonwealth Scientific and Industrial Research Organisation 1979). Currently there have been no studies undertaken to determine the levels of these compounds in penguins, and from the nestbox data there is no evidence to suggest that eggs are accidentally broken during incubation (an indicator that egg shells are thinner and weaker than normal) (Cannell pers. comm.).

Butyltins (BT)

Butyltin compounds include tributyltin (TBT) and its degradation products monobutyltin (MBT) and dibutyltin (DBT). Tributyltin has been used for several decades as the active ingredient in certain marine anti-fouling paints and has been banned on vessels under 25 m in length in W.A. since 1992. It is extremely toxic to marine life, and causes a sexual deformity (imposex) in marine snails. In birds it has been found to reduce fertility and hatching success (Schlatterer *et al.* 1993). It has been found throughout sediments in Warnbro Sound and the northern half of Comet Bay (Department of Environmental Protection 1996). Although levels of TBT in the sediment do not necessarily indicate levels of TBT in the water column, bioaccumulation up through the food chain means that little penguins could accumulate TBT if their prey forage in areas where it is still present in the sediment. A recent survey of the rate of imposex in the whelk, *Thais orbita,* from various study sites showed that the rate had decreased around Penguin Island and the Sisters Reef (Reitsema *et al.* 2003). It would therefore appear that levels of TBT would not be of a great immediate concern to the Penguin Island colony.

In contrast, the little penguins on Garden Island may be affected by TBT. It is most likely that these penguins forage in Cockburn Sound (Cannell 2003) and the incidence of imposex in whelks between 1993 and 1998/99 remained high at northern and southern Jervoise Bay, Challenger Beach and Colpoys Point (within 50 m of a naval berthing facility) (Reitsema *et al.* 2003). TBT has also been found throughout sediments in Cockburn Sound (Department of Environmental Protection 1996).

In 2003 penguin carcasses from both Penguin and Garden Islands were sent to Defence Science and Technology Organisation (DSTO) in Melbourne, for analysis of BT levels in tissues. At the time of writing the results were still being analysed.

Copper is used as an antifouling agent on smaller craft and its effects are currently unknown.

Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs enter the coastal system via man-made processes such as urban runoff, boat/ship exhaust (particularly smaller boats due to poor exhaust systems), oil spills, industrial processes and from oil refineries (Marsili *et al.* 2001, Gagnon pers. comm.). PAHs in the aquatic environment are either quickly adsorbed on to the surface of organic and inorganic particles and settle out, or they remain in solution and are readily available to aquatic organisms (Marsili *et al.* 2001). PAHs are known to be carcinogenic, mutagenic and teratogenic (International Programme on Chemical Safety 1998). Hydrocarbon "biomarkers" have been found in fish sampled in Cockburn Sound (DAL 2001).

Water quality

The Sepia Depression is a north-south natural underwater channel found to the west of Garden Island, Rockingham and Warnbro Sound (D'Adamo *et al.* 2000). Secondary treated effluent from the Woodman Point wastewater treatment plant and primary treated effluent from the Point Peron wastewater treatment plant are discharged into the Sepia Depression via the Sepia Depression ocean outfall (previously known as the Cape Peron ocean outfall). This outfall is the largest single point source of nutrients into the region. Northerly to north-westerly winds can drive water from Cockburn Sound and the Sepia Depresssion ocean outfall into Shoalwater Bay and Warnbro Sound, thus potentially bringing a suite of chemical contaminants, nutrients and biological organisms (D'Adamo *et al.* 2000). The extended reef system running parallel to the coast and extending from near Geraldton to Mandurah reduces water exchange between the embayments and the open sea. Thus contaminated water can remain in the embayments for extended periods (D'Adamo *et al.* 2000).

In Cockburn Sound, water quality, as a function of chlorophyll a levels, is not that different from its poorest recorded state in the 1970s. This is despite the large decrease in nutrient inputs since then (Department of Environmental Protection 1996; DAL 2001). Algal blooms can be toxic to marine animals and increased turbidity can affect growth and reproduction of seagrasses, in turn potentially affecting fish availability.

Plastic pollution

Apart from fishing line, penguins can get entangled in, or swallow, plastic pollution such as the yokes from cans and bottles, plastic bags (Dann 1990).

5.5.2 Introduced predators

Currently there are no introduced predators on Penguin Island. Cats are very efficient predators, with a report of feral cats killing approximately 20 penguins in three days on Wedge Island, Tasmania (Stahel & Gales 1987), and 19 penguins killed by a cat released onto an island near Albany (Wienecke 1993). Dogs and foxes are also efficient predators, being implicated in several extinctions and declines of penguin colonies (Dann 1996). The probability of such predators making their way to the island is remote, however dogs have been found wandering by themselves on the island (Wienecke pers. comm.). There is also anecdotal evidence of surfers bringing dogs to Penguin Island on their surfboards. When the tides are low, the water level above the sandbar connecting Penguin Island and the mainland can be as low as a few centimeters. Full exposure of the sandbar would be a threat to the penguins, and would need to be assessed at the time of occurrence.

On Garden Island, cats and foxes are not established and do not appear to gain access very readily. In particular, fencing, lights and auditory devices plus observations severely restrict access across the causeway. Nevertheless, evidence of a feral predator kill of another bird species was found amongst the penguin colony in 2001, and in 2003 two different cats were sighted on base. Any signs of a cat or fox leads to a large-scale trapping, baiting and shooting program to hopefully ensure the animal is quickly eliminated.

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6. SEABIRDS

The major seabird species (other than little penguins and silver gulls) that currently use the coastal waters between Yanchep and Mandurah are:

bridled terns	*Sterna anaethetus;*
caspian terns	*Hydroprogne caspia*;
fairy terns	*S. nereis*;
roseate tern	*S. dougallii*;
crested terns	*S. bergii*;
little pied cormorants	*Phalacrocorax melanoleucos*;
pied cormorants	*P. varius*;
pied oystercatchers	*Haematopus longirostris*;
wedge-tailed shearwaters	*Puffinus pacificus*;
little shearwaters	*Puffinus assimilis*;
pelicans	*Pelecanus conspicillatus*; and
ospreys	*Pandion haliaetus*.

Apart from those listed above, a group of immature and adult white-breasted sea eagles (*Haliaeetus leucogaster*), roost and feed at Garden Island every year in the autumn (Wykes *et al.* 1999). This species is classified as a rare visitor to Perth (Storr & Johnstone 1988).

It is also noteworthy that in 2003, two tropical seabird species, sooty terns (*S. fuscata*) and brown noddies (*Anous stolidus*), were observed at Penguin Island. Whilst not breeding, they were likely to be prospecting for breeding sites (Dunlop pers. comm.). In 1991/92, five nests were reported on Lancelin Island – this was the first time they had been known to nest south of Pelsaert Island in the Houtman Abrolhos. By 1997/98 more than 900 pairs were breeding at Lancelin Island (Dunlop & Rippey 2000). Similarly, sooty terns displayed prospecting behaviour for a couple of years at Lancelin Island before four pairs nested there in 1998/99 (Dunlop & Rippey 2000). It is therefore likely that these tropical birds are shifting their range further southwards and in the future may breed on Penguin Island.

6.1 CONSERVATION STATUS

The seabirds in the Perth metropolitan area are protected under various state, commonwealth and/or international statutes (Table 1). The Natural Heritage Trust 2 (NHT2) has formed a Bilateral Agreement between the Western Australian State Government and the Commonwealth Government. That agreement specifies priorities for the delivery of marine and coastal natural resource management, through the Coastcare funding stream of NHT2. CALM has responded to the Coastcare priorities of the bilateral agreement through the development of a set of biodiversity conservation management priorities, resulting in a set of priorities for each NHT2 region and a set that addresses Statewide issues. As part of this process a risk assessment of marine fauna was undertaken. Tern species in the Perth metropolitan area were identified as having a high conservation value and medium relative threat (Department of Conservation and Land Management 2003) (Appendix I). Within Western Australia they have also been acknowledged as a group where (Simpson & Holley 2003):

- the W.A. population of one or more of these species is ‘at risk’; and
- the ‘sub populations’, groups or individuals of one or more of these species are ‘at risk’ from recreational interaction.

Cormorants and pelicans in the Perth metropolitan area have been identified as having a medium relative threat and a medium conservation value (Department of Conservation and Land Management

2003) (Appendix I). Within W.A. they have also been acknowledged as species where the 'sub populations', groups or individuals of one or more of these species are 'at risk' from recreational interaction (Simpson & Holley 2003).

Table 1. List of state, commonwealth and/or international statutes protecting each species.
(See Appendix III for details of each category).

Species	Status
Bridled terns	WAWCA 1950* Listed Migratory Species (EPBC 1999) Listed Marine Species (EPBC 1999) JAMBA# CAMBA**
Caspian terns	WAWCA 1950 Migratory Marine Bird (EPBC 1999) Listed Marine Species (EPBC 1999) CAMBA
Fairy terns	WAWCA 1950 Listed Marine Species (EPBC 1999)
Roseate terns	WAWCA 1950 Listed Marine Species (EPBC 1999)
Crested terns	WAWCA 1950 Listed Marine Species (EPBC 1999)
Little pied cormorants	WAWCA 1950
Pied cormorants	WAWCA 1950
Pied oystercatchers	WAWCA 1950
Wedge-tailed shearwaters	WAWCA 1950 Listed Marine Species (EPBC 1999) JAMBA
Little shearwaters	WAWCA 1950 Listed Marine Species (EPBC 1999)
Pelicans	WAWCA 1950 Listed Marine Species (EPBC 1999)
Ospreys	WAWCA 1950 Listed Marine Species (EPBC 1999)

*WAWCA 1950 – Western Australian Wildlife Conservation Act 1950
JAMBA- Agreement between the Government of Japan and the Government of Australia for the Protection of Migratory Birds, Birds in Danger of Extinction and their Environment.
**CAMBA– Agreement between the Government of Australia and the Government of the Peoples' Republic of China for the Protection of Migratory Birds and their Environment

6.2 GENERAL ECOLOGY AND OCCURRENCE

For many of the seabird species, studies on their general ecology and occurrence in the Perth metropolitan area have not been undertaken for approximately 20 years. Research is undertaken on the Shoalwater Islands each summer, and whilst effort is concentrated on bridled terns and Penguin

Island, an inventory of species occurring on all the islands in this group is also collected (Dunlop pers. comm.).

6.2.1 Bridled terns

Bridled terns breed on a number of islands in the Perth metropolitan area. They have a high nest site fidelity, although they may move short distances within the colony (Dunlop & Jenkins 1992). They nest under low dense vegetation, slabs of limestone, beach-rock coral rubble or in cavities in outcropping rock (Dunlop & Rippey 2000). They return to their breeding sites between late September and early October, having spent the austral winter in the north western sector of the Sulawesi Sea (Dunlop & Johnstone 1994). Eggs are usually present in the colony from early November to the end of December, and chicks from early December to early April (Dunlop & Bamford 1987a). There is a mass exodus from the Western Australian islands of all Bridled Terns from mid-April to early May (Dunlop & Johnstone 1994). Young birds return to their natal colony around three years of age but do not appear to begin breeding until they are four years old (Dunlop & Jenkins 1992). They feed 40 – 80 km offshore dispersing on the middle-outer continental shelf (Dunlop *et al.* 1988) and are strongly associated with detached *Sargassum* rafts (Dunlop 1997). They mainly feed on small clupeids such as sandy sprat (*Hyperlophus vittatus*), pilchards (*Sardinops sp.*) and blue sprat (*Spratelloides robustus*); larval goatfish (*Parupeneus signatus*) and columbus crab (*Planes cyaneus* megalopae), a range of other larval fishes and insects (Dunlop 1997; Dunlop & Bamford 1987a).

6.2.2 Caspian terns

Unlike bridled terns, caspian terns do not return to the same nest site each year. They breed from July – November (Storr & Johnstone 1988), and they breed and roost on Rottnest, Carnac, Bird, Gull and Seal islands and roost only on Penguin Island. The breeding numbers are low, 1-20 pairs, with the largest colony recorded at Seal Island. They tend to make cryptic nests in shallow soil areas with little vegetation (Dunlop & Rippey 2000). During the nonbreeding season, the birds (particularly immatures) probably move to the upper reaches of the estuaries. They forage in shallow waters inshore over seagrass or limestone reef (Dunlop pers. comm.; Surman & Wooller 2003). They feed on demersal fish such as mullet, wrasse and whiting (Dunlop pers. comm.).

6.2.3 Fairy terns

Fairy terns change their breeding station every year. It is very difficult to get an accurate count of the number of fairy terns in the Perth metropolitan area, however it is estimated to be between 100 and 500 pairs (Dunlop pers. comm.). They nest on beaches or sand sheets with flotsam shell or coral clinker cover (Dunlop & Rippey 2000). During the nonbreeding period the fairy terns migrate north, probably to the Pilbara (Saunders & de Rebeira 1985). They are inshore feeders (Surman & Wooller 2003), feeding in coastal embayments, estuary mouths and on the inner continental shelf often behind surf breaks or along sand bars (Dunlop pers. comm.). They have been frequently observed roosting and foraging around the sandbars at Alfred Cove in the Swan Estuary Marine Park (Bamford *et al.* 2003). They usually feed on fish such as hardyheads and blue sprat (Dunlop pers. comm.).

6.2.4 Roseate terns

Roseate terns breed in autumn and spring (Dunlop & Wooller 1986). They do not have fixed nest sites and use rocky islands for breeding. There are less than 50 pairs known to breed in the metropolitan area. They have a few main breeding stations and are likely to breed elsewhere but the nesting sites haven't as yet been located. Although they breed in tightly packed colonies, the individual pairs partially conceal their nests amongst broken ground, talus, coral rubble or low vegetation (Burton *et al.* 1996; Dunlop & Rippey 2000). On the inshore islands between Shoalwater Bay and Mandurah, they nest on the edges of limestone plateaux or amongst the talus at the base of the cliffs (Dunlop &

Rippey 2000 and refs. within). They forage close to their breeding colony in deep channels, deep water behind breakers and the inner continental shelf (Dunlop pers. comm.; Surman & Wooller 2003). They mainly eat sprats and beaked salmon (Surman & Wooller 2003). They move northwards along the coast following breeding (Dunlop pers. comm.).

6.2.5 Crested terns

The population of crested terns appears to have dramatically declined since the pilchard mass mortality in 1995 and then in 1998/99, from approximately 1,200-1,500 pairs down to 500-600 pairs. Prior to the pilchard mass mortality in 1995, the crested terns exhibited peak breeding in autumn and spring (Dunlop 1985; Dunlop & Bamford 1987b), but now they breed in late spring only. The terns have traditional areas where they assemble and will nest after a period of group display and social facilitation (Dunlop 1987). Breeding sites occur on islands throughout the metropolitan area, but are not necessarily used every year or even over periods of years (Dunlop & Bamford 1987b). They tend to return, at least initially, to successful breeding sites. They nest on limestone plateau with scattered low woody or succulent shrubs (Dunlop & Rippey 2000). After breeding the breeding birds do not migrate past approximately 40 km although juveniles have moved as far as NW Cape (Dunlop pers. comm.).

Crested terns forage close to the breeding colonies, on shallow reef flats and coastal shelf waters (Surman & Wooller 2003). They mainly forage on pilchard, blue sprat and buffalo bream *(Kyphosus* spp.) (Dunlop 1986), sardinella (*Sardinella lemuru*) and Australian anchovy (*Engraulis australis*) (Surman & Wooller 2003).

6.2.6 Little pied cormorants

Little pied cormorants are spring breeders. The marine system is not as important to them for breeding compared to wetland systems, although they are found to breed intermittently on islands. Approx. 4-6 pairs were found breeding on the northern end of Penguin Island in the 1990's and again in 2004 (Dunlop pers. comm.). They breed in small numbers at Rottnest Island (Storr & Johnstone 1988) and are a regular visitor to Garden Island (Wykes *et al.* 1999). They nest on clumps of nitre bush (*Nitraria billardierei*) when available, but as they only nest intermittently in small colonies, they do not totally destroy their nesting habitat (Dunlop & Rippey 2000).

6.2.7 Pied cormorants

Pied cormorants breed in autumn and winter, on several of the Shoalwater Islands, Carnac, Garden and Dyer islands (Storr & Johnstone 1988; Wykes *et al.* 1999). They build their nests on clumps of nitre bush when available, or sometimes on summer-scented wattle (*Acacia rostellifera*) growing on cliff edges (Wooller & Dunlop 1981). They breed in tightly packed colonies, but as they usually kill the shrubs they nest upon, the colony must shift each season (Dunlop & Rippey 2000). They can occasionally be found nesting on low succulents or bare ground (Rippey *et al.* 2002). They feed in inshore embayments such as Cockburn and Warnbro Sounds, probably on anchovies and demersal species such as wrasse, cobbler and weed whiting in seagrass habitats (Dunlop pers. comm.). Breeding populations have increased dramatically over the last decade or so (Dunlop pers. comm.).

6.2.8 Pied oystercatchers

Pied oystercatchers breed on Rottnest, Carnac and Penguin islands from July-October (Storr & Johnstone 1988). They are usually only seen in ones, twos or small parties. They prefer seaweedy beaches, reef flats, edge of salt lakes and estuaries (Storr & Johnstone 1988).

6.2.9 Wedge-tailed shearwater

Wedge-tailed shearwaters arrive in mid-August and depart around May (Burbidge *et al.* 1996). In the Perth metropolitan area they breed on Carnac and Rottnest islands (Storr & Johnstone 1988). The numbers have dramatically increased on Rottnest Island eg. 2,570 in 1982 to 5,865 in 1993 and 11,745 in 2002 (Bancroft *et al.* in prep.). They nest in burrows and have a strong nest site fidelity (Dunlop & Rippey 2000). They probably feed mainly on baitfish and squid over outer shelf waters (Dunlop pers. comm.).

6.2.10 Little shearwater

Little shearwaters breed in winter, laying eggs in June and chicks fledging in October. The birds are sedentary but remain out to sea prior to courtship which begins in February/March. They forage on the mid-outer continental shelf. There are approximately 25 pairs on Penguin Island (Dunlop pers. comm.).

6.2.11 Pelicans

Similar to crested terns, the breeding sites of pelicans are not predetermined, but are dependent on where the flocks aggregate. They do have a tendency to return to successful breeding sites. For example, pre-breeding flocks have been seen on Penguin Island since 1999. Prior to breeding on Seal and Penguin islands, a flock of pelicans were breeding at Boundary Island. However, a float aircraft attempted to land over the pelicans, after which the pelicans deserted the area and seemingly moved to Penguin Island. The peak number of pelicans observed breeding at any one time on Penguin Island is approximately 150 pairs. However, over the course of a year 700–800 pairs would use the island. Pelicans feed inshore over sandy, seagrass waters, mostly on fish such as mullet and whiting. They probably disperse to estuaries after breeding (Dunlop pers. comm.).

6.2.12 Osprey

Whilst ospreys are uncommon, about 2-3 pairs bred on Garden Island in 1995-1997 (Wykes *et al.* 1999), four nests are currently being used at Rottnest, one pair breed on the telstra tower at Quinns Rock, and another pair breed at Devils Elbow (behind Christchurch Grammar School) (Delamare pers. comm.). Numbers of osprey have declined in recent years at Rottnest (Delamare pers. comm.). They lay eggs in August/September.

6.3 CURRENT THREATS

The current threats to seabirds in the Perth metropolitan area are:

- human disturbance:
  - visitation to seabird colonies; and
  - boating activity.
- habitat loss/change.

6.3.1 Human disturbance

Visitation to seabird colonies

Seabird colonies in the Shoalwater Islands Marine Park (SIMP) are one of the major attractions for visitors (Department of Conservation and Land Management in prep.). Human disturbance has been shown to impact colonial waterbirds whilst nesting, foraging and roosting. Adverse effects include egg and chick mortality; premature fledging or nest evacuation; reduced body mass or slower growth

of chicks; altered foraging patterns of adults; altered social behaviour and community dynamics; disrupted occupation of colony sites, foraging areas, pair-bond establishment and selection of nest-site; increased predation; and population decline (Anderson & Keith 1980; Buckley & Buckley 1976; Burger & Gochfeld 1993; Rodgers & Smith 1995 and references within; Carney & Sydeman 1999; Stokes *et al.* 1996 and references within).

The severity and likely impact of the disturbance is dependent on many factors such as the frequency and duration of the disturbance (Hill *et al.* 1997), the activity causing the disturbance, the type of visitors (e.g. ecotourists, recreationists, scientists), (Burger & Gochfeld 1993; Ellison & Cleary 1978; Klein 1993), the number of visitors (Stokes *et al.* 1996), time of the year (Buckley & Buckley 1976) and the proximity of the disturbance to the seabirds. The distance at which seabirds respond to a disturbance is further known to be affected by the species (Erwin 1989; Klein 1993), the time of the day and year (Erwin 1989) and the habituation of the species to the disturbance (Erwin 1989; Hill *et al.* 1997; Rodgers & Smith 1995). However there is very little detailed research investigating the factors associated with disturbance for many seabird species (Burger & Gochfeld 1998; Carney & Sydeman 1999; Hill *et al.* 1997).

In general, seabirds with a low attachment (i.e. fidelity) to their breeding sites, such as crested, roseate, fairy and caspian terns, are very sensitive to disturbance whilst the colony is in the early stages of its formation prior to breeding. They are likely to abandon an area if disturbance occurs at this critical period (Dunlop & Rippey 2000). These species also tend to nest in concentrated sites with small numbers of breeding pairs and are therefore easily disturbed even after the colony is established. Nearby human activity can cause the adults to abandon their nests and even temporary abandonment leaves the eggs and chicks open to predation (Dunlop & Rippey 2000). For example, fairy terns nest on scrapes on beaches and are easily disturbed by beach users and dogs (Saunders & de Rebeira 1985; Singor 1998; Wykes *et al.* 1999). Silver gulls and ravens will scavenge on disturbed nest sites, taking the eggs and chicks (Saunders & de Rebeira 1985). Therefore protected island beaches are becoming increasingly important to the continued existence of fairy terns in the region (Wykes *et al.* 1999).

Seabirds with a high fidelity to a breeding site tend to be more tolerant of human disturbance, although this is dependent on the frequency and type of disturbance (Dunlop 1996; Dunlop & Rippey 2000).

Boating activity

Water-based recreation has been identified as a source of disturbance to roosting, nesting and foraging seabirds (Hill *et al.* 1997; Rodgers & Schwikert 2002). The ramifications of such disturbance are detailed in the preceding section. The level of disturbance to the seabirds is affected by the distance of the watercraft to the colony, the speed it is travelling at and watercraft type (Burger 1998; Burger & Leonard 2000; Rodgers & Schwikert 2002). In recent years, personal watercraft (PWC) have been implicated to potentially disturb seabirds more than outboard-powered motor boats as the former can manoeuvre rapidly and erratically and can travel in relatively shallow water (Burger 1998). Wind surfers and particularly kite sailing are also probable agents of disturbance, particularly that latter because of the elevated kite. Terns have been shown to react more significantly to PWC compared to other types of watercraft (Burger 1998; Burger & Leonard 2000), and PWC have negatively impacted their breeding success (Burger & Leonard 2000). Nesting birds in the Everglades National Park in Florida were negatively impacted by PWC and were banned in the park (Heinrich 1997). PWC have been banned from the majority of national parks throughout the USA as the use of PWC does not fit with the preservation of natural, cultural, and wilderness values in national parks (Heinrich 1997; National Parks 2002). However, outboard-powered motor boats have been shown to disturb many seabird species at similar distances as PWC, particularly when rapidly and directly approaching seabirds (Rodgers & Schwikert 2002). Recent available modifications to outboard-powered motor boats mean they can also disturb seabirds in shallow waters (Rodgers & Schwikert 2002).

6.3.2 Habitat loss/change

Habitat loss or degradation is a major threat to the long-term survival of all waterbirds (Kingsford & Norman 2002). The seabirds that utilise the Perth metropolitan area have varied requirements for nesting. Shearwaters are ground burrowers and need sand/soil deep enough to excavate nests in or limestone crevices. The terns need rock or vegetation with various amounts of concealment or open spaces that provide a cryptic background. Cormorants nest above ground on woody shrubs (Dunlop & Rippey 2000). The overabundance of one seabird species on an island can result in a change in the vegetation structure, ultimately affecting the suitability of the island for other species (Dunlop & Rippey 2000; Gillham 1961). For example, pied cormorants numbers on Carnac Island have significantly increased, their guano and mechanical damage of vegetation has resulted in the loss of succulent shrubs used by wedge-tailed shearwaters and little penguins for burrowing under. The latter two species now rarely use this island (Dunlop & Rippey 2000).

When guano and physical damage alter vegetation structure, vegetation recovery can occur initially through the growth of ornitocoprophilous plants such as Australian hollyhock (*Lavatera plebeia*), which essentially reduce the nutrient loads from the guano and then allow other successional plants to grow. However, many other weeds also thrive under such high nutrient conditions. The tree mallow (*Lavatera arborea*), out-competes the hollyhock and persists in the environment rather than being succeeded by indigeneous shrub cover (Dunlop & Rippey 2000). It has been implicated as the main cause of a decline in plant species richness on the smaller Shoalwater Islands (Rippey *et al.* 1998) and has altered the nesting habitats and thus suitability of Seal and Carnac islands to various seabird species (Dunlop & Rippey 2000).

6.4 POTENTIAL THREATS

The major potential threats to seabirds in the Perth metropolitan area are:

- reduction in food resources:
  - commercial and recreational fisheries; and
  - destruction of fish habitat.
- entanglements;
- pollution:
  - oil spills;
  - chemical contaminants; and
  - plastic pollution.
- introduced predators on islands; and
- climate change.

6.4.1 Reduction of food resources

The degree to which each species is affected by the reduction of food resources is dependent on where each species preferentially feeds and its prey species.

Commercial and recreational fisheries

The Beach Bait Managed Fishery targets whitebait, although yellow-eye mullet (*Aldrichetta forsteri*), pilchards (*Sardinops sagax*) and blue sprat are amongst other retained species from this fishery. The latter two species have only been taken from the fishery in Cockburn Sound (Department of Fisheries 2002; 2003). The West Coast Purse Seine Fishery primarily catches pilchards and sardinella, but also takes Australian anchovy amongst other fish species (Department of Fisheries 2003). Both fisheries are well managed for specific species. For example, much research has been completed on whitebait stocks in south-western Australia (Gaughan *et al.* 1996). The spawning biomass of pilchards is surveyed bi-annually, and the total catch allowable is set at 10-15% of the spawning biomass

(Department of Fisheries 2003). As many seabirds are reliant on a variety of small pelagic fish, it is important to consider all pelagic species not just the primary target species when managing such fisheries. To this end, the Department of Fisheries is currently developing a strategy to manage the purse seine fishery from an ecosystem base (Department of Fisheries 2003).

Recreational fishing is one of the most popular leisure activities in Western Australia (Sumner & Williamson 1999). Between Yanchep and Mandurah approximately 290,000 fishers are estimated to fish, generating an estimated 1.3million fishing days a year (Department of Fisheries 2003 and references within). A survey of recreational boat based fishing on the west coast in 1997 showed that the overall catch of many species was of similar magnitude to the commercial catch (Department of Fisheries 2002). The sustainability of recreationally fished stocks in Western Australia is threatened by population growth, coastal development, improved fishing and fish storage technology, a low participation cost and access to areas previously protected from significant levels of fishing due to their remoteness (Department of Fisheries 2003). There is anecdotal evidence of a reduction of abundance of popular target reef fish species at least within the Shoalwater Islands Marine Park (Department of Conservation and Land Management in prep.).

Destruction of fish habitat

Seagrass beds are important nursery areas for juvenile fish and feeding grounds for adult fish. For example, within the SIMP, over half of the 75 finfish species that have been recorded in nearshallow waters have an affiliation with seagrass (Department of Conservation and Land Management in prep.). Seagrass beds have also been shown to influence the assemblages of fish in adjacent sandy surf-zone areas (Ayvazian & Hyndes 1995). The large wracks of detached macrophyte detritus that originate from the seagrass beds provide food, particularly for juvenile fish, and shelter from predators (Lenanton & Caputi 1989; Robertson & Lenanton 1984).

The seagrass ecosystems are affected by direct degradation as well as high sediment and nutrient loads, which reduces seagrass productivity (Blaber & Blaber 1980). Boating activity in shallow areas can scar seagrass beds, increase sediments in suspension and cause bottom-shear stress that will erode seagrass beds (Marsh *et al.* 2003).

6.4.2 Entanglements

Seabirds can become entangled in fishing nets, fishing lines, nylon ropes and hooks and other plastic pollution such as plastic bags. Cormorants and terns have been reported amongst the many species listed as bycatch by inshore commercial fisheries in Victoria (Norman 2000). Seabirds caught tended to die (Norman 2000). Wedge-tailed shearwaters, Australian pelicans, pied cormorants and crested terns were amongst those species reported by the Australian Bird and Bat Banding Scheme to be found entangled in fishing gear or human objects in South Australia, New South Wales and Victoria. Recreational fishing gear was thought to be responsible for the deaths of the pied cormorants and crested terns (Norman 2000). It is also a major problem with pelicans including those in SIMP and the Peel Harvey Inlet where birds are commonly observed carrying embedded hooks or trailing line (Dunlop pers. comm.).

6.4.3 Pollution

The extended reef system running parallel to the coast and extending from near Geraldton to Mandurah reduces water exchange between the embayments in the Perth metropolitan region and the open sea. Thus contaminated water can remain in the embayments for extended periods (D'Adamo *et al.* 2000). Northerly to north-westerly winds can drive water from Cockburn Sound and the Woodman Point Treatment Plant, which discharges treated effluent at the Cape Peron outfall, into Shoalwater Bay and Warnbro Sound, thus potentially bringing a suite of chemical contaminants, nutrients and biological organisms (D'Adamo *et al.* 2000).

Oil spills

Oil spills cause fouling of feathers, a loss of buoyancy and thermal control, internal organ damage such as kidney and liver lesions and gut mucosal damage, and immune system damage (Briggs *et al.* 1996 and references within). Breeding seabirds with oil on their feathers can coat their eggs in oil, decreasing their hatching success (Burger & Gochfeld 2002; Lewis & Malecki 1954). Growth and developmental defects of chicks (Hunt 1987) are also caused by exposure to oil.

Chemical contaminants

Heavy metals

A study of coastal waters in Perth from 1991-1994 (Department of Environmental Protection 1996) showed that heavy metal loads in Warnbro Sound were relatively low (Department of Environmental Protection 1996). In a more recent study, the levels of chromium and copper in the sediments were found to have increased from 1994 to 1999, but were below Interim Sediment Quality Guidelines for the protection of marine ecosystems (DAL 2001). In both the 1994 and 1999 sediment surveys, arsenic was found to be elevated in sediments of the Warnbro Sound Basin (Department of Environmental Protection 1996; DAL 2001), and was generally greater than the criterion for the maintenance of ecosystem integrity at an EQO2 Class II level[4] (Department of Environmental Protection 1996). The principal source was thought to be the storm water drains. Arsenic is carcinogenic to animals and is toxic in other ways (Newman 1985).

In Cockburn Sound concentrations of heavy metals were found to be generally lower than in the 1970s and 1980s, but some large point discharges have occurred (Department of Environmental Protection 1996). For example, copper loads into Cockburn Sound were found to increase from 1992 to 1993 and zinc loads increased from 1991 to 1995. The major contributors of these heavy metals into Cockburn Sound are heavy industry (Department of Environmental Protection 1996). Subsequent surveys of sediments from various sites in Cockburn Sound in 1999 indicated that levels of chromium, copper and zinc have increased, but remain below Interim Sediment Quality Guidelines for the protection of marine ecosystems (DAL 2001). Water samples taken in 2003 indicated that the concentrations of heavy metals in Cockburn Sound were similar to that of open ocean and uncontaminated coastal waters (Department of Environment in press). Even so, there is the potential for heavy contamination from unlicensed inputs or accidental spills from toxic substances (Environmental Protection Authority 2005).

In the Sepia Depression, discharge is mainly through the wastewater outfall. Annual loads of copper, zinc, cadmium, chromium, lead and mercury have decreased since the Woodman Point wastewater treatment plant was upgraded in 2002. The levels are predicted to remain relatively constant until 2019 (Water Corporation of Western Australia 2003), although the maximum toxicant load allowable in 2019 has been capped at 3½ times the typical load in 2004 (Environmental Protection Authority 2004).

In seabirds, cadmium causes behavioural changes, suppressed egg production, thinning of egg-shells and testicular damage (Furness 1996). In animals it is known to cause kidney toxicity and to be carcinogenic (Burger & Gochfeld 2002 and references within). Lead poisoning can cause drooped wings, loss of appetite, lethargy, weakness, tremors, neurobehavioural effects including impaired locomotion, balance and depth perception, and death (Burger & Gochfeld 2002 and references within). Mercury can cause various reproductive and neural effects (Burger & Gochfeld 2002 and references within).

[4] EQO2 Class II represents a high level of protection which requires that any contaminant discharges or human-made changes which do occur may be readily absorbed or withstood by the waterbody without any detectable effects on the biota or the functioning of the ecosystem. Department of Environmental Protection (1996). Southern Metropolitan Coastal Waters Study (1991-1994). Final Report No. 17. Department of Environmental Protection, Perth, Western Australia, p 288

Increased loads of pesticides and polychlorinated biphenyls (PCBs)

DDT was the most common organochlorine (OC) pesticide detected, with the majority of detection sites in Cockburn Sound being linked with marinas, harbours and industrial and municipal outfalls (Department of Environmental Protection 1996). It was found to be more widespread in Warnbro Sound and Comet Bay and probably entered via storm water drains and estuarine outflows (Department of Environmental Protection 1996). PCBs were found in sediments at the Jervoise Bay Marina and in the southern basin of Warnbro Sound (Department of Environmental Protection 1996). (Department of Environmental Protection 1996). In 2003, water samples from sites in Cockburn Sound and Warnbro Sound were tested for 49 different organic compounds (Department of Environment in press). Whilst the concentrations of all the compounds were below the Limit of Reporting, the Limit of Reporting for four of the chemicals was above the national guidelines set for 99% species protection (Department of Environment in press). For 36 of the compounds, there are no national guidelines for 90%, 95% or 99% species protection (Department of Environment in press).

DDT causes eggshell thinning (Peakall 1970) and abnormalities in shell structure resulting in hypoxia of the embryo (Fox 1976). Increased levels of OCs and PCBs have been associated with increased rates of anomalies in Caspian Tern eggs, including live-deformed embryos (Yamashita *et al.* 1993). Other effects of PCBs found in gulls, terns and cormorants include embryo mortality, growth retardation and liver damage (Gilbertson 1989). A deformed Pelican chick was recently recovered on Penguin Island and this could be symptomatic of contamination eg. from PCBs (Dunlop pers. comm.).

Butyltins (BT)

Butyltin compounds include tributyltin (TBT) and its degradation products monobutyltin (MBT) and dibutyltin (DBT). Tributyltin has been used for several decades as the active ingredient in certain marine anti-fouling paints and has been banned on vessels under 25 m in length in W.A. since 1992. It is extremely toxic to marine life, and causes a sexual deformity (imposex) in marine snails, whereby females develop a penis and vas deferens and can become sterile (Reitsema *et al.* 2003 and refs within). High levels of TBT have been associated with toxic effects in quail, reducing their fertility and hatching success (Schlatterer *et al.* 1993), and coastal seabirds have been found to have higher levels of BTs in liver and kidney compared to oceanic seabirds (Guruge *et al.* 1997). BT levels in cormorant feathers have been found to be very high, and it is likely that seabirds excrete a significant level of BTs from their body during the moult (Guruge *et al.* 1996).

TBT has been found throughout sediments in Warnbro Sound, the northern half of Comet Bay , Cockburn Sound, Fremantle Harbour, the waters between Fremantle and Rottnest and surrounding the western half of Rottnest (Department of Environmental Protection 1996). Although levels of TBT in the sediment do not necessarily indicate levels of TBT in the water column, bioaccumulation up through the food chain means that seabirds could accumulate TBT if their prey forage in areas where it is still present in the sediment. In a recent study comparing the incidence of imposex in whelks (*Thais orbita*) between 1993 and 1998/99, the incidence of imposex remained high at Thompsons Bay, Fremantle Harbour, northern and southern Jervoise Bay, Challenger Beach Colpoys Point, Trigg and Cottesloe (Reitsema *et al.* 2003). Of the whelks examined from Yanchep, Hillary's Boat Harbour, Carnac Island, Penguin Island and several sites around Rottnest, 11-70% had an incidence of imposex (Reitsema *et al.* 2003).

Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs enter the coastal system via man-made processes such as urban runoff, boat/ship exhaust (particularly smaller boats due to poor exhaust systems), oil spills, industrial processes and from oil refineries (Marsili *et al.* 2001, Gagnon pers. comm.). PAHs in the aquatic environment are either quickly adsorbed on to the surface of organic and inorganic particles and settle out, or they remain in solution and are readily available to aquatic organisms (Marsili *et al.* 2001). PAHs are known to be carcinogenic, mutagenic and teratogenic (International Programme on Chemical Safety 1998). Hydrocarbon "biomarkers" have been found in fish sampled in Cockburn Sound (DAL 2001).

Plastic pollution

Plastic debris in the oceans is an increasing problem (Derraik 2002; Furness 1983). Huge amounts of synthetic packaging materials, plastic containers, plastic pellets, food wrappers etc end up in the marine environment each day (Derraik 2002; Gregory 1999). Although the disposal of plastics is prohibited from all watercraft under the International Convention for the Prevention of Pollution from Ships (MARPOL), a convention upheld by Australian law, compliance with MARPOL is variable (Jones 1995). Besides, recreational fishing and urban sources are also responsible for the plastic pollution (Derraik 2002; Gregory 1999). The ability of plastics to float and their durability also means that they can be carried large distances due to wind and current action. Not only can seabirds become entangled in plastic pollution, but they can also ingest them (Blight & Burger 1997) and the amount being ingested by seabirds is increasing (Furness 1983; Robards *et al.* 1995). Species that feed at the surface are more likely to ingest plastic particles that float on the sea surface, although such particles have also been found in pursuit-diving species (Blight & Burger 1997). Ingestion of plastics can reduce the available room in the stomach, thus limiting food consumption and possibly overall fitness (Derraik 2002 and references within). Indeed, the body mass of seabirds has been shown to be decrease with increasing number of plastic particles ingested (Spear *et al.* 1995). Ingested particles can also cause blockages in the gut passage and/or impair digestive efficiency (Spear *et al.* 1995). They can also be a source of PCB contamination in seabirds (Ryan *et al.* 1988).

6.4.4 Introduced predators on islands

Mammalian predators such as the black rat (*Rattus rattus*), cats, foxes and dogs can decimate seabird colonies (Dunlop & Rippey 2000). On Penguin Island, a pair of Australian ravens (*Corvus coronoides perplexus*) and their offspring were observed to kill many adult bridled terns as well as other fauna in 2003 (Dixon pers. comm.) and penguin chicks in 2004 (Dunlop pers. comm.). The presence of these native predators is made possible by food supplementation from the picnic area and planted Norfolk pine trees.

6.4.5 Climate change

For many seabirds, El Nino Southern Oscillation (ENSO) events are known to affect breeding participation rates and success and body condition through influences on marine productivity (Dunlop *et al.* 2002; Wienecke *et al.* 1995). Over the past century, the frequency and severity of ENSO events has increased (Burbidge *et al.* 2004), increasing the potential vulnerability of seabird colonies to extinction. Therefore management strategies for seabird colonies need to be mindful that the colonies are subject to extra pressure with these climatic events and thus their tolerance to other current or potential threats may be reduced.

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7. WADERS

Many waders in the Perth metropolitan area are migrant species coming from as far away as the Arctic, Siberia, China and Japan. The main species that spend the austral summer in Perth include:

bar-tailed godwit	*Limosa lapponica*.
common greenshank	*Tringa nebularia*
common sandpiper	*T. hypoleucos*
curlew sandpiper	*Calidris ferruginea*
great knot	*C. tenuirostris*
grey plover	*Pluvialis squatarola*
grey-tailed tattler	*T. brevipes*
red knot	*C. canutus*
red-necked stint	*C. ruficollis*
ruddy turnstone	*Arenaria interpres*
sanderling	*C. alba*
sharp-tailed sandpiper	*C. acuminata*

7.1 CONSERVATION STATUS

All the species listed above, and their habitats, are protected under international conservation treaties with Japan (JAMBA) and China (CAMBA) (Appendix III). They are also all listed migratory species under the EPBC Act (1999). This means they are a matter of national environmental significance under the EPBC Act's assessment and approval provisions. As such, a person must not take an action that has, will have, or is likely to have a significant impact on a listed migratory species, without approval from the Commonwealth Environment Minister (EPBC Act 1999) (Appendix III).

The Natural Heritage Trust 2 (NHT2) has formed a Bilateral Agreement between the Western Australian State Government and the Commonwealth Government. That agreement specifies priorities for the delivery of marine and coastal natural resource management, through the Coastcare funding stream of NHT2. CALM has responded to the Coastcare priorities of the bilateral agreement through the development of a set of biodiversity conservation management priorities, resulting in a set of priorities for each NHT2 region and a set that addresses Statewide issues. As part of this process a risk assessment was undertaken. Migratory birds in the Perth metropolitan area were assessed as having a medium conservation value and high relative threat in the Swan Region (Department of Conservation and Land Management 2003) (Appendix I). They were also birds were identified to have (Simpson & Holley 2003):

- The W.A. population of one or more of these species 'at risk'; and
- The 'sub populations', groups or individuals of one or more of these species 'at risk' from recreational interaction.

7.2 GENERAL ECOLOGY

Migratory waders generally arrive in spring and depart for their northern hemisphere breeding grounds in autumn. A very small proportion of each population may remain here for the whole year (Bamford pers. comm.; Congdon & Catterall 1994). The amount of fat the waders have been able to build up prior to migration and breeding status appear to affect the likelihood of waders remaining in the Perth area for the year (Bamford pers. comm.).

Waders generally feed on worms, snails, insects and small crustaceans found in mudflats, reef and rocky platforms and sandy beaches (Dann 1999a; Thomson-Dans *et al.* 2000). They use a variety of methods for feeding: pecking – food taken from surface; jabbing – less than half the length of the bill is inserted into the substrate; and probing – more than half the bill is inserted into the substrate (Dann 1987). The smaller the wader, the longer they must feed for on each tide cycle (Dann 1987). Waders forage during both the day and night (Dann 1987; Rohweder & Baverstock 1996) and references within; Dann 1999b), sometimes using the same habitat, e.g. bar-tailed godwits (Rohweder & Baverstock 1996), and sometimes using different habitats. For example, in NSW, sanderlings, red-necked stints, ruddy turnstones, greenshanks, great knots and curlew sandpipers were found to use different habitats at night (Rohweder & Baverstock 1996). Not all wader species use the same site for foraging, and the sites used are dependent on the morphological features and feeding behaviour of each species (Dann 1987) (Kingsford & Norman 2002), food availability, degree of disturbance, and spatial and temporal availability of preferred substrate type (Burger *et al.* 1977; Congdon & Catterall 1994; Connors *et al.* 1981; Finn *et al.* 2002; Jaensch 1987). The spatial and temporal availability of foraging and roosting sites is affected by tidal cycles, wind and barometric pressure (Bamford 1999; Bamford *et al.* 2003; Congdon & Catterall 1994; Dann 1999b; Finn *et al.* 2002; Jaensch 1987). Even though the low-water feeding grounds utilized by waders are generally close to their high-water roosting sites (Burton *et al.* 1996; Congdon & Catterall 1994; Finn *et al.* 2002), the waders may have to use a number of different foraging areas to maximize fat deposition in crucial periods such as prior to migration (Dann 1999b).

Waders may use a number of roosting grounds, but they tend to only use a few roosting sites that are short distances from each other (Rehfisch *et al.* 1996). The degree of disturbance at each roosting site will determine if the birds remain there or not.

7.2.1 Bar-tailed godwits

The bar-tailed godwits that visit Australia breed in north-eastern Siberia and Alaska (Lane 1987a). They feed in both seagrass beds and moist, sandy mudflats (Lane 1987a; Rohweder & Baverstock 1996), repeatedly probing their bill into the soft substrate (Lane 1987a). They have been observed feeding in tight flocks during both the day and night (Rohweder & Baverstock 1996). Up to 100 bar-tailed godwits were regularly seen in the Swan Estuary but in early 1990s they disappeared. Low numbers are now being seen in the Swan, this is probably associated with the dog fence recently erected at Alfred Cove (Bamford pers. comm.).

7.2.2 Common greenshanks

Common greenshanks breed from northern Scotland and Scandinavia eastwards to the Kamchatka Peninsula (Lane 1987a). They occur on near-coastal saline wetlands, saltmarshes and intertidal flats (Lane 1987a). They tend to feed in seagrass during the day and on moist, sandy mud at night (Rohweder & Baverstock 1996).

7.2.3 Common sandpipers

Common sandpipers breed throughout Europe and northern and eastern Asia, including eastern Siberia, Korea, Japan and central China (Lane 1987a). In the Perth metropolitan area, they are sparsely distributed, usually only seen in ones and twos. (Bamford pers. comm.; Storr & Johnstone 1985). No studies have been done on their feeding behaviour in Australia, but they chase and catch insects on the mud surface and they probe amongst rocks and in shallow water for invertebrates (Lane 1987a).

7.2.4 Curlew sandpipers

Curlew sandpipers breed in central high-arctic Siberia (Lane 1987a). They are one of the most abundant species in the Swan Estuary Marine Park (SEMP) (Jaensch 1987). They prefer belly-deep shallow water but will also forage at the water's edge, probing the mud (Dann 1987, 1999a; Lane 1987a). They forage at Alfred Cove, and as the tides rise they have been observed to fly west over the ocean, possibly heading for Rottnest (Bamford & Bamford 1999).

7.2.5 Great knots

Great knots breed in north-eastern Siberia. They forage at low tide on intertidal mud flats, roosting on sandy spits and beaches at high tide. They feed by repeatedly jabbing their bills into the mud, at the water's edge on the falling tide or in shallow water (Lane 1987a).

7.2.6 Grey plovers

Grey plovers breed north of 65ºN in the tundra zone. They forage at low tide on muddy tidal flats and roost at high tide on sandy beaches and spits. They peck their food form the surface of the mudflats (Lane 1987a).

7.2.7 Grey-tailed tattler

Grey-tailed tattlers breed in alpine tundra (Lane 1987a). They predominantly feed amongst seagrass beds (Rohweder & Baverstock 1996) but also feed over intertidal mudflats and rocky intertidal reefs (Lane 1987a). They roost on sandy beaches and rocks (Lane 1987a).

7.2.8 Red knot

Red knots that visit Australia breed in north-central Siberia eastwards to western Alaska (Lane 1987a). They feed on intertidal mudflats, rapidly drilling soft sand and mud at the water's edge or in shallow water (Lane 1987a). They appear to prefer open roosting sites such as sand spits (Burton *et al.* 1996; Lane 1987a).

7.2.9 Red-necked stints

Red-necked stints are the smallest of the migratory waders and are the most abundant species in the SEMP (Bamford *et al.* 2003; Jaensch 1987). They breed in far north-eastern Siberia (Lane 1987a). They prefer to forage in wet mud zones (Bamford & Bamford 1999; Dann 1987, 1999a), although they have been observed to take food items off the surface of water or floating seagrass at high tide (Dann 1999b). They have been observed to move to ocean beaches in the evening for foraging during low tides (Rohweder & Baverstock 1996). Their small size means they can only forage in the shallowest water (Bamford & Bamford 1999). They roost on sandy beaches and spits (Lane 1987a).

7.2.10 Ruddy turnstones

The ruddy turnstones that migrate to Australia breed in eastern Siberia and Alaska (Lane 1987a). In the south of Australia, they prefer banks, reef platforms and rocky platforms (Bamford pers. comm.; Lane 1987a). They have been found feeding at sandy ocean beaches with negligible surf action, from water's edge up to 10 m away from the water's edge (Burger *et al.* 1977), on rocky shores and intertidal mudflats (Lane 1987a). They feed by flicking over seaweed, shells and stones and probing under rocks (Lane 1987a).

7.2.11 Sanderlings

Sanderlings breed in the high arctic regions (Lane 1987a). They prefer exposed, steeply shelved beaches, feeding in the wave-washed zone at low tide, pecking in the wet sand (Lane 1987a; Storr & Johnstone 1985). In the northern hemisphere they feed in the water-covered zone and have been found feeding up to 10 m from the water's edge (Burger *et al.* 1977). In Australia, they have also been observed foraging on mudflats during the day and then moving to ocean beaches during low tides at night (Rohweder & Baverstock 1996). Sanderlings are easily disturbed by people when feeding along the water's edge and at roost sites (Saunders & de Rebeira 1985), constantly shifting habitats when disturbed (Rohweder & Baverstock 1996). Their diet consists of small crustaceans, molluscs, worms, insects, amphipods and polychaetes (Saunders & de Rebeira 1985).

7.2.12 Sharp-tailed sandpipers

Sharp-tailed sandpipers breed in the high-latitude arctic lowlands of north-eastern Siberia (Lane 1987a). They prefer non-tidal wetlands (Lane 1987a), and preferentially forage in 2-5 cm of water over soft mud and over masses of loose, partially submerged seaweed (Serventy *et al.* 1962; Dann 1987). However, they have been observed foraging in areas above the water's edge that retains a film of water (Dann 1987).

7.3 OCCURRENCE

The main areas used by migratory waders within the Perth metropolitan area are located at the SEMP; beaches north of Milyu; Rottnest Island (both the coast and inland lakes), Garden Island, Shoalwater Islands and Woodmans Point (Bamford 1999; Jaensch 1987) (Appendix II, Fig. 11). The waders are very dynamic and patterns of movement are connected to tidal movements. For example, as the numbers of waterbirds decline at Alfred Cove with the rising tide, there is a corresponding increase of waterbirds at Milyu, and to a lesser extent Pelican Point (Bamford *et al.* 2003).

7.3.1 Swan Estuary Marine Park

The Swan Estuary Marine Park is a Class "A" Marine Reserve No. 4 and is composed of three separate sections found off the foreshores at South Perth (Milyu), Alfred Cove and Pelican Point (Department of Conservation and Land Management 1999). The Swan-Canning Estuary is listed as an important wetland in Western Australia (Australian Nature Conservation Agency 2001).

Alfred Cove

The extensive mudflats and the last surviving substantial salt marshes of the lower Swan/Canning system make Alfred Cove the main foraging area for the waders (Bamford & Bamford 1999; Jaensch 1987). The waders mainly feed on mud flats around Point Waylen, with extensive mud flats back to Point Walter. Feeding occurs when the mudflats are exposed at low tides, i.e. 0.5 m or less (Bamford & Bamford 1999). The waders roost on a series of sandbars just north of Point Waylen. When the tides get very high, the birds are displaced and move to beaches at Milyu, Pelican Point (both sites for roosting) and even Rottnest (Bamford 1999; Bamford & Bamford 1999). Larger waders, such as grey plovers and greenshank, roost on the Samphire and lawns at Alfred Cove when the tide is high (Bamford pers. comm.).

Milyu

Milyu is a feeding, and more importantly, a roosting habitat, with feeding occurring only on the moderately extensive mudflats at exceptionally low tides. Roosting occurs on the point approximately half way along the foreshore edge of the park and on beaches outside the park, between Milyu and the Narrows Bridge (Bamford & Bamford 1999; Bamford *et al.* 2003).

Pelican Point

Large numbers of migratory waders visited Pelican Point up until the mid 1980s, and it was once described as the finest waterbird sanctuary found in the world (Bamford *et al.* 2003). Now, it supports the lowest number of birds but several species still rely on the sand-bar and west-facing beach for roosting (Bamford *et al.* 2003). The decline in numbers using this area is linked to the water level in the lagoon, as red-necked stints can only roost here overnight when this is low (Bamford *et al.* 2003). However, disturbance associated with human activity is suggested to be the major factor limiting the usage of this area (Bamford & Bamford 1999; Creed & Bailey 1998).

7.3.2 Other areas utilized by waders

The Freeway Foreshore

During a study of the affects of personal watercraft (PWC) on waterbirds in the Swan River, Bamford and Bamford (1999) divided the Freeway Foreshore between Como Jetty and the northern limit of a trial PWC area into eight zones (Appendix II, Fig. 12). They found the major roosting beach for migratory waders lies to the north of the Milyu reserve, in Zone 3, and Zone 5 was found to important on weekends (Bamford & Bamford 1999; Bamford *et al.* 2003). Zone 3 is the only high tide roost available on the Swan River for small waders (Bamford & Bamford 1999).

Woodman Point.

Only a small number of waders are supported at Woodman Point. Waders are found on the groins, in the breakwaters and amongst the dead weed. Waders using this area include ruddy turnstones and grey-tailed tattler (Bamford pers. comm.).

Rottnest Coastline

Waders are dispersed around the coastline, particularly feeding on reef flats exposed at low tide (Bamford pers. comm.).

Garden Island

Sanderlings, grey plovers, ruddy turnstones and bar-tailed godwits spend the austral summer on Garden Island's coast. It is a preferred and important habitat in south-western Australia for sanderlings (Wykes *et al.* 1999).

7.4 CURRENT THREATS

The current threats to migratory waders in the Perth metropolitan area are:

- human disturbance:
  - pedestrians;
  - anglers;
  - kayaks and small boats;
  - PWC;
  - kite surfers and wind surfers;
  - prawning parties; and
  - domestic dogs.

7.4.1 Human disturbance

Human disturbance can affect waders at their feeding and roosting sites (Burton *et al.* 2002). The response of the birds to the disturbance will be dependent on the intensity, frequency and duration of the disturbance (Burger 1986; Hill *et al.* 1997), the species affected and the activity of each species at the time of the disturbance (Bamford *et al.* 2003). For example, foraging may be interrupted (Burger & Gochfeld 1991; Rohweder & Baverstock 1996), foraging efficiency may be compromised (Burger 1988), birds may be displaced for short periods (Burger 1988; Hill *et al.* 1997), or displaced permanently (Hill *et al.* 1997). Repeated disturbance at roosting sites is particularly damaging as a large number of birds are usually affected at any one time (Bamford & Bamford 1999) and roosting can occupy a large proportion of the time budget of waders (Burton *et al.* 1996). Disturbances can cause unnecessary expenditure of energy and birds must either forage for longer periods in order to make up the energy expended, or lose condition (Roberts & Evans 1993). This situation is exacerbated if the foraging efficiency of the birds is also compromised during disturbance events (Burger 1988; Burger & Gochfeld 1998). Foraging for longer periods is not always an option however, as the waders are usually restricted by periods of low tide (Burger 1986). Disturbance events are especially significant for migratory waders when they first arrive in spring with low body weights, or when they must depart in autumn with increased body weight to survive their migration.

In the SEMP, Pelican Point has the highest level of human usage of all three reserves (Bamford *et al.* 2003) and human disturbance is considered to have contributed to the decline of migratory waders here (Bamford & Bamford 1999; Creed & Bailey 1998). Flocks of birds have been regularly observed to arrive at, but then depart from, Pelican Point due to disturbance (Bamford *et al.* 2003). As Alfred Cove is the remaining major foraging site for migratory waders, and the low tide exposure of the feeding mudflats only happens for a few hours at a time, disturbance here is likely to have severe impacts (Bamford & Bamford 1999). On weekends, when disturbance levels are high, it appears that the waders are displaced from many areas of the freeway foreshore, particularly the peripheral areas (Appendix II, Fig. 12). Higher numbers of birds are concentrated in the central areas where levels of disturbance are low (Bamford & Bamford 1999).

Pedestrians

People walking/jogging along the beach/footpath and people associated with others using the water such as kite-surfers, wind-surfers and PWC users are classed as pedestrians. They can disturb waders whilst feeding (Wilson 1990; Bamford & Bamford 1999; Bamford *et al.* 2003; Reid & Park 2003) and roosting (Bamford & Bamford 1999; Bamford *et al.* 2003; Burton *et al.* 1996; Reid & Park 2003). Pedestrians caused the most disturbance events of waders in New Jersey (Burger 1986) and the numbers of waders using an area are negatively influenced with decreasing distance from a footpath (Burton *et al.* 2002). This effect was more marked on weekends with increasing pedestrian use of the footpaths (Burton *et al.* 2002). The noise and activity level of the pedestrians has also been shown to affect the degree of response by birds, with birds being more responsive with increasing noise or activity (Burger & Gochfeld 1991; Burger & Gochfeld 1998). In the SEMP, pedestrians are a significant cause of disturbance to waders at all three reserves (Bamford & Bamford 1999; Bamford *et al.* 2003).

Anglers

Anglers are present in all three reserves and can disturb waders whilst feeding and roosting (Bamford & Bamford 1999; Burton *et al.* 1996; Reid & Park 2003; Wilson 1990). They predominantly occur on the edges of sandbanks, particularly at Alfred Cove. At this location, anglers are a major cause of disturbance as they are near the sand-bars where the birds roost (Bamford *et al.* 2003). Every time an angler goes fishing they can repeatedly disturb the waders (Bamford *et al.* 2003).

Kayaks and small boats

Kayaks and small boats have a high disturbance ratio[5] . They are a major cause of disturbance at Alfred Cove near the sand-bars where the birds roost. At Pelican Point kayaks and small boats approaching from the east cause disturbance (Bamford *et al.* 2003).

Personal watercraft

PWC and the people associated with PWC users can cause disturbance to waders feeding (Wilson 1990), and roosting (Bamford & Bamford 1999). PWC activity in the PWC area north of Milyu, is most likely to disturb roosting waders on the beaches (Bamford & Bamford 1999). When PWC are active, the abundance of birds close to the PWC area declines but increases in areas distant from the PWC area (Bamford & Bamford 1999).

Kite surfers and wind surfers

Both kite-surfers and wind-surfers have the potential to cause a high level of disturbance (Bamford & Bamford 1999; Reid & Park 2003; Wilson 1990), and had the highest disturbance ratio of all disturbance events at Alfred Cove (Bamford *et al.* 2003). Kite-surfers and wind-surfers are mainly seen at Pelican Point, particularly in the afternoon when favourable winds are blowing. At Alfred Cove, the numbers of kite-surfers and wind-surfers is much lower. However, kite-surfers are especially problematic here as a small number surf in shallows between the sand-bars and the shoreline. Wind-surfers have also been observed surfing across the reserve at Alfred Cove and landing on sand-bars important for waders (Bamford *et al.* 2003).

Prawning parties

Hand trawling for prawns can disturb feeding grounds (Wilson 1990) and damage the larger benthic fauna which is a primary food source for the waders (Rose 1994). Prawners can disturb roosting birds at night on sandy beaches. This was particularly prevalent in the 1980s, but as prawn numbers seem to have dropped dramatically in recent years, the incidence of prawning parties has also dropped (Bamford pers. comm.).

Domestic dogs

Dogs disturb waders (Bamford & Bamford 1999; Burger 1986; Wilson 1990), often causing them to move large distances and therefore having a large impact on the birds (Bamford pers. comm.). Uncontrolled dogs were found to be an important factor of disturbance along the freeway foreshore. Anecdotal evidence suggests more birds are using specific areas within Alfred Cove after a fence restricting the movement of dogs in these areas was erected (Bamford *et al.* 2003).

7.5 POTENTIAL THREATS

The major potential threats to migratory waders in the Perth metropolitan area are:

- habitat destruction/alteration;
- pollution:
  - chemical contaminants;
  - water quality; and
  - plastic pollution.
- introduced predators.

[5] The disturbance ratio is calculated from the total number of disturbance events caused by a specific activity relative to the frequency of the activity Bamford, M.J., Bamford, A.R. & Bancroft, W. (2003). Social (human use) monitoring programme for the Swan Estuary Marine Park No. Draft. Swan Coastal District, Department of Conservation and Land Management, Perth, Western Australia, p 60.

7.5.1 Habitat destruction/alteration

The destruction or alteration of both foraging and roosting habitats can have serious consequences for migratory waders (Lane 1987b) and has been identified as the greatest threat to long-term survival of waterbirds (Kingsford & Norman 2002). Wetlands are only suitable for use by migratory waders if the various roosting/feeding sites are close enough for the birds to fly to without expending too much energy and if they supply critical resources (Farmer & Parent 1997; Haig *et al.* 1998; Rehfisch *et al.* 1996). It is therefore imperative that areas used by waders are within the spatial limits of their movement patterns. Such landscape connectivity ultimately determines the quality of a migration stopover (Farmer & Parent 1997). Any habitat loss/degradation occurring within the spatial limits of the waders is likely to have negative impacts on the birds. In the short term such impacts could include loss of body condition and inability to increase fat deposition which may affect outcome of migration and ability to successfully breed. In the long term it may inhibit the waders' use of the area. For some waders, specific requirements for feeding/roosting may only be found in localized areas. For example, a massive decline in sharp-tailed sandpipers from the Swan River has been attributed to the destruction of the salt marshes on Burswood Island in the 1960s (Tarburton 1974).

Loss of peripheral vegetation affects the ecology of the wetlands (Chambers 1987). Peripheral vegetation is important as it (Chambers 1987):

- contributes to the total primary productivity of the estuary, often contributing the highest proportion;
- stabilizes river banks and helps prevent erosion;
- acts as a buffer between the river and stormwater and urban runoff; and
- can act as a filter of nutrients and pollutants, including nitrogen, phosphorus and heavy metals, from stormwater and urban sources.

Since the 1940s, peripheral vegetation along the Swan Estuary has been cleared, giving rise to weed communities. The reclamation of land for landfill sites, city development and eradication of mosquito breeding areas has also resulted in the loss of peripheral vegetation (Pen 1987). In the 1980s, there were further significant reductions of peripheral vegetation, particularly on Burswood Island (Pen 1987). Many saltwater marshes are threatened by the flushing of peripheral vegetation with stormwater (Pen 1987).

Changes in the salinity and water level of wetlands can alter the suitability of wetlands for different wader species (Lane 1987b; Reid & Park 2003). These changes can be deliberate, such as flood mitigation and irrigation schemes, or unanticipated such as the rising of water tables to due the clearance of natural vegetation (Lane 1987b).

Estuaries are dynamic and new mudflats, sand-bars and spits are formed as the estuaries flood (Bamford pers. comm.). However, the building of concrete walls (e.g. the freeway) around estuaries inhibits this dynamic process. With global warming and the changing of sea levels, the ability of the estuary to maintain the needs of the waders may be in question.

7.5.2 Pollution

Potential sources of pollution into the Swan River include drains, industrial contamination and nutrient-loaded river runoff from the Avon and Canning catchments, causing eutrophication (Wilson 1990), (Rate *et al.* 2000). Stormwater drains can introduce fecal coliforms, pesticides, fertilizers, heavy metals, oil and petrol residues and a range of chemicals into the river (Department of Conservation and Land Management 1996).

Chemical contaminants

Pesticides are sprayed on wetlands to control midges and mosquitoes (Davis & Froend 1999). Although the consequences of pesticides on waders is poorly understood (Davis & Froend 1999; Kingsford & Norman 2002), it is of concern (Jaensch 1987).

Water quality

Large heavy metals loads have been linked to decreases in wader numbers in Tasmania (Reid & Park 2003). The concentrations of zinc, cadmium, lead and copper have risen in the Swan River estuary since European settlement (Gerritse *et al.* 1998). However, total metal concentrations in sediments in the Swan River estuary were found to be low in comparison to Australian environmental assessment guidelines for soils (Rate *et al.* 2000). This includes lead, even though levels of this metal were highest near stormwater drains (Rate *et al.* 2000).

Increased levels of nutrients in wetlands can cause algal blooms and anoxic conditions. Invertebrates can die from algal toxicity and depletion of oxygen (Davis & Froend 1999), so even if the waders are not directly affected, their prey resource may be depleted.
Drainage systems that introduce freshwater into areas near wetlands can create pockets of fresh water where weeds can persist and spread (Department of Conservation and Land Management 1996). They can also alter the salinity of areas, which may affect the fauna.

Plastic pollution

Plastic rubbish and fishing lines can entangle birds (Department of Conservation and Land Management 1996). However, it is not a significant threat to the waders on the SEMP (Bamford pers. comm.).

7.5.3 Introduced predators

Cats and foxes are a threat to the birds using the SEMP (Department of Conservation and Land Management 1996), but not very likely to disturb birds in mudflats or on sandbars or spits (Bamford pers. comm.).

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APPENDICES

APPENDIX I: SWAN REGION MARINE FAUNA MANAGEMENT PRIORITISATION FRAMEWORK

RELATIVE THREAT	RELATIVE CONSERVATION VALUE: HIGH	RELATIVE CONSERVATION VALUE: MEDIUM	RELATIVE CONSERVATION VALUE: LOW
HIGH	Little Penguin Cockburn Sound Dolphins	Migratory birds	
MEDIUM	Australian sea lion Blue whale Humpback whale Southern right whale Tern spp.	Marine Raptors NZ fur seals Cormorants/ Pelicans Dolphin spp.	Sting Rays
LOW			

APPENDIX II: FIGURES

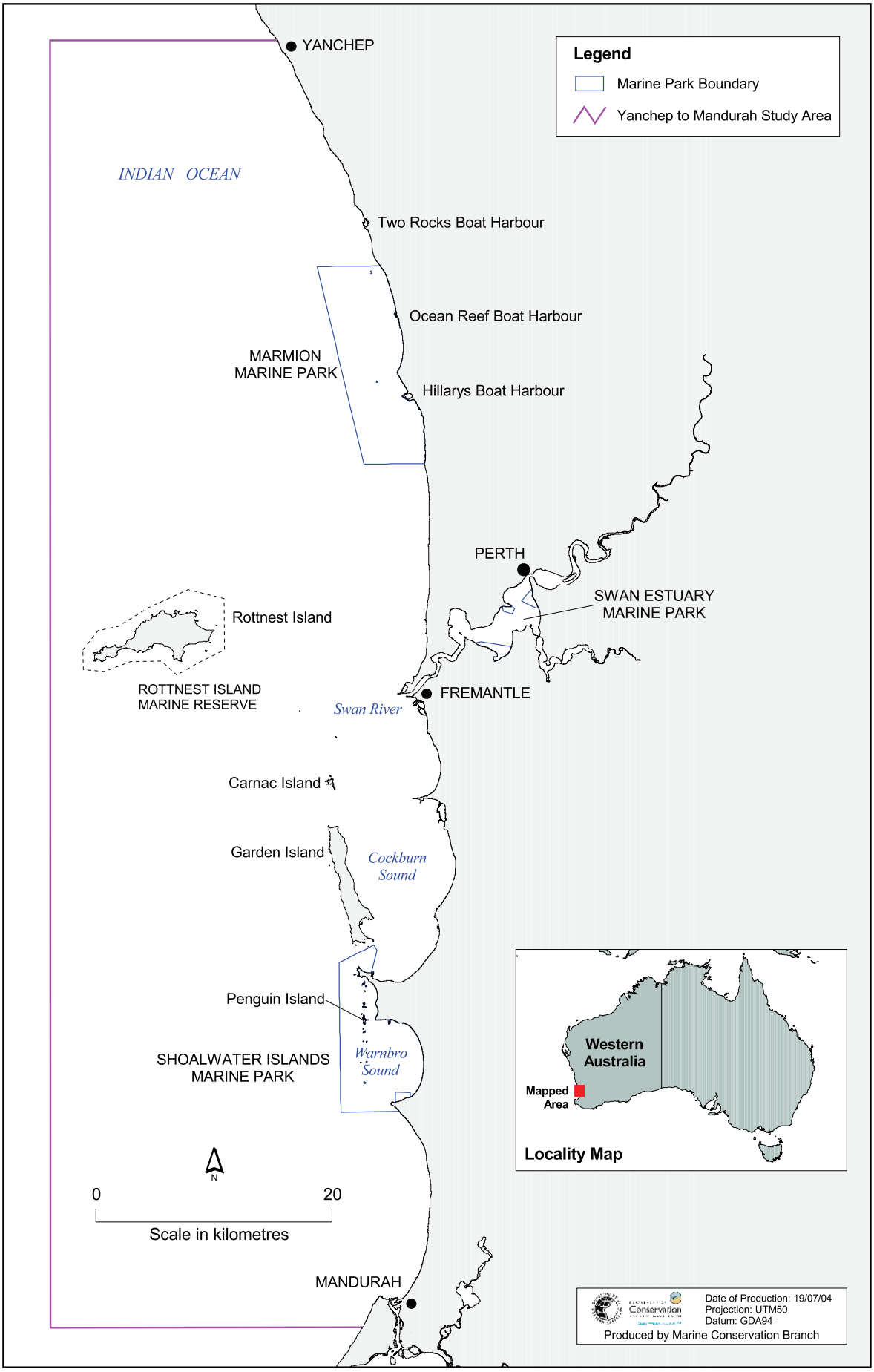

Figure 1: Locality Map showing the Yanchep to Mandurah study area

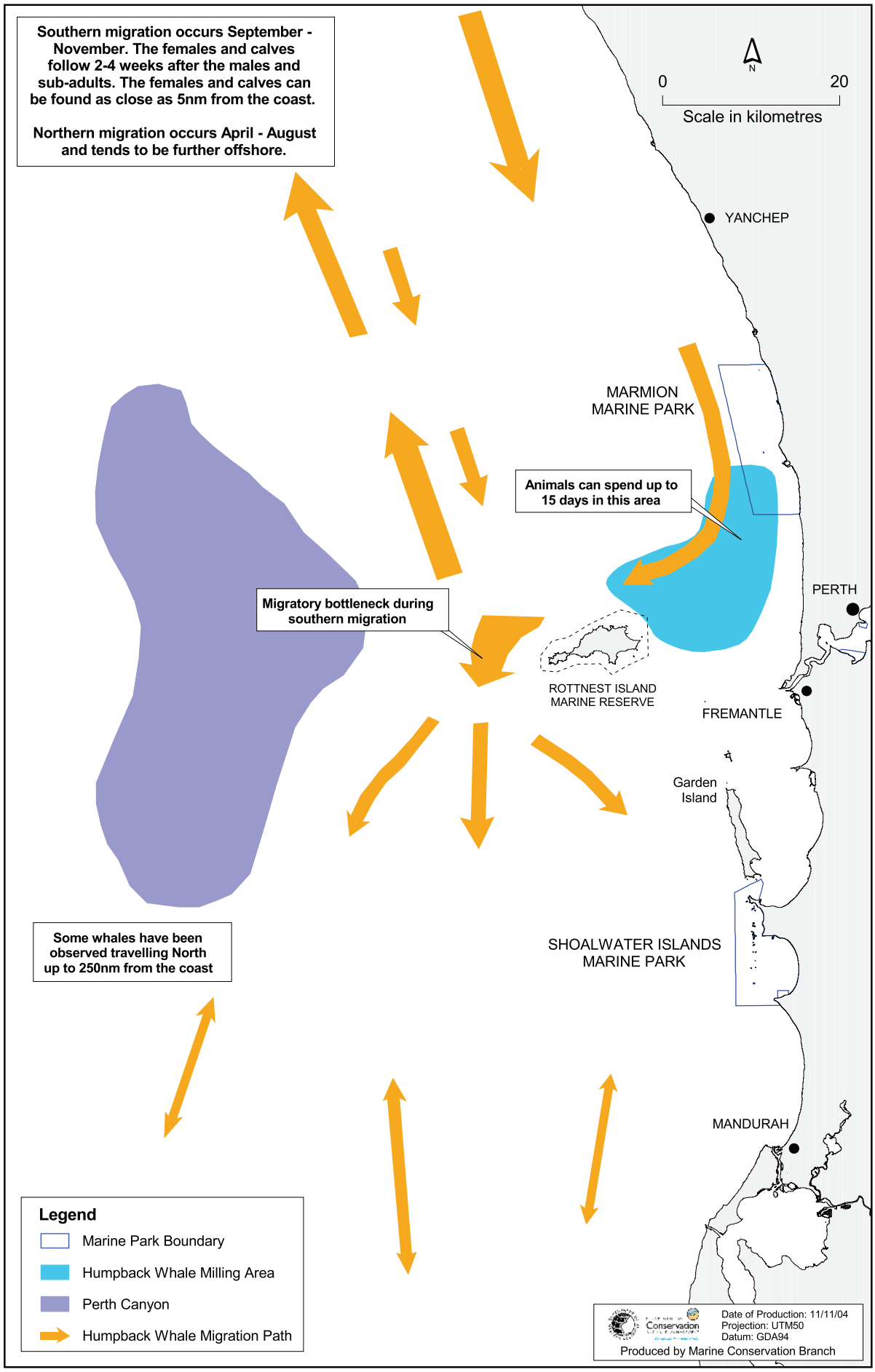

Figure 2: Humpback Whale Activity in the Perth Metropolitan Area

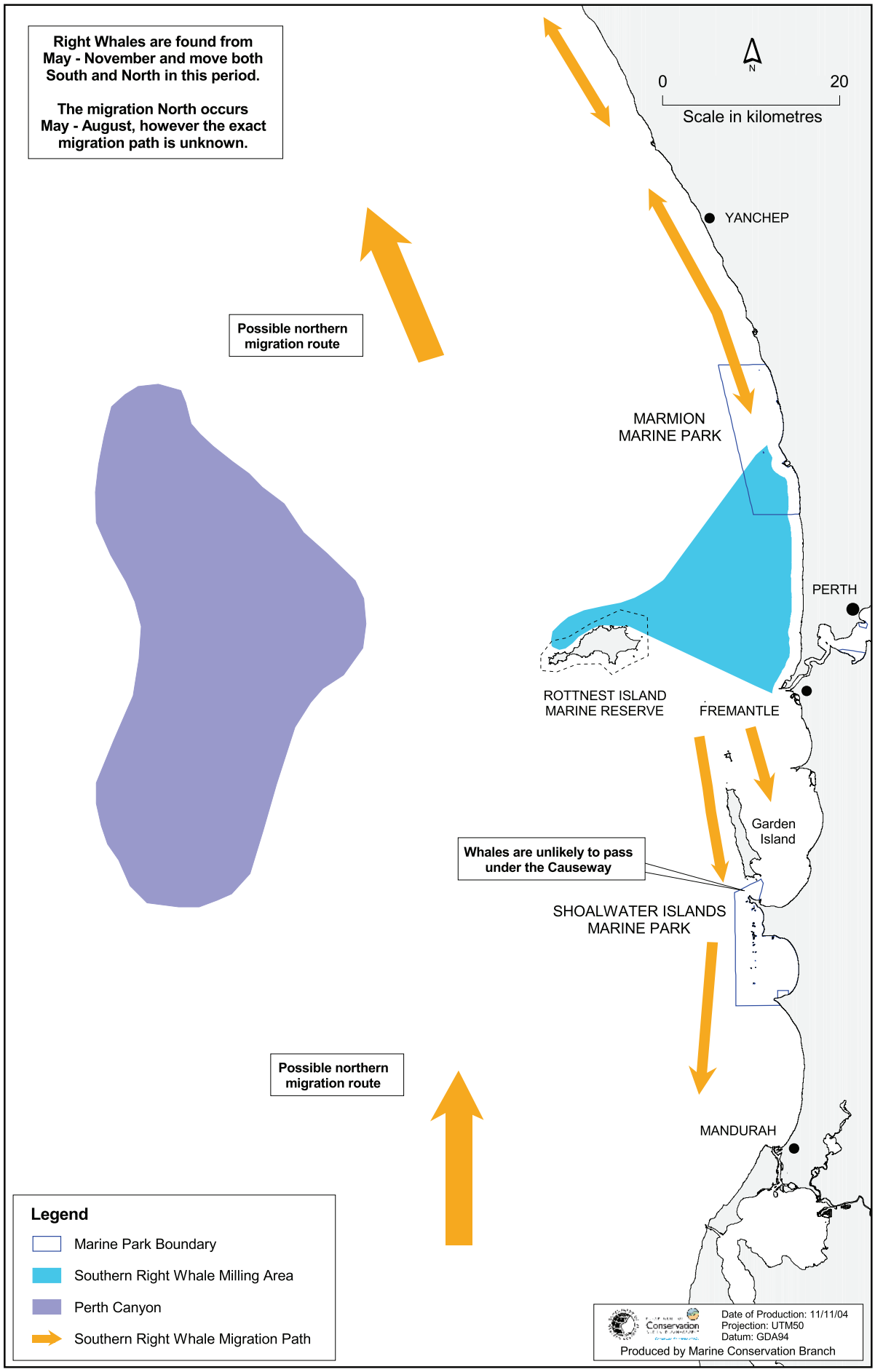

Figure 3: Southern Right Whale Activity in the Perth Metropolitan Area

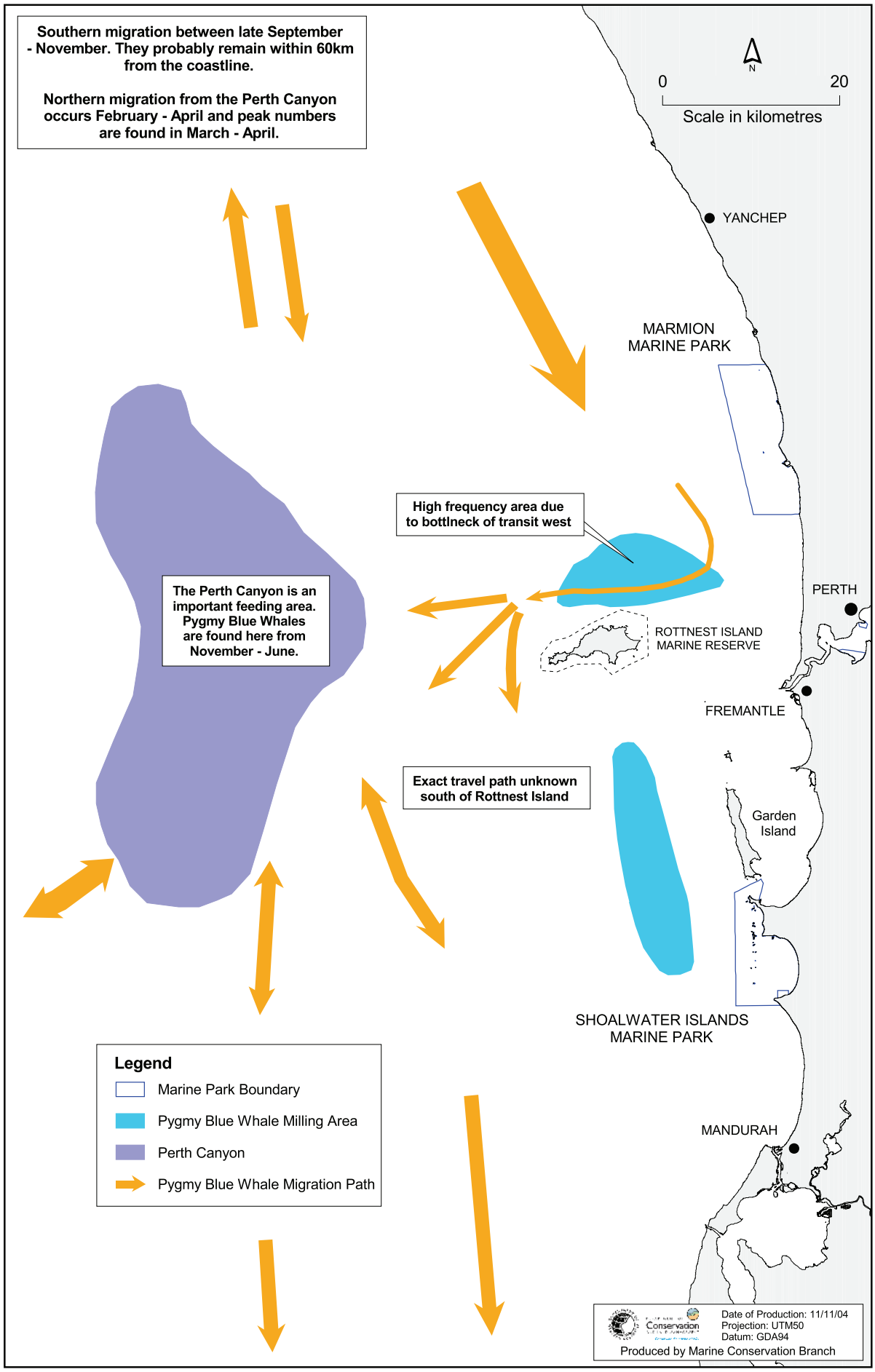

Figure 4: Pygmy Blue Whale Activity in the Perth Metropolitan Area

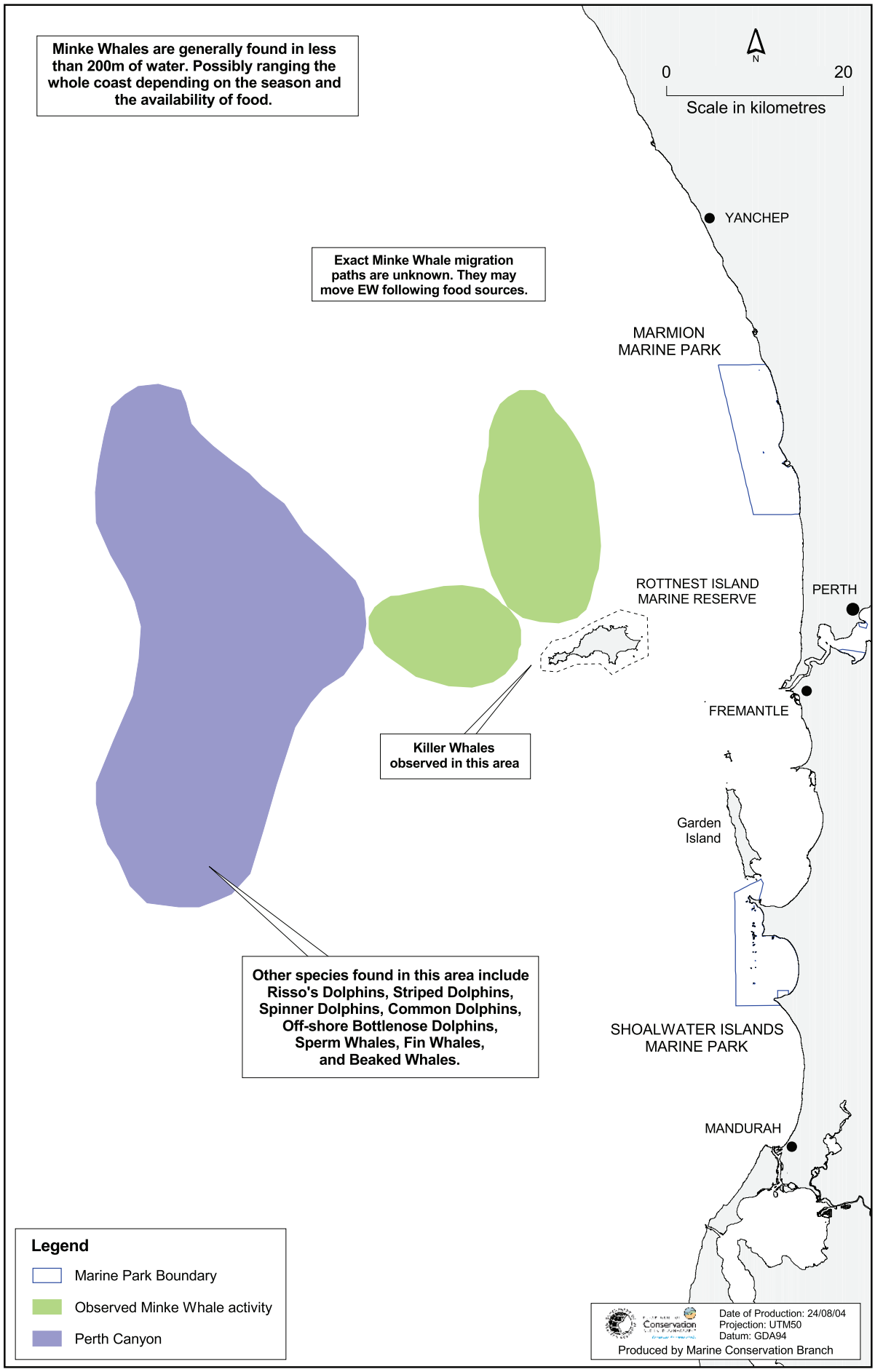

Figure 5: Minke Whale and Other Cetacean Activity in the Perth Metropolitan Area

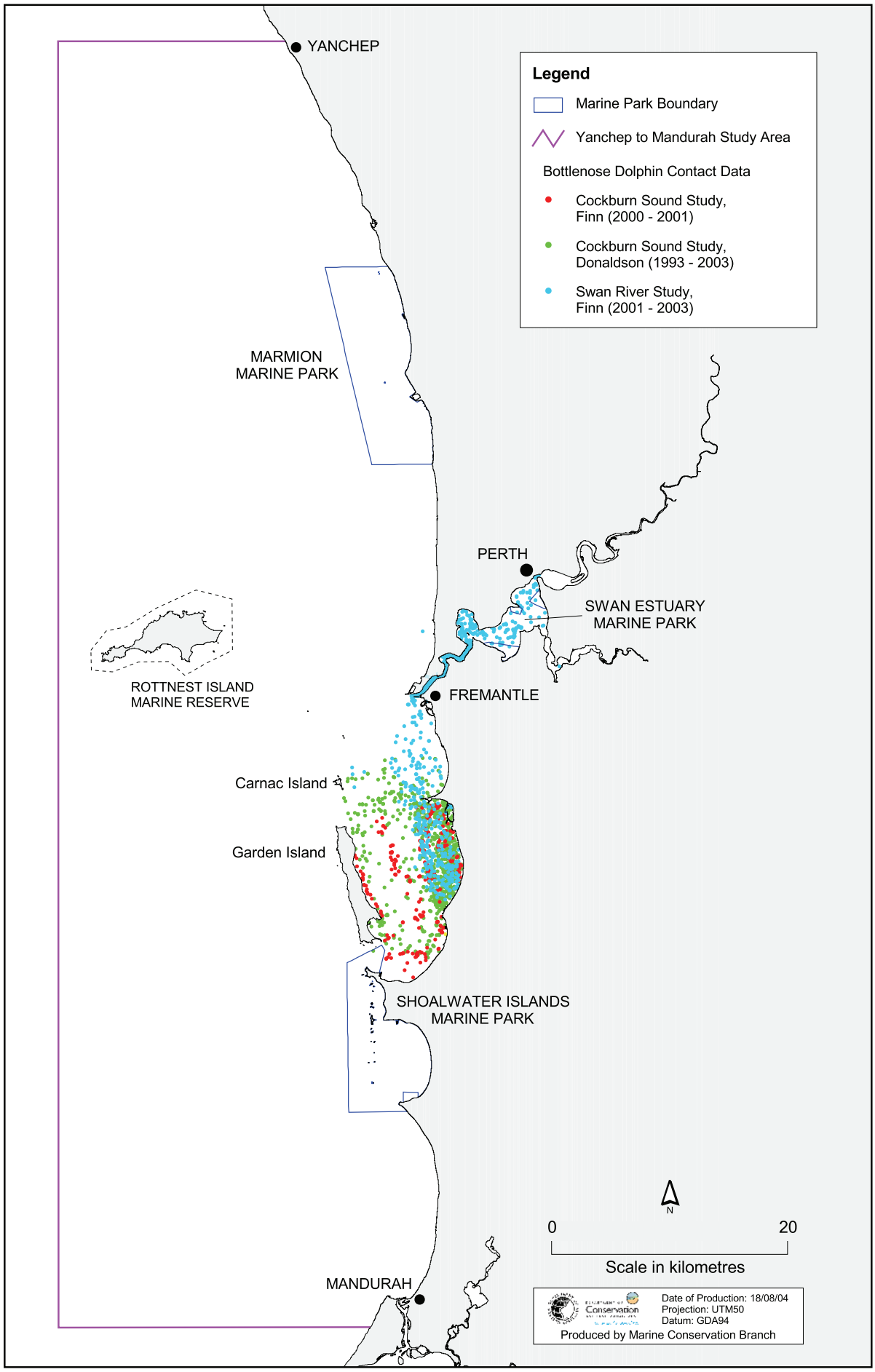

Figure 6: Bottlenose Dolphin contact data in the Swan River and Cockburn Sound

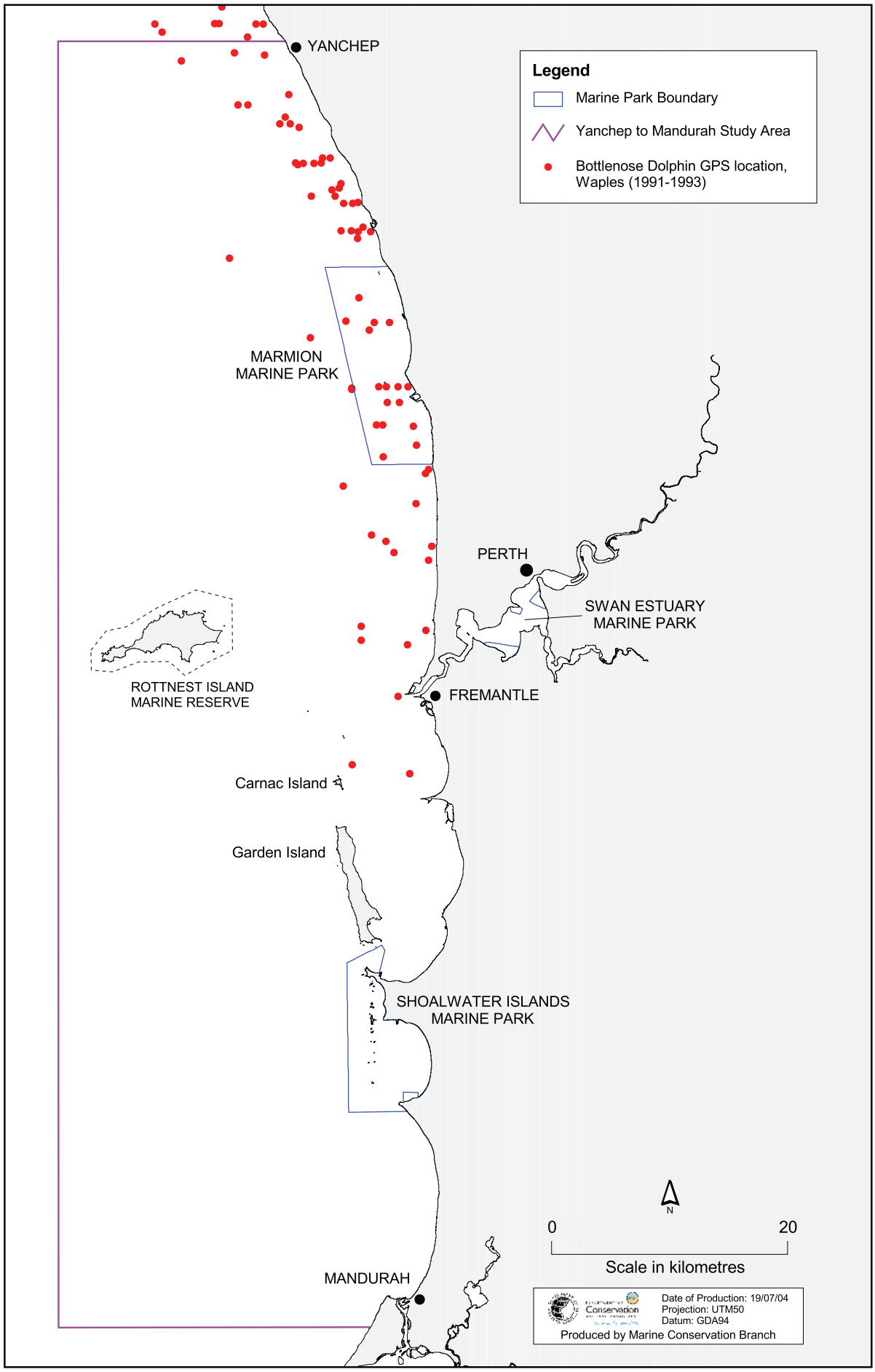

Figure 7: Bottlenose Dolphin GPS locations between Fremantle and Yanchep during March 91 - June 93

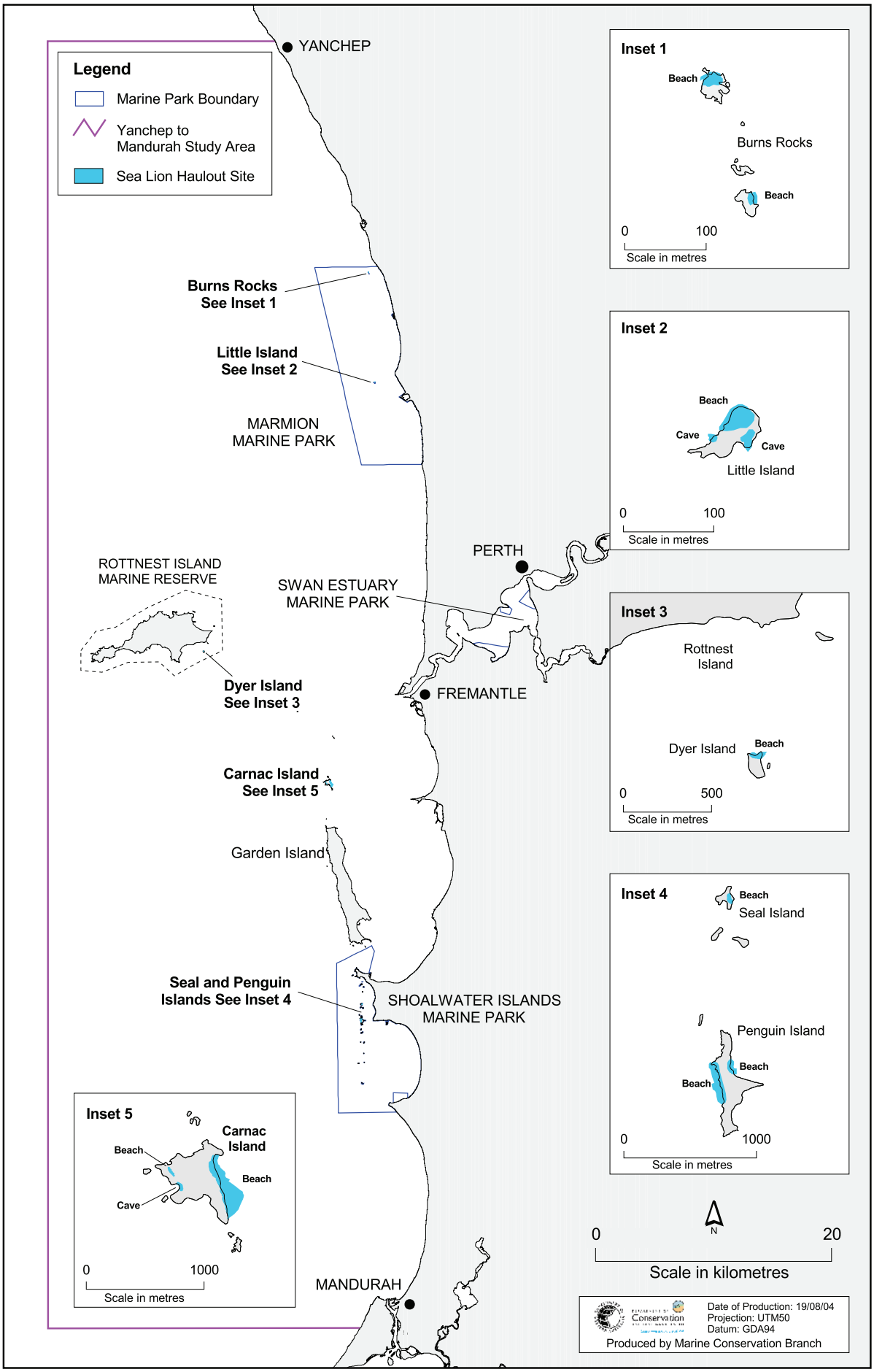

Figure 8: Sea Lion haulout sites in the Perth Metropolitan Area

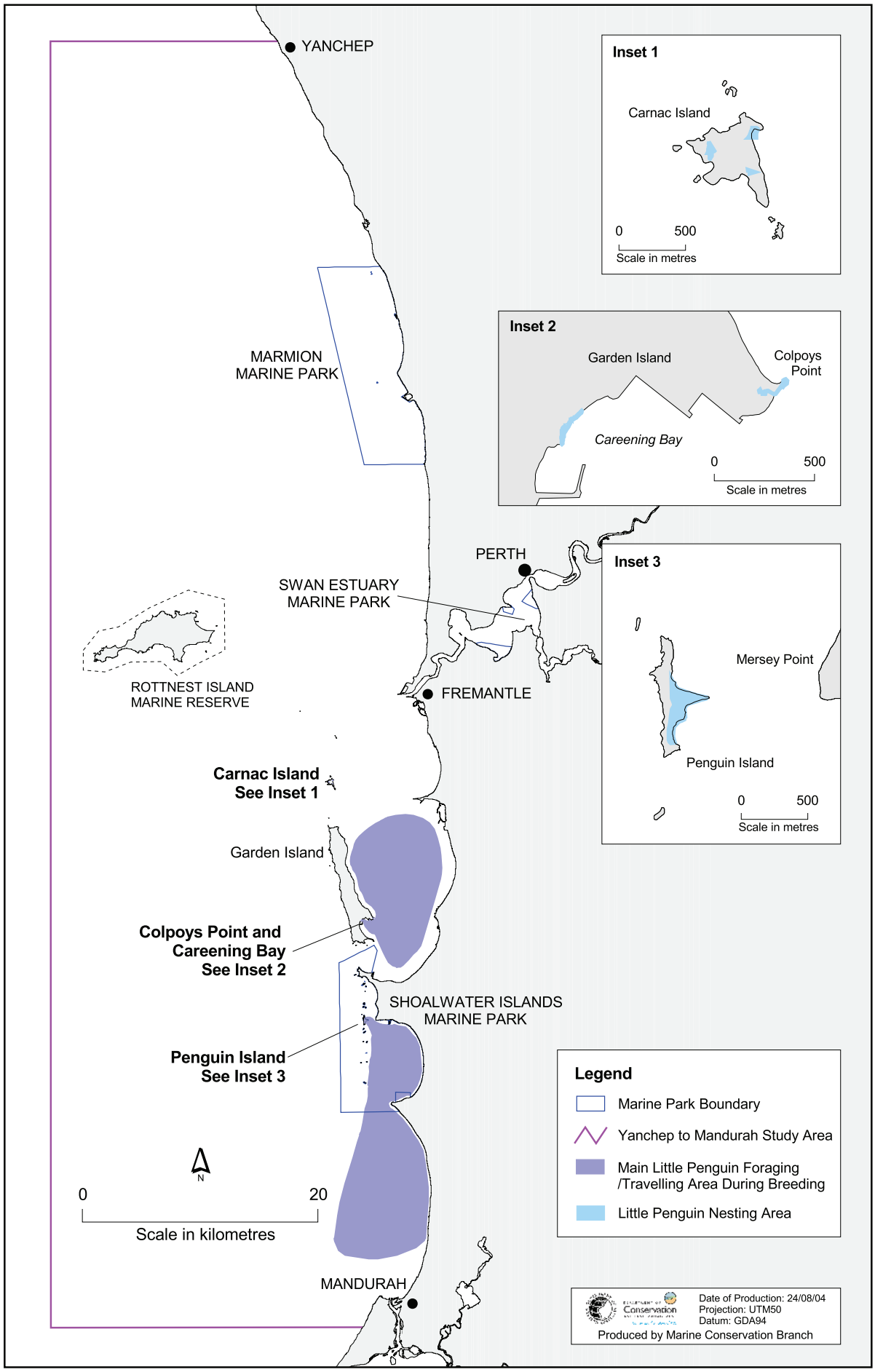

Figure 9: Little Penguin Activity in the Perth Metropolitan Area

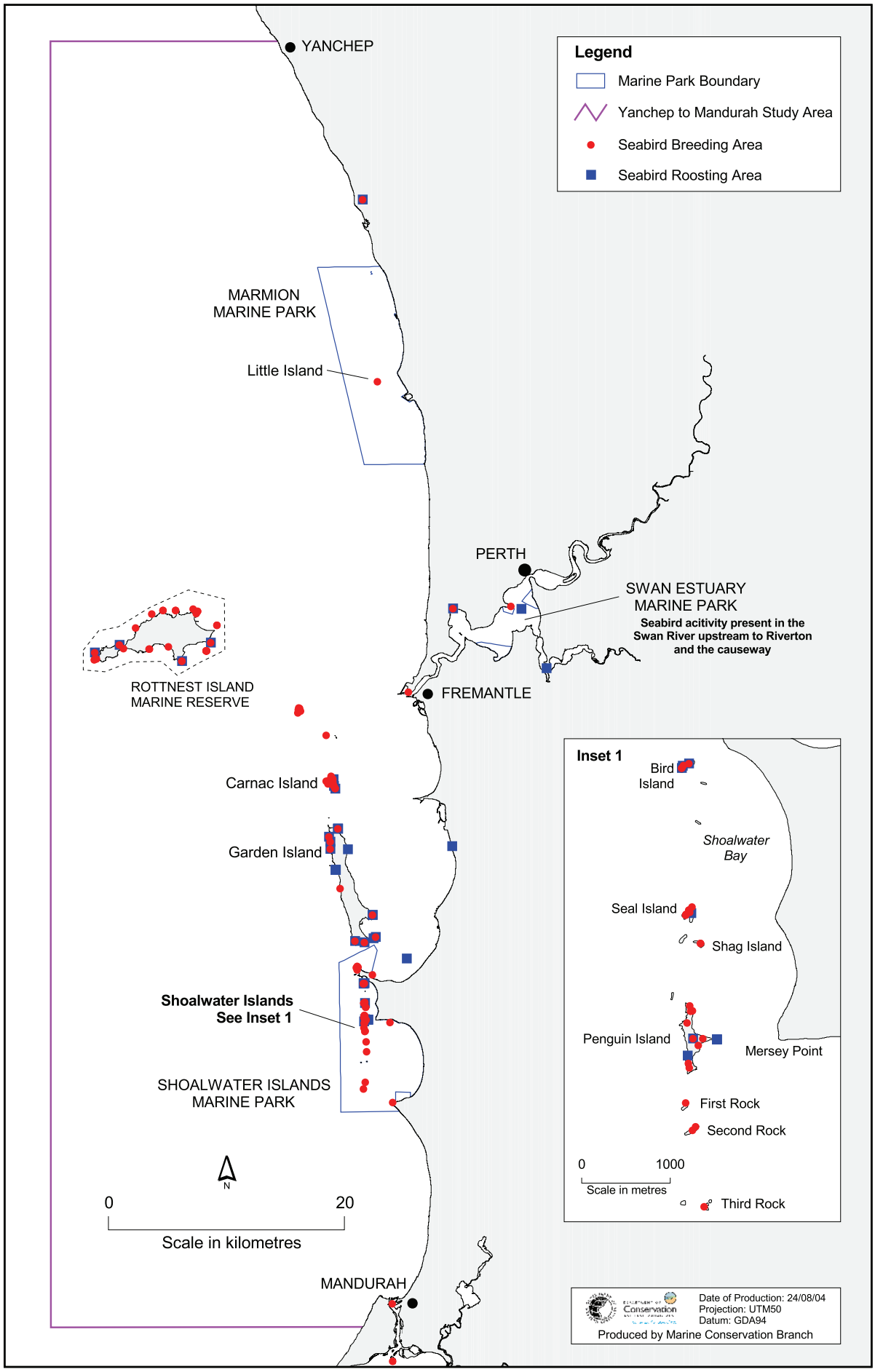

Figure 10: Seabird Activity in the Perth Metropolitan Area

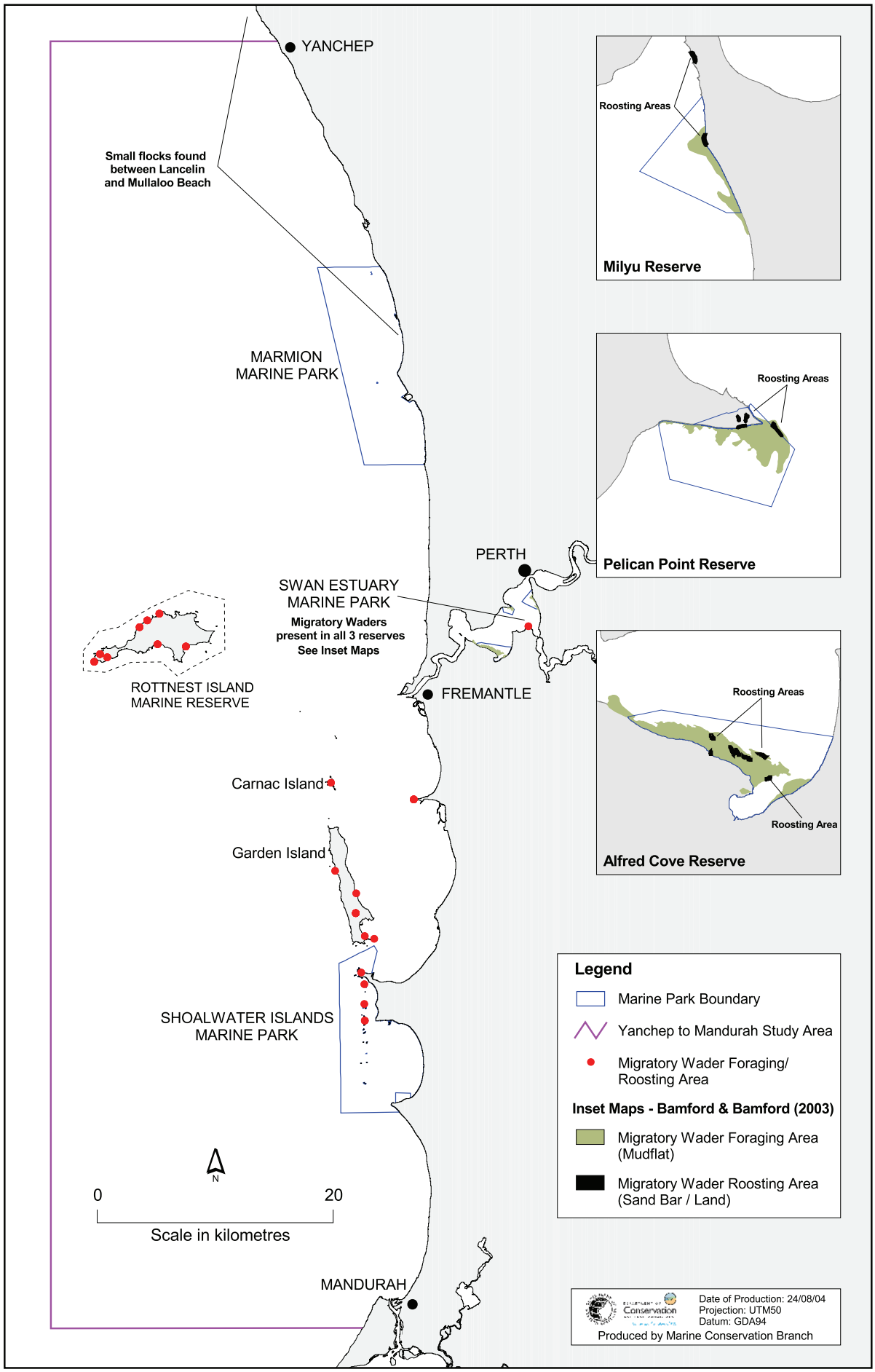

Figure 11: Migratory Wader Activity in the Perth Metropolitan Area

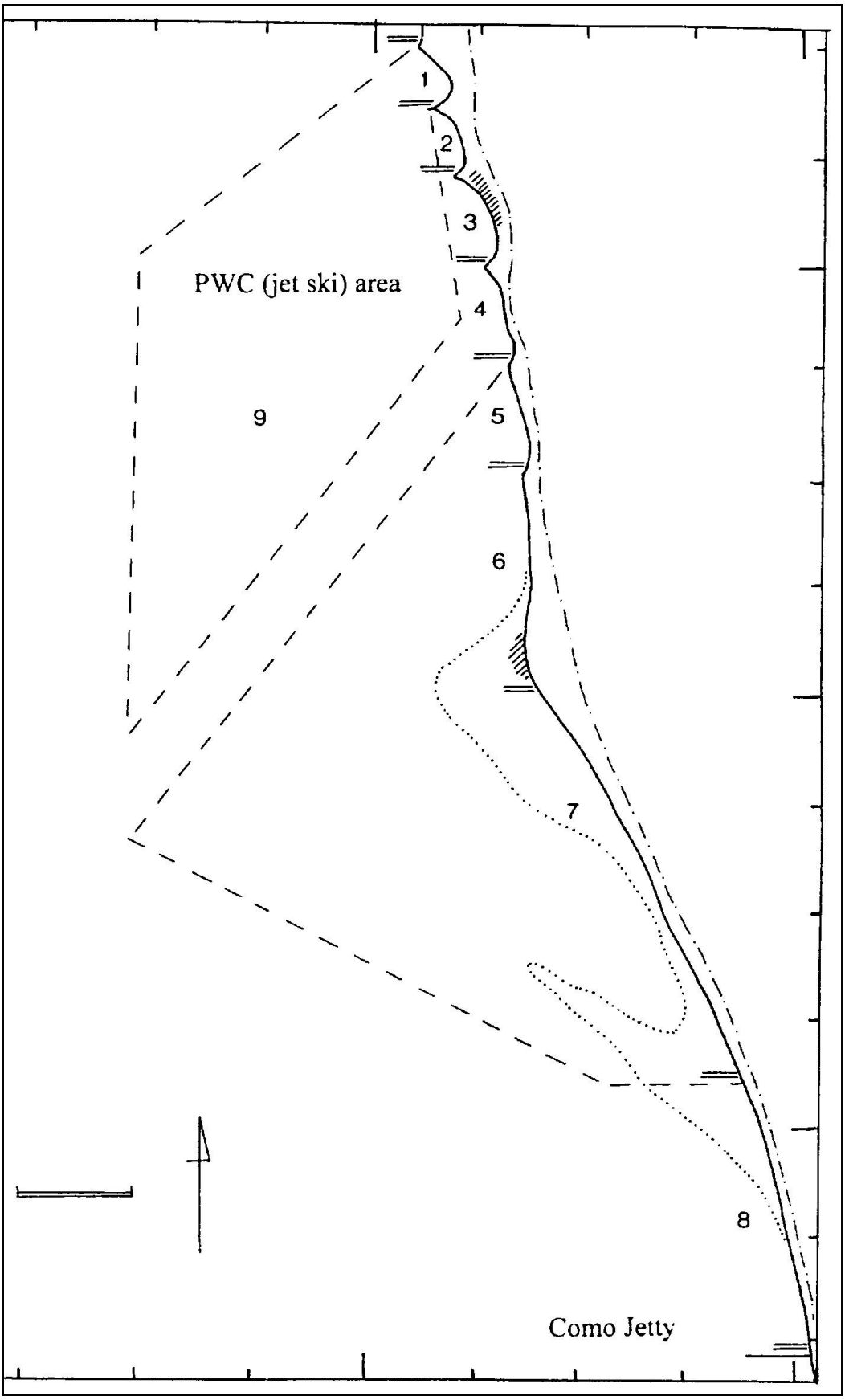

Figure 12. Freeway foreshore zones (from Bamford *et al.* 2003)

APPENDIX III: STATE, NATIONAL AND INTERNATIONAL STATUTES

Appendix III(a). Western Australian Wildlife Conservation Act 1950

WESTERN AUSTRALIAN WILDLIFE CONSERVATION ACT 1950

Section 14 Protection of fauna

(1) Except to the extent which the Minister declares by notice published in the *Government Gazette* pursuant to the provisions of this section all fauna is wholly protected throughout the whole of the State at all times.

(2) (a) Subject to section 15A, the Minister may from time to time declare-

that any of the fauna is not protected or is protected to such extent for such period of time throughout the whole or such part or parts of the State as he shall think fit,

and for these purposes may from time to time by notice published in the *Government Gazette* declare-

a close season or an open season in respect of any of the fauna and place such restrictions on either the taking or disposal or the taking and disposal of the fauna as he considers advisable.

(b) The Minister may from time to time, by notice published in the *Government Gazette* , vary the provisions and operation of a notice promulgated pursuant to the power conferred upon him by this section by cancelling those provisions and that operation wholly or in part absolutely, or by cancelling those provisions and that operation wholly or in part, and substituting other provisions and their operation for those so cancelled.

(ba) The Minister may, from time to time by notice published in the *Government Gazette* , declare that any fauna specified in the notice is for the purposes of this Act fauna which is likely to become extinct, or is rare, or otherwise in need of special protection and while such declaration is in operation-

(i) such fauna is wholly protected throughout the whole of the State at all times; and

(ii) (ii) a person who commits an offence under section 16 or section 16A with respect to or in relation to such fauna is liable, notwithstanding any other provision of this Act, to a penalty of $1000.

(c) A declaration promulgated by a notice pursuant to the provisions of this section shall, by virtue of this section, have the force of law while in operation.

[Section 14 amended by No. 38 of 1954 s.6; No. 99 of 1969 s.7; No. 53 of 1970 s.3; No. 67 of 1975 s.16; No. 58 of 1985 s.2; No. 18 of 1992 s.4.]

GOVERNMENT GAZETTE 11 APRIL 2003 pp 1158-1167

Wildlife Conservation Act 1950

Wildlife Conservation (Specially Protected Fauna) Notice 2003

Given by the Minister under section 14(2) (ba) of the Act.

1. Citation

This notice may be cited as the *Wildlife Conservation (Specially Protected Fauna) Notice 2003*.

2. Interpretation

In this notice -

"taxon" includes any taxon that is described by a family name or a genus name or any other name or description.

Note: The plural form of "taxon" is "taxa".

3. Declaration of specially protected fauna

For the purposes of the Act, all taxa of the fauna

(a) specified in Schedule 1, being fauna that is rare or likely to become extinct, are declared to be fauna that is in need of special protection;

(b) specified in Schedule 2, being fauna that is presumed to be extinct, are declared to be fauna that is in need of special protection;

(c) specified in Schedule 3, being birds that are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction, are declared to be fauna that is in need of special protection; and

(d) specified in Schedule 4 are declared to be fauna that is in need of special protection, otherwise than for the reasons mentioned in paragraphs (a), (b) and (c).

4. Revocation

The *Wildlife Conservation (Specially Protected Fauna) Notice 2002 is* revoked.

Schedule 1 - Fauna that is rare or is likely to become extinct
Schedule 2 - Fauna presumed to be extinct
Schedule 3 - Birds protected under an international agreement
Schedule 4 - Other specially protected fauna

Appendix III(b). Environmental Protection and Biodiversity Conservation Act 1999

ENVIRONMENTAL PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999

WHALES, DOLPHINS, AND PORPOISES (CETACEANS)[1]

Protecting cetaceans

The EPBC Act protects cetaceans in three broad ways:

1. The Act established the Australian Whale Sanctuary, which includes all Australian Commonwealth waters (the Act allows for the future inclusion of State and Northern Territory waters in the Sanctuary, subject to the agreement of the relevant State or Territory Minister). Within the Sanctuary, it is an offence for anyone to kill, injure, take, trade, keep, move, interfere with, or treat*, any cetacean. The Act also makes it an offence for Australians to carry out any of these actions beyond the outer limits of the Australian Whale Sanctuary, that is, in international or foreign waters. In certain circumstances, the Commonwealth Environment Minister can issue permits to allow a person to interfere with, injure, take, trade, keep, move, possess or treat a cetacean in the Australian Whale Sanctuary or waters beyond the Australian Whale Sanctuary.

2. In all Australian Commonwealth and State and Northern Territory waters, the Act regulates actions that will have, or are likely to have, a significant impact on threatened or migratory cetacean species that are listed under the Act. Five whale species found in Australian waters are listed as threatened species under the Act. Nine whale or dolphin species are listed under the Convention on the Conservation of Migratory Species of Wild Animals, and are therefore classed as migratory species under the Act. Proposed actions that may have a significant impact on any of these species should be referred to the Commonwealth Environment Minister, who will decide whether the action requires environmental assessment.

3. The Act provides for:

    - the identification of key threatening processes for native cetacean species; and
    - the preparation of threat abatement plans, wildlife conservation plans, conservation agreements and recovery plans.

**To treat a cetacean means to divide or cut up, or extract any product from, the cetacean.*

LISTED MIGRATORY SPECIES[2]

What is a listed migratory species?

Listed migratory species include species listed in

- appendices to the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animals) for which Australia is a Range State under the Convention;
- the Agreement between the Government of Australia and the Government of the Peoples Republic of China for the Protection of Migratory Birds and their Environment (CAMBA); and
- the Agreement between the Government of Japan and the Government of Australia for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment (JAMBA).

Listed migratory species also include any native species identified in an international agreement approved by the Commonwealth Environment Minister. The Minister may approve an international agreement for this purpose if satisfied that it is an agreement relevant to the conservation of migratory species.

Protecting listed migratory species

[1] From EPBC Act 1999, 15/11/2004 http://www.deh.gov.au/epbc/biodiversityconservation/cetaceans/index.html

[2] From EPBC Act 1999 15/11/2004 http://www.deh.gov.au/epbc/assessmentsapprovals/nes/migratory.html

Assessment and approval provisions
Listed migratory species are a matter of national environmental significance under the EPBC Act's assessment and approval provisions.
A person must not take an action that has, will have, or is likely to have, a significant impact on a listed migratory species, without approval from the Commonwealth Environment Minister. To obtain approval, the action must undergo a rigorous environmental assessment and approval process .
To find out whether an action is likely to have a "significant" impact on a listed migratory species, see the EPBC Act Administrative Guidelines on Significance.

Biodiversity conservation provisions

Under the Act's biodiversity conservation provisions, it is an offence to kill, injure, take, trade, keep, or move, any member of a listed migratory species on Commonwealth land or in Commonwealth waters (Commonwealth areas) without a permit
To assist the conservation of listed migratory species the Act provides for:

- the identification of key threatening processes for native migratory species and the making of threat abatement plans ;
- the preparation of wildlife conservation plans and conservation agreements .

LISTED MARINE SPECIES[3]

What are listed marine species?
The list of marine species is the list established under s248 of the EPBC Act. The list may be amended from time to time.

Protecting listed marine species
It is an offence to kill, injure, take, trade, keep, or move any member of a listed marine species on Commonwealth land or in Commonwealth waters without a permit.
To assist the conservation of listed marine species, the Act provides for:

- the identification of key threatening processes for native marine species; and
- the preparation of threat abatement plans, wildlife conservation plans and conservation agreements.

THREATENED ECOLOGICAL COMMUNITIES[4]

Categories of ecological communities
Three categories exist for listing threatened ecological communities. An ecological community may be included in the:

- **Critically Endangered** category if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future.
- **Endangered** category if, at that time, it is not critically endangered and is facing a very high risk of extinction in the wild in the near future.
- **Vulnerable** category if, at that time, it is not critically endangered or endangered, and is facing a high risk of extinction in the wild in the medium-term future.

LISTED THREATENED SPECIES AND ECOLOGICAL COMMUNITIES[5]

An action will require approval from the Environment Minister if the action has, will have, or is likely to have a significant impact on a species listed in any of the following categories:

- extinct in the wild,
- critically endangered,
- endangered, or
- vulnerable.

An action will also require approval from the Environment Minister if the action has, will have, or is likely to have a significant impact on an ecological community listed in any of the following categories:

[3] From the EPBC website 23/11/04 http://www.deh.gov.au/epbc/biodiversityconservation/marine.html:
[4] From EPBC website 23/11/04: http://www.deh.gov.au/biodiversity/threatened/communities/index.html
[5] From EPBC website 23/11/04: http://www.deh.gov.au/epbc/assessmentsapprovals/guidelines/administrative/index.html#threatened

- critically endangered, or
- endangered.

An action does not require approval if it is covered by one of the exceptions identified above.
Threatened species and ecological communities are listed by the Minister for the Environment under Part 13, Division 1, Subdivision A of the Act. The lists are available through the EPBC website at http://www.deh.gov.au/epbc.
Some of the criteria below refer to the concept of 'habitat critical to the survival of a species or ecological community'. This habitat includes the critical habitat for many species and community identified in recovery plans for those species/communities and the critical habitat on the Register maintained by the Minister for the Environment under the Act. However, there may not be recovery plans in place for all listed species and communities, as plans take some time to prepare. Similarly, the Register may not be comprehensive. The absence of a recovery plan or the fact that an area may not be listed on the Register of Critical Habitat does not mean that there is no habitat critical to the survival of the species or community.
Habitat critical to the survival of a species or ecological community may include areas that are necessary:

- for activities such as foraging, breeding, roosting, or dispersal,
- for succession,
- to maintain genetic diversity and long term evolutionary development, or
- for the reintroduction of populations or recovery of the species / community.

Habitat critical to the survival of a species or ecological community will depend largely on the particular requirements of the species/community in question. For example, areas only incidentally used by a vulnerable species, and which the species is unlikely to be dependent upon for its survival or recovery, are not areas of habitat critical to the survival of a species or ecological community.
Some of the criteria below refer to actions likely to lead to a "longterm decrease" in the size of a population or a "long-term adverse affect" on a community. Depending on the level of endangerment and the nature of the action, not all actions which create an immediate decrease in the population of a nationally listed threatened species or impact on a community will have long-term consequences. For example, an action which causes injury or death to only one or a very small number of a species will not, except in the case of the most endangered of species, generally lead to a long-term or irreversible decrease in the population that normal processes, rates of mortality and recruitment could not buffer.

Critically endangered and endangered species

Criteria
An action has, will have, or is likely to have a significant impact on a critically endangered or endangered species if it does, will, or is likely to:

- lead to a long-term decrease in the size of a population, or
- reduce the area of occupancy of the species, or
- fragment an existing population into two or more populations, or
- adversely affect habitat critical to the survival of a species, or
- disrupt the breeding cycle of a population, or
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, or
- result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species´ habitat*, or
- interfere with the recovery of the species.

**Introducing an invasive species into the habitat may result in that species becoming established. An invasive species may harm a critically endangered or endangered species by direct competition, modification of habitat, or predation.*

Vulnerable species
Criteria
An action has, will have, or is likely to have a significant impact on a vulnerable species if it does, will, or is likely to:

- lead to a long-term decrease in the size of an important population of a species, or
- reduce the area of occupancy of an important population, or
- fragment an existing important population into two or more populations, or
- adversely affect habitat critical to the survival of a species, or

- disrupt the breeding cycle of an important population, or
- modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, or
- result in invasive species that are harmful a vulnerable species becoming established in the vulnerable species´ habitat*, or
- interferes substantially with the recovery of the species.

An important population is one that is necessary for a species' long-term survival and recovery. This may include populations that are:

- key source populations either for breeding or dispersal,
- populations that are necessary for maintaining genetic diversity, and/or
- populations that are near the limit of the species range.

**Introducing an invasive species into the habitat may result in that species becoming established. An invasive species may harm a vulnerable species by direct competition, modification of habitat, or predation.*

Critically endangered and endangered ecological communities

Criteria

An action has, will have, or is likely to have a significant impact on a critically endangered or endangered ecological community if it does, will, or is likely to:

- lead to a long-term adverse affect on an ecological community, or
- reduce the extent of a community, or
- fragment an occurrence of the community, or
- adversely affect habitat critical to the survival of an ecological community, or
- modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for the community's survival, or
- result in invasive species that are harmful to the critically endangered or endangered community becoming established in an occurrence of the community*, or
- interfere with the recovery of an ecological community.

In addition to the above information, Commonwealth adopted Recovery Plans may also provide further guidance on whether an action is likely to be significant.

**Introducing an invasive species into the occurrence may result in that species becoming established. An invasive species may harm a critically endangered or endangered ecological community by direct competition, modification of habitat, or predation.*

LISTED MIGRATORY SPECIES

An action will require approval from the Environment Minister if the action has, will have, or is likely to have a significant impact on a listed migratory species. (However, an action does not require approval if it is covered by one of the exceptions identified above.)

Lists of migratory species are established by the Minister for the Environment under Part 13, Division 2, Subdivision A of the Act. The lists are available through the EPBC website at http://www.deh.gov.au/epbc.

Note that some migratory species are also listed as threatened species. The criteria below are relevant to migratory species that are not threatened.

Criteria

An action has, will have, or is likely to have a significant impact on a migratory species if it does, will, or is likely to:

- substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat of the migratory species, or
- result in invasive species that is harmful to the migratory species becoming established* in an area of important habitat of the migratory species, or
- seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of thespecies.

An area of important habitat is:

1. habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species, or

2. habitat utilised by a migratory species which is at the limit of the species range, or

3. habitat within an area where the species is declining.

Listed migratory species cover a broad range of species with different life cycles and population sizes. Therefore, what is an ecologically significant proportion of the population varies with the species (each circumstance will need to be evaluated).

**Introducing an invasive species into the habitat may result in that species becoming established. An invasive species may harm a migratory species by direct competition, modification of habitat, or predation.*

Appendix III(c). International Union for the Conservation of Nature (IUCN)

INTERNATIONAL UNION FOR THE CONSERVATION OF NATURE (IUCN)

CATEGORIES AND CRITERIA[6]

ENDANGERED (EN)
A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.
VULNERABLE (VU)
A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Section V), and it is therefore considered to be facing a high risk of extinction in the wild.
LOWER RISK Conservation Dependent (cd)[*]
Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation programme targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years.
DATA DEFICIENT (DD)
A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.
NOT EVALUATED (NE)
A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.

V. THE CRITERIA FOR ENDANGERED AND VULNERABLE

ENDANGERED (EN)
A taxon is Endangered when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing a very high risk of extinction in the wild:
A. Reduction in population size based on any of the following:

1.An observed, estimated, inferred or suspected population size reduction of ≥70% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are clearly reversible AND understood AND ceased, based on (and specifying) any of the following:

(a) direct observation
(b) an index of abundance appropriate to the taxon
(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
(d) actual or potential levels of exploitation
(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

2. An observed, estimated, inferred or suspected population size reduction of ≥50% over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

3. A population size reduction of ≥50%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.

4. An observed, estimated, inferred, projected or suspected population size reduction of ≥50% over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where

[6] From the IUCN website 22/11/2004: http://www.redlist.org/info/categories_criteria2001.html
[*] From 1994 Categories & Criteria (v 2.3) of IUCN Red List of Threatened Species: http://www.redlist.org/info/categories_criteria1994.html

the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy) OR both:

1. Extent of occurrence estimated to be less than 5000 km², and estimates indicating at least two of a-c:

a. Severely fragmented or known to exist at no more than five locations.

b. Continuing decline, observed, inferred or projected, in any of the following:
(i) extent of occurrence
(ii) area of occupancy
(iii) area, extent and/or quality of habitat
(iv) number of locations or subpopulations
(v) number of mature individuals.

c. Extreme fluctuations in any of the following:
(i) extent of occurrence
(ii) area of occupancy
(iii) number of locations or subpopulations
(iv) number of mature individuals.

2. Area of occupancy estimated to be less than 500 km², and estimates indicating at least two of a-c:

a. Severely fragmented or known to exist at no more than five locations.

b. Continuing decline, observed, inferred or projected, in any of the following:
(i) extent of occurrence
(ii) area of occupancy
(iii) area, extent and/or quality of habitat
(iv) number of locations or subpopulations
(v) number of mature individuals.

c. Extreme fluctuations in any of the following:
(i) extent of occurrence
(ii) area of occupancy
(iii) number of locations or subpopulations
(iv) number of mature individuals.

C. Population size estimated to number fewer than 2500 mature individuals and either:

1. An estimated continuing decline of at least 20% within five years or two generations, whichever is longer, (up to a maximum of 100 years in the future) OR

2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of the following (a-b):

(a) Population structure in the form of one of the following:
(i) no subpopulation estimated to contain more than 250 mature individuals, OR
(ii) at least 95% of mature individuals in one subpopulation.

(b) Extreme fluctuations in number of mature individuals.

D. Population size estimated to number fewer than 250 mature individuals.

E. Quantitative analysis showing the probability of extinction in the wild is at least 20% within 20 years or five generations, whichever is the longer (up to a maximum of 100 years).

VULNERABLE (VU)

A taxon is Vulnerable when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing a high risk of extinction in the wild:

A. Reduction in population size based on any of the following:

1. An observed, estimated, inferred or suspected population size reduction of ≥50% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are: clearly reversible AND understood AND ceased, based on (and specifying) any of the following:

(a) direct observation

(b) an index of abundance appropriate to the taxon

(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
(d) actual or potential levels of exploitation
(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

2. An observed, estimated, inferred or suspected population size reduction of ≥30% over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

3. A population size reduction of ≥30%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.

4. An observed, estimated, inferred, projected or suspected population size reduction of ≥30% over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy) OR both:
1. Extent of occurrence estimated to be less than 20,000 km², and estimates indicating at least two of a-c:
a. Severely fragmented or known to exist at no more than 10 locations.

b. Continuing decline, observed, inferred or projected, in any of the following:
(i) extent of occurrence
(ii) area of occupancy
(iii) area, extent and/or quality of habitat
(iv) number of locations or subpopulations
(v) number of mature individuals.

c. Extreme fluctuations in any of the following:
(i) extent of occurrence
(ii) area of occupancy
(iii) number of locations or subpopulations
(iv) number of mature individuals.

2. Area of occupancy estimated to be less than 2000 km², and estimates indicating at least two of a-c:
a. Severely fragmented or known to exist at no more than 10 locations.

b. Continuing decline, observed, inferred or projected, in any of the following:
(i) extent of occurrence
(ii) area of occupancy
(iii) area, extent and/or quality of habitat
(iv) number of locations or subpopulations
(v) number of mature individuals.

c. Extreme fluctuations in any of the following:
(i) extent of occurrence
(ii) area of occupancy
(iii) number of locations or subpopulations
(iv) number of mature individuals.

C. Population size estimated to number fewer than 10,000 mature individuals and either:
1. An estimated continuing decline of at least 10% within 10 years or three generations, whichever is longer, (up to a maximum of 100 years in the future) OR

2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of the following (a-b):
(a) Population structure in the form of one of the following:
(i) no subpopulation estimated to contain more than 1000 mature individuals, OR
(ii) all mature individuals are in one subpopulation.

(b) Extreme fluctuations in number of mature individuals.

D. Population very small or restricted in the form of either of the following:

1. Population size estimated to number fewer than 1000 mature individuals.

2. Population with a very restricted area of occupancy (typically less than 20 km²) or number of locations (typically five or fewer) such that it is prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and is thus capable of becoming Critically Endangered or even Extinct in a very short time period.

E. Quantitative analysis showing the probability of extinction in the wild is at least 10% within 100 years.

Appendix III(d). The Convention of Internation Trade in Endangered Species of Wild Flora and Fauna (CITES)

THE CONVENTION ON INTERNATIONAL TRADE IN ENDAGERED SPECIES OF WILD FAUNA AND FLORA (CITES)[7]

Appendices I, II and III to the Convention are lists of species afforded different levels or types of protection from over-exploitation

Appendix I lists species that are the most endangered among CITES-listed animals and plants. These are threatened with extinction and CITES generally prohibits commercial international trade in specimens of these species. However trade may be allowed under exceptional circumstances, e.g. for scientific research. In these cases, trade may be authorized by the granting of both an export permit (or re-export certificate) and an import permit.

Appendix II lists species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled. It also includes so-called "look-alike species", i.e. species of which the specimens in trade look like those of species listed for conservation reasons. International trade in specimens of Appendix-II species may be authorized by the granting an export permit or re-export certificate; no import permit is necessary. Permits or certificates should only be granted if the relevant authorities are satisfied that certain conditions are met, above all that trade will not be detrimental to the survival of the species in the wild.

APPENDIX I & II OF CONVENTION OF MIGRATORY SPECIES (CMS)[8]

APPENDIX I-ENDANGERED MIGRATORY SPECIES

Migratory species that have been categorized as being in danger of extinction throughout all or a significant proportion of their range are listed on Appendix I of the Convention.

States strive towards strictly protecting these animals, conserving or restoring the habitats in which they live, mitigating obstacles to migration and controlling other factors that might endanger them.

APPENDIX II- MIGRATORY SPECIES CONSERVED THROUGH AGREEMENTS

Migratory species that have an unfavourable conservation status or would benefit significantly from international co-operation organised by tailored agreements are listed in Appendix II to the Convention. For this reason, the Convention encourages the Range States to conclude global or regional Agreements for the conservation and management of individual species or, more often, of a group of species listed on Appendix II.

In this respect, CMS acts as a framework convention from which independent instruments evolve. The Agreements may range from legally binding treaties to less formal instruments, such as Memoranda of Understanding, and can be adapted to the requirements of particular regions. The development of models tailored according to the conservation needs throughout the migratory range is a unique capacity of CMS.

Such agreements have the great advantage that the Range States themselves decide on a tailored and structured action plan that includes the organization of joint research, monitoring activities and harmonisation of legislation.

[7] From CITES website 15/11/2004 http://www.cites.org/eng/append/index.shtml

[8] From the CMS website 15/11/2004 http://www.cms.int/documents/appendix/cms_app1_2.htm

Appendix III(e). Japan and Australia Migratory Birds Agreement (JAMBA)

AGREEMENT BETWEEN THE GOVERNMENT OF AUSTRALIA AND THE GOVERNMENT OF JAPAN FOR THE PROTECTION OF MIGRATORY BIRDS AND BIRDS IN DANGER OF EXTINCTION AND THEIR ENVIRONMENT [9]

THE GOVERNMENT OF AUSTRALIA AND THE GOVERNMENT OF JAPAN,
CONSIDERING that birds constitute an important element in the natural environment and play an essential role in enriching the natural environment and that this role may be enhanced by proper management thereof,
RECOGNISING the special international concern, as expressed, for example, at the United Nations Conference on the Human Environment, for the protection of migratory birds and birds in danger of extinction,
NOTING the existence of bilateral and multilateral agreements for the protection of migratory birds and birds in danger of extinction,
CONSIDERING that many species of birds migrate between Australia and Japan and live seasonally in respective countries and that there are certain species of birds which are in danger of extinction and also that co-operation between the two Governments is essential for the conservation of these birds, and
DESIRING to co-operate in taking measures for the management and protection of migratory birds and birds in danger of extinction and also for the management and protection of their environments,
HAVE AGREED as follows:

Article I

1. In this Agreement, the term "migratory birds" means:
(a) the species of birds for which there is reliable evidence of migration between the two countries from the recovery of bands or other markers; and
(b) the species of birds with subspecies common to both countries or, in the absence of subspecies, the species of birds common to both countries (excepting those whose non-migratory nature is biologically evident). The identification of these species and subspecies shall be based upon specimens, photographs or other reliable evidence.
2. (a) The list of the species defined as migratory birds in accordance with paragraph 1 of this Article is contained in the Annex to this Agreement.
(b) The competent authorities of the two Governments shall review from time to time the Annex and, if necessary, make recommendations to their respective Governments to amend it.
(c) The Annex shall be considered amended three months after the date upon which the two Governments confirm, by an exchange of diplomatic notes, their respective acceptance of such recommendations.

Article II

1. Each Government shall prohibit the taking of migratory birds or their eggs. However, exceptions to the prohibition of taking may be permitted in accordance with the laws and regulations in force in each country in the following cases:
(a) for scientific, educational, propagative or other specific purposes not inconsistent with the objectives of this Agreement;
(b) for the purpose of protecting persons and property;
(c) during hunting seasons established in accordance with paragraph 3 of this Article; and
(d) to allow the hunting and gathering of specified birds or their eggs by the inhabitants of certain regions who have traditionally carried on such activities for their own food, clothing or cultural purposes, provided that the population of each species is maintained in optimum numbers and that adequate preservation of the species is not prejudiced.
2. Each Government shall prohibit any sale, purchase or exchange of migratory birds or their eggs, whether they are alive or dead, except those taken in accordance with the second sentence of paragraph 1 of this Article, or of the products thereof or their parts.
3. Each Government may establish seasons for hunting migratory birds taking into account the maintenance of normal annual reproduction of those birds.

Article III

1. Each Government shall take special protective measures, as appropriate, for the preservation of species or subspecies of birds which are in danger of extinction.

[9] From the Australian Treaty Series website 23/11/04: http://www.austlii.edu.au/au/other/dfat/treaties/1981/6.html

2. Whenever either Government has determined the species or subspecies of birds which are in danger of extinction and taken special protective measures therefore, the Government shall inform the other Government of such determination and of any cancellation thereafter of such determination.
3. Each Government shall control the exportation or importation of such species or subspecies of birds as are determined in accordance with paragraph 2 of this Article, and of the products thereof.

Article IV

1. The two Governments shall exchange data and publications regarding research on migratory birds and birds in danger of extinction.
2. Each Governments shall encourage the formulation of joint research programs on migratory birds and birds in danger of extinction.
3. Each Government shall encourage the conservation of migratory birds and birds in danger of extinction.

Article V

Each Government shall endeavour to establish sanctuaries and other facilities for the management and protection of migratory birds and birds in danger of extinction and also of their environment.

Article VI

Each Government shall endeavour to take appropriate measures to preserve and enhance the environment of birds protected under the provisions of this Agreement. In particular, it shall:
(a) seek means to prevent damage to such birds and their environment;
(b) endeavour to take such measures as may be necessary to control the importation of animals and plants which it determines to be hazardous to the preservation of such birds; and
(c) endeavour to take such measures as may be necessary to control the introduction of animals and plants which could disturb the ecosystems of unique island environments.

Article VII

Each Government agrees to take measures necessary to carry out the purposes of this Agreement.

Article VIII

Upon the request of either Government, the two Governments shall hold consultations regarding the operation of this Agreement.

Article IX

1. This Agreement shall be ratified and the instruments of ratification shall be exchanged at Canberra as soon as possible.[1]
2. This Agreement shall enter into force on the date of the exchange of the instruments of ratification. It shall remain in force for fifteen years and shall continue in force thereafter until terminated as provided herein.
3. Either Government may, by giving one year's notice in writing, terminate this Agreement at the end of the initial fifteen year period or at any time thereafter.

IN WITNESS WHEREOF the undersigned, being duly authorised by their respective Governments, have signed this Agreement.

DONE in duplicate, in the English and Japanese languages, each text being equally authentic, at Tokyo, this sixth day of February, one thousand nine hundred and seventy-four.

FOR THE GOVERNMENT OF FOR THE GOVERNMENT OFAUSTRALIA: JAPAN:

Appendix III(f). China and Australia Migratory Birds Agreement (CAMBA)

AGREEMENT BETWEEN THE GOVERNMENT OF AUSTRALIA AND THE GOVERNMENT OF THE PEOPLE'S REPUBLIC OF CHINA FOR THE PROTECTION OF MIGRATORY BIRDS AND THEIR ENVIRONMENT[10]

THE GOVERNMENT OF AUSTRALIA AND THE GOVERNMENT OF THE PEOPLE'S REPUBLIC OF CHINA (hereinafter referred to as the Contracting Parties):
CONSIDERING that birds constitute an important element in the natural environment and are also important natural resources of great value in carrying on scientific, cultural, artistic, recreational and economic activities;

RECOGNISING the existence of special international concern for the protection of migratory birds;

NOTING the existence of bilateral and multilateral agreements for the protection of migratory birds;

CONSIDERING that many species of birds that are known to be migratory occur in Australia and in the People's Republic of China;

DESIRING to co-operate in the protection of migratory birds and their environment;

HAVE REACHED THE FOLLOWING AGREEMENT as a result of friendly discussions:

Article I

1. In this Agreement, the term "migratory birds" means:
(a) Birds for which there is reliable evidence of migration between the two countries from the recovery of bands or other markers; and
(b) Birds which are jointly determined by the competent authorities of the Contracting Parties to migrate between the two countries on the basis of published reports, photographs and other information.
However, migratory birds known to have been introduced by man to either country shall be excluded.
2. (a) The species recognised as migratory birds in accordance with paragraph 1 of this Article are listed in the Annex to this Agreement.
(b) The competent authorities of the Contracting Parties shall, from time to time, review the Annex. If they consider it necessary, the Contracting Parties may amend it by mutual arrangement.
(c) The Annex shall be considered amended ninety days after the date upon which each Party informs the other in a diplomatic note that it accepts the amendments.

Article II

1. Each Contracting Party shall prohibit the taking of migratory birds and their eggs. However, exceptions to that prohibition may be permitted in accordance with the laws and regulations in force in each country in the following cases:
(a) for scientific, educational, propagative or other specific purposes not inconsistent with the objectives of this Agreement;
(b) for the purpose of protecting persons or property;
(c) during hunting seasons established in accordance with paragraph 3 of this Article; and
(d) to allow the hunting and gathering of specified migratory birds or their eggs by the inhabitants of specified regions who have traditionally carried on such activities for their own food, clothing or cultural purposes, provided that the population of each species is maintained in optimum numbers and that adequate preservation of the species is not prejudiced.
2. Each Contracting Party shall prohibit any sale, purchase or exchange of migratory birds or their eggs, whether they are alive or dead, or of the products thereof or their parts, except those taken in accordance with paragraph 1 of this Article.
3. Each Contracting Party may establish seasons for hunting migratory birds taking into account the maintenance of annual reproduction required for the survival of those birds.

Article III

1. Each Contracting Party shall encourage exchanges of data and publications regarding research on migratory birds.
2. The Contracting Parties shall encourage the formulation of joint research programs on migratory birds.

[10] From the Australian Treaty Series website 23/11/04 :http://www.austlii.edu.au/au/other/dfat/treaties/1988/22.html

3. Each Contracting Party shall encourage the conservation of migratory birds, especially those species in danger of extinction.

Article IV

Each Contracting Party shall endeavour, in accordance with its laws and regulations in force, to:
(a) establish sanctuaries and other facilities for the management and protection of migratory birds and also of their environment; and
(b) take appropriate measures to preserve and enhance the environment of migratory birds. In particular, each Contracting Party shall:
(i) seek means to prevent damage to migratory birds and their environment, and
(ii) endeavour to take such measures as may be necessary to restrict or prevent the importation and introduction of animals and plants which are hazardous to the preservation of migratory birds and their environment.

Article V

Upon the request of either of the Contracting Parties, the Contracting Parties shall hold consultations regarding the operation of this Agreement.

Article VI

1. This Agreement shall enter into force on the day upon which both Contracting Parties have notified each other that their respective constitutional and other requirements necessary to give effect to this Agreement have been complied with. [1] It shall remain in force for fifteen years and shall continue in force thereafter until terminated in accordance with the provisions in paragraph 2 of this Article.
2. Either Contracting Party may, by giving one year's notice in writing, terminate this Agreement at the end of the initial fifteen year period or at any time thereafter.
IN WITNESS WHEREOF the undersigned, being duly authorized thereto by their respective Governments, have signed this Agreement.
Done in duplicate, at Canberra, on twenty October, 1986 in the English and Chinese languages, both texts being equally authentic.
FOR THE GOVERNMENT OF FOR THE GOVERNMENT OF THE AUSTRALIA: PEOPLE'S REPUBLIC OF CHINA:

APPENDIX IV: RESEARCH AND MONITORING MATRICES

Appendix IV(a). Strategic research priorities for the major marine fauna found in the Perth metropolitan area

Value	E1	E2	E3	E4	B1	B2	B3	B4	C1	C2	C3	C4	V	k1	k2	k3	k4	K	V(12-K)	Rank	Priority
Blue Whales	1	2	1	2	3	3	2	2	1	1	3	1	**22**	1	1	1	1	**4**	**176**	1	H
Autralian Sea lions	1	2	3	3	3	3	3	3	2	2	3	2	**30**	2	1	2	2	**7**	**150**	2	H
Southern Right Whales	1	2	2	2	2	2	2	1	1	2	2	1	**20**	2	1	2	1	**6**	**120**	3	H
Little Penguins	1	2	3	2	3	3	3	1	2	2	3	2	**27**	2	2	2	2	**8**	**108**	4	M
Migratory waders	1	3	2	1	3	3	3	3	1	1	3	2	**26**	2	2	2	2	**8**	**104**	5	M
Humpback whales	1	2	1	2	3	3	2	1	2	2	2	2	**23**	3	2	2	2	**9**	**69**	6	M
Dolphins	1	2	2	1	2	1	1	1	2	1	1	1	**16**	2	1	2	3	**8**	**64**	7	L
Sea-birds	1	2	2	2	2	2	2	1	1	1	2	2	**20**	2	2	2	3	**9**	**60**	8	L
Cockburn Sound Dolphins	1	1	2	2	3	2	1	1	2	2	2	2	**21**	3	2	2	3	**10**	**42**	9	L

Appendix IV(b). Applied research priorities for the major marine fauna found in the Perth metropolitan area

Value	Pressure	E1	E2	E3	E4	B1	B2	B3	B4	C1	C2	C3	C4	V	p1	p2	p3	p4	p5	P	k1	k2	k3	k4	K	VP(12-K)	Rank	Priority
Australian Sea Lions	Human disturbance (swimming, commercial tourism, walkers)	1	2	3	3	3	3	3	3	2	2	3	2	**30**	1	2	3	3	3	**27**	2	2	2	2	**8**	**3240**	1	H
Little Penguins	disturbance by watercraft, incl boatstrikes	1	2	3	2	3	3	3	1	2	2	3	2	**27**	1	3	2	3	3	**27**	2	2	2	2	**8**	**2916**	2	H
Southern right whales	acoustic disturbance	1	2	2	2	2	2	2	1	1	2	2	1	**20**	1	3	3	2	2	**18**	1	1	1	1	**4**	**2880**	3	H
Little Penguins	entanglements	1	2	3	2	3	3	3	1	2	2	3	2	**27**	1	3	3	3	3	**30**	2	2	3	2	**9**	**2430**	4	H
Migratory waders	Human disturbance (walkers, PWC, water craft)	1	3	2	1	3	3	3	3	1	1	3	2	**26**	1	3	3	3	3	**30**	2	2	2	3	**9**	**2340**	5	H
Cockburn Sound Dolphins	human disturbance (recreation/tourism)	1	1	2	2	3	2	1	1	2	2	2	2	**21**	1	3	2	2	3	**24**	3	1	2	2	**8**	**2016**	6	H
Australian Sea Lions	entanglements	1	2	3	3	3	3	3	3	2	2	3	2	**30**	1	3	2	2	2	**16**	2	2	2	2	**8**	**1920**	7	H
Migratory waders	Introduced predators (cats and foxes)	1	3	2	1	3	3	3	3	1	1	3	2	**26**	1	2	2	1	2	**12**	1	1	2	2	**6**	**1872**	8	H
Blue Whales	acoustic disturbance	1	2	1	2	3	3	2	2	1	1	3	1	**22**	1	2	3	2	2	**16**	2	2	1	2	**7**	**1760**	9	H
Humpback whales	acoustic disturbance	1	2	1	2	3	3	2	1	2	2	2	2	**23**	1	3	3	2	2	**18**	2	2	2	2	**8**	**1656**	10	M
Southern right whales	human disturbance (recreation/tourism)	1	2	2	2	2	2	2	1	1	2	2	1	**20**	1	3	2	2	2	**16**	2	1	2	2	**7**	**1600**	11	M
Dolphins	food availability (commercial and recreational fishing, loss of habitat)	1	2	2	1	2	1	1	1	2	1	1	1	**16**	1	2	2	1	2	**12**	1	1	2	2	**6**	**1152**	12	M
Southern right whales	Boat strikes	1	2	2	2	2	2	2	1	1	2	2	1	**20**	1	2	2	2	2	**14**	2	1	3	2	**8**	**1120**	13	M
Dolphins	entanglements	1	2	2	1	2	1	1	1	2	1	1	1	**16**	1	3	2	1	2	**14**	1	1	3	2	**7**	**1120**	13	M
Seabirds	Human disturbance at breeding colonies	1	2	2	2	2	2	2	1	1	1	2	2	**20**	1	2	1	1	2	**10**	1	2	2	2	**7**	**1000**	15	M
Little Penguins	disturbance to nest sites	1	2	3	2	3	3	3	1	2	2	3	2	**27**	1	1	2	2	2	**12**	2	3	2	2	**9**	**972**	16	M
Humpback whales	entanglements	1	2	1	2	3	3	2	1	2	2	2	2	**23**	1	2	2	2	3	**21**	2	2	3	3	**10**	**966**	17	M
Humpback whales	human disturbance (recreation/tourism)	1	2	1	2	3	3	2	1	2	2	2	2	**23**	1	2	2	2	2	**14**	2	1	3	3	**9**	**966**	17	M
Australian Sea Lions	Boat strikes	1	2	3	3	3	3	3	3	2	2	3	2	**30**	1	2	1	1	1	**5**	1	2	2	1	**6**	**900**	19	M
Cockburn Sound Dolphins	food availability (commercial and recreational fishing, loss of habitat)	1	1	2	2	3	2	1	1	2	2	2	2	**21**	1	2	2	2	3	**21**	2	2	3	3	**10**	**882**	20	L
Blue Whales	entanglements	1	2	1	2	3	3	2	2	1	1	3	1	**22**	1	1	2	2	2	**12**	1	2	3	3	**9**	**792**	21	L
Little Penguins	Disturbance to whitebait nursery	1	2	3	2	3	3	3	1	2	2	3	2	**27**	1	1	3	3	3	**24**	3	3	3	2	**11**	**648**	22	L
Migratory waders	Loss of habitat for foraging and roosting	1	3	2	1	3	3	3	3	1	1	3	2	**26**	1	1	1	1	2	**8**	3	2	2	2	**9**	**624**	23	L
Humpback whales	Boat strikes	1	2	1	2	3	3	2	1	2	2	2	2	**23**	1	2	2	1	1	**6**	2	1	3	2	**8**	**552**	24	L
Southern right whales	entanglements	1	2	2	2	2	2	2	1	1	2	2	1	**20**	1	3	3	2	3	**27**	3	2	3	3	**11**	**540**	25	L
Dolphins	illegal feeding	1	2	2	1	2	1	1	1	2	1	1	1	**16**	1	1	1	1	2	**8**	2	2	2	2	**8**	**512**	26	L
Cockburn Sound Dolphins	illegal feeding	1	1	2	2	3	2	1	1	2	2	2	2	**21**	1	3	2	2	3	**24**	3	2	3	3	**11**	**504**	27	L
Little Penguins	food availability (commercial and recreational fishing, El Nino)	1	2	3	2	3	3	3	1	2	2	3	2	**27**	1	2	3	3	2	**18**	2	3	3	3	**11**	**486**	28	L
Blue Whales	Boat strikes	1	2	1	2	3	3	2	2	1	1	3	1	**22**	1	1	1	1	1	**4**	1	1	3	2	**7**	**440**	29	L

Appendix IV(c). Monitoring priorities for the major marine fauna found in the Perth metropolitan area

Value	Pressure	E1	E2	E3	E4	B1	B2	B3	B4	C1	C2	C3	C4	V	p1	p2	p3	p4	p5	P	VP	Rank	Prority
Little Penguins	entanglements	1	2	3	2	3	3	3	1	2	2	3	2	27	1	3	3	3	3	30	810	1	H
Australian Sea Lions	Human disturbance (swimming, commercial tourism, walkers)	1	2	3	3	3	3	3	3	2	2	3	2	30	1	2	3	3	3	27	810	1	H
Migratory waders	Human disturbance (walkers, PWC, water craft)	1	3	2	1	3	3	3	3	1	1	3	2	26	1	3	3	3	3	30	780	3	H
Little Penguins	disturbance by watercraft, incl boatstrikes	1	2	3	2	3	3	3	1	2	2	3	2	27	1	3	2	3	3	27	729	4	H
Little Penguins	Disturbance to whitebait nursery	1	2	3	2	3	3	3	1	2	2	3	2	27	1	1	3	3	3	24	648	5	H
Southern right whales	entanglements	1	2	2	2	2	2	2	1	1	2	2	1	20	1	3	3	2	3	27	540	6	H
Cockburn Sound Dolphins	human disturbance (recreation/tourism)	1	1	2	2	3	2	1	1	2	2	2	2	21	1	3	2	2	3	24	504	7	H
Cockburn Sound Dolphins	illegal feeding	1	1	2	2	3	2	1	1	2	2	2	2	21	1	3	2	2	3	24	504	7	H
Little Penguins	food availability (commercial and recreational fishing, El Nino)	1	2	3	2	3	3	3	1	2	2	3	2	27	1	2	3	3	2	18	486	9	H
Humpback whales	entanglements	1	2	1	2	3	3	2	1	2	2	2	2	23	1	2	2	2	3	21	483	10	M
Australian Sea Lions	entanglements	1	2	3	3	3	3	3	3	2	2	3	2	30	1	3	2	2	2	16	480	11	M
Cockburn Sound Dolphins	food availability (commercial and recreational fishing, loss of habitat)	1	1	2	2	3	2	1	1	2	2	2	2	21	1	2	2	2	3	21	441	12	M
Humpback whales	acoustic disturbance	1	2	1	2	3	3	2	1	2	2	2	2	23	1	3	3	2	2	18	414	13	M
Southern right whales	acoustic disturbance	1	2	2	2	2	2	2	1	1	2	2	1	20	1	3	3	2	2	18	360	14	M
Blue Whales	acoustic disturbance	1	2	1	2	3	3	2	2	1	1	3	1	22	1	2	3	2	2	16	352	15	M
Little Penguins	disturbance to nest sites	1	2	3	2	3	3	3	1	2	2	3	2	27	1	1	2	2	2	12	324	16	M
Humpback whales	human disturbance (recreation/tourism)	1	2	1	2	3	3	2	1	2	2	2	2	23	1	2	2	2	2	14	322	17	M
Southern right whales	human disturbance (recreation/tourism)	1	2	2	2	2	2	2	1	1	2	2	1	20	1	3	2	2	2	16	320	18	M
Migratory waders	Introduced predators (cats and foxes)	1	3	2	1	3	3	3	3	1	1	3	2	26	1	2	2	1	2	12	312	19	M
Southern right whales	Boat strikes	1	2	2	2	2	2	2	1	1	2	2	1	20	1	2	2	2	2	14	280	20	L
Blue Whales	entanglements	1	2	1	2	3	3	2	2	1	1	3	1	22	1	1	2	2	2	12	264	21	L
Dolphins	entanglements	1	2	2	1	2	1	1	1	2	1	1	1	16	1	3	2	1	2	14	224	22	L
Migratory waders	Loss of habitat for foraging and roosting	1	3	2	1	3	3	3	3	1	1	3	2	26	1	1	1	1	2	8	208	23	L
Seabirds	Human disturbance at breeding colonies	1	2	2	2	2	2	2	1	1	1	2	2	20	1	2	1	1	2	10	200	24	L
Dolphins	food availability (commercial and recreational fishing, loss of habitat)	1	2	2	1	2	1	1	1	2	1	1	1	16	1	2	2	1	2	12	192	25	L
Australian Sea Lions	Boat strikes	1	2	3	3	3	3	3	3	2	2	3	2	30	1	2	1	1	1	5	150	26	L
Humpback whales	Boat strikes	1	2	1	2	3	3	2	1	2	2	2	2	23	1	2	2	1	1	6	138	27	L
Dolphins	illegal feeding	1	2	2	1	2	1	1	1	2	1	1	1	16	1	1	1	1	2	8	128	28	L
Blue Whales	Boat strikes	1	2	1	2	3	3	2	2	1	1	3	1	22	1	1	1	1	1	4	88	29	L

APPENDIX V: METADATA

Appendix V(a). Metadata for whales-humpback_s_20040420_II_gda94.shp

DATASET whales-humpback_s_20040420_ll_gda94.shp	
Title	Humpback Whale (*Megaptera novaeangliae*) Migration Paths and activity in Perth metropolitan waters
Custodian	Department of Conservation and Land Management (CALM)
Jurisdiction	Western Australia
DESCRIPTION	
Abstract	This dataset consists of polygons representing whale migration paths and other activity areas within the Perth metropolitan waters for Humpback Whales *Megaptera novaeangliae*. The behavioral categories recorded include, where applicable, southerly and northerly migration, milling, possible birthing and nursing, foraging and travelling. The data were generated from **anecdotal information** provided by the experts and from reports and published information gathered during a literature review of whales in the region. References include: i) Jenner, C. & Jenner, M.-N. personal communication (2003) ii) Burton, C. personal communication (2003) iii) Coughran, D. personal communication (2003) iv) McCauley, R. personal communication (2004) v) (McCauley et al. 2003). This dataset can be used in conjunction with the other whale datasets created as part of the same data collection project performed by Belinda Cannell 2003-2004 for the MCB.
Search Word(s)	Humpback Whale, *Megaptera novaeangliae*, migration, milling, birthing, nursing, foraging, traveling
Geographic Extent	WA Coastal Waters adjacent to the Perth Metropolitan area (Yanchep to Mandurah). Central West Coast (CWC) IMCRA Region.
DATA CURRENCY	
Begin Date	1988
End Date	12/2003
DATASET STATUS	
Progress	Complete with respect to the collection exercise by Belinda Cannell
Maintenance & Update Frequency	Complete
ACCESS	
Stored Data Format	DIGITAL ArcView shapefile, geographical coordinates from Geocentric Datum of Australia 1994 (GDA94).
Available Format Type	DIGITAL ArcView 3.2 shapefile.
Access Constraint	Data available for external use. Information has been provided for better management of species. Please respect and acknowledge intellectual property. Contact CALM's database administrator for further details.
DATA QUALITY	
Lineage	**MCB Processing 20040501 - PKI** Lines and polygons were created and attributed by the following methods: i) Blank hard copy maps were taken to each expert who, in turn, drew/annotated areas utilised by each species for the various behavioural categories (where known). Certainty and accuracy of the information was noted as research is limited to specific areas. Some whale movements are therefore surmised. Major contributions for Humpbacks were from C. and M. Jenner and D. Coughran, C.

	Burton and R. McCauley. ii) the paper base maps were then digitised by PKI in Arcview 3.2 over the hydro chart (Chart-a00334_200201_utm50_gda94.ecw) and a poly dataset was created with the attributes as per the CALM Marine Conservation's Branch's attribute and naming standards. iii) First drafts of the maps were reviewed by each of the experts in March and April 2004 and modifications were incorporated where appropriate by Phil Kindleysides in March and April 2004 under the instruction of Ray Lawrie and Belinda Cannell.
Positional Accuracy	Positional accuracy can be considered as medium due to the anecdotal nature of the supplied information. Each polygon's spatial extent is however a good representation of the information collected by Belinda Cannell with respect to the current understanding of whale activity in the area.
Attribute Accuracy	Attribute values are true to the data collected by Belinda Cannell.
Logical Consistency	Attribute values were quickly compared to the annotated collector sheets (maps supplied to experts), validated for consistency, and checked for logic in relation to attribute names. All attributes that require values have been assigned values.
Completeness	The dataset is complete as at the date of this metadata statement.
CONTACT INFORMATION	
Contact Organisation	Department of Conservation and Land Management, Marine Conservation Branch.
Contact Position	
Mail Address 1	47 Henry Street
Mail Address 2	
Suburb or Place or Locality	Fremantle
State or Locality 2	Western Australia
Country	Australia
Postcode	6160
Telephone	08 9336 0109
Facsimile	08 9430 5408
Electronic Mail Address	rayl@calm.wa.gov.au
METADATA DATE	
Metadata Date	09/07/2004
ADDITIONAL METADATA	
Additional Metadata	i) Jenner, C., M.-N. Jenner, and K. McCabe. 2000. Geographical and temporal movements of humpback whales in Western Australia: A preliminary report and description of a computer assisted matching system. Centre for Whale Research (Western Australia) Inc., Perth, Western Australia. ii) McCauley, R., J. Bannister, C. Burton, C. Jenner, S. Rennie, and C. van Etten. 2003. Western Australian Exercise Area Blue Whale Project Milestone 4. Page 37pp. Australian Defence, Perth iii) Bannister, J.L, Kemper, C. M. & Warneke, R. M. (1996). The Action Plan for Australian Cetaceans. Australian Nature Conservation Agency

Appendix V(b). Metadata for whales-right_s_20040503_II_gda94.shp

DATASET whales-right_s_20040503_ll_gda94.shp	
Title	Southern Right Whale (*Eubalaena australis*) Migration Paths and activity in Perth metropolitan waters
Custodian	Department of Conservation and Land Management (CALM)
Jurisdiction	Western Australia
DESCRIPTION	
Abstract	This dataset consists of polygons representing whale migration paths and other activity areas within the Perth metropolitan waters for Southern Right Whales *Eubalaena australis*. The behavioural categories recorded include, where applicable, southerly and northerly migration, milling, possible birthing and nursing, foraging and traveling. The data were generated from **anecdotal information** provided by the experts and from reports and published information gathered during a literature review of whales in the region. References include: i) Burton, C. personal communication (2003) ii) Coughran, D. personal communication (2003) This dataset can be used in conjunction with the other whale datasets created as part of the same data collection project performed by Belinda Cannell 2003-2004 for the MCB.
Search Word(s)	Southern Right Whale, Eubalaena australis, migration, milling, birthing, nursing, foraging, travelling
Geographic Extent	WA Coastal Waters adjacent to the Perth Metropolitan area (Yanchep to Mandurah). Central West Coast (CWC) IMCRA Region.
DATA CURRENCY	
Begin Date	1988
End Date	12/2003
DATASET STATUS	
Progress	Complete with respect to the collection exercise by Belinda Cannell
Maintenance & Update Frequency	Complete
ACCESS	
Stored Data Format	DIGITAL ArcView shapefile, geographical coordinates from Geocentric Datum of Australia 1994 (GDA94).
Available Format Type	DIGITAL ArcView 3.2 shapefile.
Access Constraint	Data available for external use. Information has been provided for better management of species. Please respect and acknowledge intellectual property. Contact CALM's database administrator for further details.
DATA QUALITY	
Lineage	**MCB Processing 20040501 - PKI** Lines and polygons were created and attributed by the following methods: i) Blank hard copy maps were taken to each expert who, in turn, drew/annotated areas utilised by each species for the various behavioural categories (where known). Certainty and accuracy of the information was noted as research is limited to specific areas. Some whale movements are therefore surmised. Major contributions for Southern Rights were from Chris Burton and Dave Coughran who also suggested that there was not a lot of study activity occurring in the winter months. ii) the paper base maps were then digitised by PKI in Arcview 3.2 over the hydro chart (Chart-a00334_200201_utm50_gda94.ecw) and a poly dataset was created with the attributes as per the CALM Marine Conservation's Branch's attribute and naming standards. iii) First drafts of the maps were reviewed by each of the experts in March and April 2004 and modifications were incorporated where appropriate by Phil Kindleysides in March and April 2004

	under the instruction of Ray Lawrie and Belinda Cannell.
Positional Accuracy	Positional accuracy can be considered as medium due to the anecdotal nature of the supplied information. Each polygon's spatial extent is however a good representation of the information collected by Belinda Cannell with respect to the current understanding of whale activity in the area.
Attribute Accuracy	Attribute values are true to the data collected by Belinda Cannell.
Logical Consistency	Attribute values were quickly compared to the annotated collector sheets (maps supplied to experts), validated for consistency, and checked for logic in relation to attribute names. All attributes that require values have been assigned values.
Completeness	The dataset is complete as at the date of this metadata statement.
CONTACT INFORMATION	
Contact Organisation	Department of Conservation and Land Management, Marine Conservation Branch.
Contact Position	
Mail Address 1	47 Henry Street
Mail Address 2	
Suburb or Place or Locality	Fremantle
State or Locality 2	Western Australia
Country	Australia
Postcode	6160
Telephone	08 9336 0109
Facsimile	08 9430 5408
Electronic Mail Address	rayl@calm.wa.gov.au
METADATA DATE	
Metadata Date	09/07/2004
ADDITIONAL METADATA	
Additional Metadata	i) Bannister, J.L, Kemper, C. M. & Warneke, R. M. (1996). The Action Plan for Australian Cetaceans. Australian Nature Conservation Agency

Appendix V(c). Metadata for whales-blue_s_20040407_II_gda94.shp

DATASET whales-blue_s_20040407_ll_gda94.shp	
Title	Blue Whale and Pygmy Blue Whale (*Balaenoptera musculus* sp.) Migration Paths and activity in Perth metropolitan waters
Custodian	Department of Conservation and Land Management (CALM)
Jurisdiction	Western Australia
DESCRIPTION	
Abstract	This dataset consists oof polygons representing whale migration paths and other activity areas within the Perth metropolitan waters for Pygmy Blue Whales, *Balaenoptera musculus brevicauda*. The behavioural categories recorded include, where applicable, southerly and northerly migration, milling, possible birthing and nursing, foraging and traveling. The data were generated from **anecdotal information** provided by the experts and from reports and published information gathered during a literature review of whales in the region. References include: i) Jenner, C. & Jenner, M.-N. personal communication (2003) ii) Burton, C. personal communication (2003) iii) Coughran, D. personal communication (2003) iv) McCauley, R. personal communication (2004) v) (McCauley et al. 2003). This dataset can be used in conjunction with the other whale datasets created as part of the same data collection project performed by Belinda Cannell 2003-2004 for the MCB.
Search Word(s)	Pygmy, Blue Whales, Balaenoptera musculus, migration, milling, birthing, nursing, foraging, travelling
Geographic Extent	WA Coastal Waters adjacent to the Perth Metropolitan area (Yanchep to Mandurah). Central West Coast (CWC) IMCRA Region.
DATA CURRENCY	
Begin Date	1988
End Date	12/2003
DATASET STATUS	
Progress	Complete with respect to the collection exercise by Belinda Cannell
Maintenance & Update Frequency	Complete
ACCESS	
Stored Data Format	DIGITAL ArcView shapefile, geographical coordinates from Geocentric Datum of Australia 1994 (GDA94).
Available Format Type	DIGITAL ArcView 3.2 shapefile.
Access Constraint	Data available for external use. Information has been provided for better management of species. Please respect and acknowledge intellectual property. Contact CALM's database administrator for further details
DATA QUALITY	
Lineage	**MCB Processing 20040501 - PKI** Lines and polygons were created and attributed by the following methods: i) Blank hard copy maps were taken to each expert who, in turn, drew/annotated areas utilised by each species for the various behavioural categories (where known). Certainty and accuracy of the information was noted as research is limited to specific areas. Some whale movements are therefore surmised. Major contributions for Blue Whales were from C. and M. Jenner and D. Coughran, C. Burton and R. McCauley. ii) the paper base maps were then digitised by PKI in Arcview 3.2 over the hydro chart (Chart-a00334_200201_utm50_gda94.ecw) and a poly dataset was created with the attributes as per the

	CALM Marine Conservation's Branch's attribute and naming standards. iii) First drafts of the maps were reviewed by each of the experts in March and April 2004 and modifications were incorporated where appropriate by Phil Kindleysides in March and April 2004 under the instruction of Ray Lawrie and Belinda Cannell.
Positional Accuracy	Positional accuracy can be considered as medium due to the anecdotal nature of the supplied information. Each polygon's spatial extent is however a good representation of the information collected by Belinda Cannell with respect to the current understanding of whale activity in the area.
Attribute Accuracy	Attribute values are true to the data collected by Belinda Cannell.
Logical Consistency	Attribute values were quickly compared to the annotated collector sheets (maps supplied to experts), validated for consistency, and checked for logic in relation to attribute names. All attributes that require values have been assigned values.
Completeness	The dataset is complete as at the date of this metadata statement.
CONTACT INFORMATION	
Contact Organisation	Department of Conservation and Land Management, Marine Conservation Branch.
Contact Position	
Mail Address 1	47 Henry Street
Mail Address 2	
Suburb or Place or Locality	Fremantle
State or Locality 2	Western Australia
Country	Australia
Postcode	6160
Telephone	08 9336 0109
Facsimile	08 9430 5408
Electronic Mail Address	rayl@calm.wa.gov.au
METADATA DATE	
Metadata Date	09/07/2004
ADDITIONAL METADATA	
Additional Metadata	i) McCauley, R., J. Bannister, C. Burton, C. Jenner, S. Rennie, and C. van Etten. 2003. Western Australian Exercise Area Blue Whale Project Milestone 4. Page 37pp. Australian Defence, Perth ii) Bannister, J.L, Kemper, C. M. & Warneke, R. M. (1996). The Action Plan for Australian Cetaceans. Australian Nature Conservation Agency

Appendix V(d). Metadata for whales-minke_s_20040302_II_gda94.shp

DATASET whales-minke_s_20040302_ll_gda94.shp	
Title	Minke Whale (*Balaenoptera acutorostrata*) observations in Perth metropolitan waters
Custodian	Department of Conservation and Land Management (CALM)
Jurisdiction	Western Australia
DESCRIPTION	
Abstract	This dataset consists of polygons representing whale observations within the Perth metropolitan waters for Minke Whales *Balaenoptera acutorostrata*. The behavioral category recorded was milling. The data were generated from **anecdotal information** provided by the experts and from reports and published information gathered during a literature review of whales in the region. References include: i) Jenner, C. & Jenner, M.-N. personal communication (2003) ii) Coughran, D. personal communication (2003) This dataset can be used in conjunction with the other whale datasets created as part of the same data collection project performed by Belinda Cannell 2003-2004 for the MCB :
Search Word(s)	Minke Whale, Balaenoptera acutorostrata, milling
Geographic Extent	WA Coastal Waters adjacent to the Perth Metropolitan area (Yanchep to Mandurah). Central West Coast (CWC) IMCRA Region.
DATA CURRENCY	
Begin Date	1988
End Date	12/2003
DATASET STATUS	
Progress	Complete with respect to the collection exercise by Belinda Cannell
Maintenance & Update Frequency	Complete
ACCESS	
Stored Data Format	DIGITAL ArcView shapefile, geographical coordinates from Geocentric Datum of Australia 1994 (GDA94).
Available Format Type	DIGITAL ArcView 3.2 shapefile.
Access Constraint	Data available for external use subject to transfer fee and license conditions. Data is not to be distributed without authorisation from CALM. Contact CALM's database administrator for further details.
DATA QUALITY	
Lineage	**MCB Processing 20040501 - PKI** Lines and polygons were created and attributed by the following methods: i) Blank hard copy maps were taken to each expert who, in turn, drew/annotated areas utilised by each species for the various behavioural categories (where known). Certainty and accuracy of the information was noted as research is limited to specific areas. Some whale movements are therefore surmised. Major contributions for Minkes were from C. and M. Jenner and D. Coughran who also suggest that Minkes hard to sight + low research effort/interest. ii) the paper base maps were then digitised by PKI in Arcview 3.2 over the hydro chart (Chart-a00334_200201_utm50_gda94.ecw) and a poly dataset was created with the attributes as per the CALM Marine Conservation's Branch's attribute and naming standards. iii) First drafts of the maps were reviewed by each of the experts in March and April 2004 and modifications were incorporated where appropriate by Phil Kindleysides in March and April 2004 under the instruction of Ray Lawrie and Belinda Cannell.

Positional Accuracy	Positional accuracy can be considered as medium due to the anecdotal nature of the supplied information. Each polygon's spatial extent is however a good representation of the information collected by Belinda Cannell with respect to the current understanding of whale activity in the area.
Attribute Accuracy	Attribute values are true to the data collected by Belinda Cannell.
Logical Consistency	Attribute values were quickly compared to the annotated collector sheets (maps supplied to experts), validated for consistency, and checked for logic in relation to attribute names. All attributes that require values have been assigned values.
Completeness	The dataset is complete as at the date of this metadata statement.
CONTACT INFORMATION	
Contact Organisation	Department of Conservation and Land Management, Marine Conservation Branch.
Contact Position	
Mail Address 1	47 Henry Street
Mail Address 2	
Suburb or Place or Locality	Fremantle
State or Locality 2	Western Australia
Country	Australia
Postcode	6160
Telephone	08 9336 0109
Facsimile	08 9430 5408
Electronic Mail Address	rayl@calm.wa.gov.au
METADATA DATE	
Metadata Date	09/07/2004
ADDITIONAL METADATA	
Additional Metadata	i) Bannister, J.L, Kemper, C. M. & Warneke, R. M. (1996). The Action Plan for Australian Cetaceans. Australian Nature Conservation Agency

Appendix V(e). Metadata for dolphins-survey-bd_s_20031201_II_gda94.shp

DATASET dolphins-survey-bd_s_20031201_II_gda94.shp	
Title	Observations of Predominant Behaviour of Bottlenose Dolphins (*Tursiops* sp.) in Cockburn Sound
Custodian	Department of Conservation and Land Management (CALM)
Jurisdiction	Western Australia
DESCRIPTION	
Abstract	This point dataset consists of Dolphin group observations recorded by GPS coordinates, point in time, group makeup and predominant group activity. All observations took place in the Perth Metropolitan area, specifically Cockburn Sound between 1993 and 1999 with 4 records in 2001 and 2002. The observations from 1993-1997were recorded by Bec Donaldson as part of her PhD in the School of Veterinary and Biomedical Studies at Murdoch University. Additional observations after 1997 were made whenever possible. Descriptor categories are : Feeding, Foraging (animals searching for food, no actual feeding observed), socialising, resting and travelling. See the Lineage or Additional Metadata sections below for the rest of the field descriptions. References include: Donaldson, R. (Pers. Comm.2003)
Search Word(s)	: Dolphin, Cockburn Sound, Feeding, Foraging, Socialising, Resting, Travelling, GPS, Bec Donaldson
Geographic Extent Name(s)	WA Coastal Waters adjacent to the Perth Metropolitan area (Warnbro Sound and Comet Bay), Central West Coast (CWC) IMCRA meso-scale biroregion.
DATA CURRENCY	
Begin Date	19930420
End Date	20021213
DATASET STATUS	
Progress	In progress
Maintenance & Update Frequency	As required
ACCESS	
Stored Data Format	DIGITAL ArcView shapefile, geographical coordinates from Geocentric Datum of Australia 1994 (GDA94).
Available Format Type	DIGITAL ArcView 3.2 shapefile.
Access Constraint	Data available for use within CALM. Data not to be distributed outside CALM without permission from R. Donaldson. Publication of this information requires approval from R. Donaldson.
DATA QUALITY	
Lineage	**Supplier Processing 200311** 1. Bec Donaldson was consulted in November 2003 to delineate areas of dolphin activity on hard copy base maps. 2. She then supplied a spreadsheet of all her observations of dolphins in Cockburn Sound directly to the Marine Conservation Branch. Her observations were recorded from 1993-1999 with four records in 2001 and 2002. This research was undertaken from 1993-1997as a PhD project in the School of Veterinary and Biomedical Studies at Murdoch University Veterinary School at Murdoch University. Observations after 1997 were made whenever possible. **MCB Processing 20031201 - SWI** 1. Original spreadsheet supplied by Bec Donaldson 200311 and after a slight reformatting renamed to dolphin-bd_metro_20031201_ll_gda94.xls. The spreadsheet contains all the information contained in the dataset. 2. Coordinates supplied were converted to decimal degrees and the spreadsheet was exported and added as an event theme. **MCB Processing 20040628 - PKI** 3. Field headings were renamed to keep them to 8 characters for Av3.2. The MCB attribute model was applied i.e. Descriptor, Source_a and Source_plp. A string date field was created from the concatenation of the original DAY, MONTH and YEAR fields. The remainder of the field name

	changes are as follows (**NEW=OLD** Donaldson's Description): **RLTNSHP = Complete Group Membership.** Note: numbers after names of all adult females indicate that female's current repro state: 0=calf under 2months, 1=calf 2mo-1yr, 2=1-2yr, 3=2-3yr, 4=over 3yr, 5=known pregnant, 35 and 45 are calf and preg, 6=no calf, unknown if preg (ie no calf seen within a yr after this, tho could have died after birth before being recorded, or else didnt follow that fem for another yr to see if had calf or not) and 7=unknown if has calf or not, and unknown if preg, ie if didnt see if calf was weaned or not yet, ie for northern fems. Where animals are not ID'd, the sex or age class is listed, e.g. apart from animal names, the other strings in this cell include mum-calf mum-calf? female female? male male? adult adult? subadult subadult? non-calf non-calf? subfemale subfemale? submale submale? female/subfemale female/subfemale? male/submale male/submale? female/subadult female/subadult? female/submale female/submale? **CALVES = Complete Group Size (including calves),** subtracting NON_CALVES **NON_CALVES = Group Size (non-calves only)** **AGE/SEX = Age/Sex categories.** This is the list of age and sex classes present in each survey. The categories are: male (adult); female (ie adult but without calf); adult (ie sex unknown); mum-calf (adult fem with calf); subadult (unknown sex); submale (subadult male); subfemale; non-calf (age/sex class not known) **AFNC = adult female without calf** (1=at least 1 present in the group, 0=none present) **AM = adult male** (1=at least 1 present in the group, 0=none present) **MC = mum-calf** (1=at least 1 present in the group, 0=none present) **SF = subadult female** (1=at least 1 present in the group, 0=none present) **SM = subadult male** (1=at least 1 present in the group, 0=none present) **AUS = adult or unknown sex** (1=at least 1 present in the group, 0=none present) **SUS = subadult of unknown sex** (1=at least 1 present in the group, 0=none present) **NCUAS = non-calf individual of unknown age/sex** (1=at least 1 present in the group, 0=none present) **DESCRIPTOR = Predominant Group Behaviour.** i.e. the behaviour of 50% or more of the group. Categories are: fd=Feed (actual feeding observed); for=Forage (animals searching for food, no actual feeding observed); soc=Socialising, either affiliative or aggressive; rest=Rest; travel=Travel. **SURF_TEMP = Surface Water Temp**
Positional Accuracy	Positional accuracy is dependent on the accuracy of the coordinates in the original spreadsheet. GPS coordinates are assumed to be WGS84 and to be accurate.
Attribute Accuracy	Attribute values are true to the data presented in the original spreadsheet supplied by Bec Donaldson. Only the column headings were renamed due to technical constraints.
Logical Consistency	Attribute values were quickly compared to the spreadsheet, validated for consistency, and checked for logic in relation to attribute names. All attributes that require values have been assigned values.
Completeness	The dataset is complete as at the date of this metadata statement.
CONTACT INFORMATION	
Contact Organisation	Department of Conservation and Land Management, Marine Conservation Branch.
Contact Position	Marine GIS Co-ordinator
Mail Address 1	47 Henry Street
Mail Address 2	
Suburb or Place or Locality	Fremantle
State or Locality 2	Western Australia
Country	Australia

Postcode	6160
Telephone	08 9336 0109
Facsimile	08 9430 5408
Electronic Mail Address	rayl@calm.wa.gov.au
METADATA DATE	
Metadata Date	20040705
ADDITIONAL METADATA	
Additional Metadata	Donaldson, R (in prep) Ecology and Social Behaviour of Bottlenose Dolphins in Cockburn Sound, Western Australia. (provisional title) PhD Thesis The original spreadsheet supplied by R. Donaldson : dolphin-bd_metro_20031201_ll_gda94.xls

Appendix V(f). Metadata for dolphins-survey-hf_s_20031201_II_gda94.shp

DATASET dolphins-survey-hf_s_20031201_ll_gda94.shp	
Title	Use of major habitat types by Bottlenose Dolphins (*Tursiops* sp.) in Cockburn Sound: A study by Hugh Finn
Custodian	Department of Conservation and Land Management (CALM)
Jurisdiction	Western Australia
DESCRIPTION	
Abstract	This dataset consists of points representing known GPS locations and behaviour of dolphins within Cockburn Sound from 02/06/2000 – 16/04/2001. The data were generated by Hugh Finn as part of a PhD project through Murdoch University. The dataset contains the following fields : Descriptor (behaviour), Date/Time, transect number, and coordinates. References include: i) Finn, H. pers. comm. ii) Finn, H. (in prep) Conservation Biology of Bottlenose Dolphins (*Tursiops* sp) in Perth Metropolitan Waters. PhD thesis, Murdoch University This dataset is to be used in conjunction with the transect dataset that contains the transects used in the dataset and the above study. See the Additional Metadata section for the location of the original spreadsheet.
Search Word(s)	Foraging, travelling, resting, socialising, dolphins, GPS, Cockburn Sound, Hugh Finn
Geographic Extent	WA Coastal Waters adjacent to the Perth Metropolitan area (Cockburn Sound). Central West Coast (CWC) IMCRA Region.
DATA CURRENCY	
Begin Date	02/06/2000
End Date	16/04/2001
DATASET STATUS	
Progress	Complete with respect to the study by Hugh Finn
Maintenance & Update Frequency	Complete
ACCESS	
Stored Data Format	DIGITAL ArcView shapefile, geographical coordinates from Geocentric Datum of Australia 1994 (GDA94).
Available Format Type	DIGITAL ArcView 3.2 shapefile.
Access Constraint	Data available for use within CALM. Data not to be distributed outside CALM without permission from H. Finn. Publication of this information requires approval from H. Finn.
DATA QUALITY	
Lineage	All the surveyed data was supplied by Hugh Finn (0417 974 138), in a spreadsheet format. **Collection Methodology - Hugh Finn** The surveys of dolphins in Cockburn Sound were conducted following a systematic spatial sampling protocol for the entire study area. The study area was divided into four habitat blocks. Within each block at least two transect areas were chosen, representing discrete habitat types within the block. The transect areas were 400 m wide and varied in length from 4.6 km to 10.5 km in length. The choice of transect to be sampled on any given day, and the direction followed, was randomly chosen. Sampling was only performed when the sea conditions were equivalent of a Beaufort sea state scale of 2 or less (i.e. small wavelets and wind speeds of less than 8 knots). For each transect sampled, a boat was driven down the centre of the transect with one or two observers on board. When a dolphin was observed the location on the transect was noted, the boat was then driven to the position of the dolphin, behavioural analysis was conducted with respect to group size and

	predominant group activity and the GPS location was obtained. Once this was completed, the boat was driven back to the position of departure along the transect line and the transect survey was continued. Up to 4 transects were sampled on any given day. (Methodology from Finn (in prep). Conservation Biology of Bottlenose Dolphins (Tursiops sp) in Perth Metropolitan Waters. PhD thesis) **MCB Processing 20031201 - SWI** Spreadsheet was prepared by converting the coordinates to decimal degrees and saved as a text file and table imported into ArcView. The points were then plotted as an event theme. The MCB attribute structure and naming convention was applied. The points were overlaid on the transect dataset described above and hard copy maps were created. The maps and hence the data were reviewed by Ray Lawrie, Hugh Finn and SWI in 200404.
Positional Accuracy	Positional accuracy is dependent on the accuracy of the coordinates in the original spreadsheet. GPS coordinates are assumed to be WGS84 and to be accurate.
Attribute Accuracy	Attribute values are true to the data presented in the original spreadsheet supplied by Hugh Finn.
Logical Consistency	Attribute values were quickly compared to the spreadsheet, validated for consistency, and checked for logic in relation to attribute names. All attributes that require values have been assigned values.
Completeness	The dataset is complete as at the date of this metadata statement.
CONTACT INFORMATION	
Contact Organisation	Department of Conservation and Land Management, Marine Conservation Branch.
Contact Position	
Mail Address 1	47 Henry Street
Mail Address 2	
Suburb or Place or Locality	Fremantle
State or Locality 2	Western Australia
Country	Australia
Postcode	6160
Telephone	08 9336 0109
Facsimile	08 9430 5408
Electronic Mail Address	rayl@calm.wa.gov.au
METADATA DATE	
Metadata Date	28/06/2004
ADDITIONAL METADATA	
Additional Metadata	Please see the currently unfinished report cited in the abstract above and the original dataset from Hugh Finn - dolphin-point_sis_20031201_ll_gda94.xls

Appendix V(g). Metadata for dolphins-survey-transect-hf_s_20031201_II_gda94.shp

DATASET dolphins-survey-transect-hf_s_20031201_ll_gda94.shp	
Title	Transect lines used in the Dolphin study in Cockburn Sound by Hugh Finn 2000-2001
Custodian	Department of Conservation and Land Management (CALM)
Jurisdiction	Western Australia
DESCRIPTION	
Abstract	This polyline dataset contains the transect lines used by Hugh Finn to collect GPS locations and behaviour observations of dolphins within Cockburn Sound from 02/06/2000 – 16/04/2001. The data were generated by Hugh Finn as part of a Ph.D. project through Murdoch University. Contains the fields : Transect Name (Descriptor), Transect number, Source_a and Source_plp. This dataset is to be used in conjunction with the point dataset that contains the observations described above. See the Additional Metadata section for the location of the original spreadsheet.
Search Word(s)	Dolphin, Transect, GPS, Cockburn Sound, Hugh Finn
Geographic Extent Name(s) or Geographic Extent Polygon(s)	WA Coastal Waters adjacent to the Perth Metropolitan area (Cockburn Sound). Central West Coast (CWC) IMCRA Region.
DATA CURRENCY	
Begin Date	02/06/2000
End Date	02/06/2000
DATASET STATUS	
Progress	Complete
Maintenance & Update Frequency	Complete
ACCESS	
Stored Data Format	DIGITAL ArcView shapefile, geographical coordinates from Geocentric Datum of Australia 1994 (GDA94).
Available Format Type	DIGITAL ArcView 3.2 shapefile.
Access Constraint	Data available for use within CALM. Data not to be distributed outside CALM without permission from H. Finn. Publication of this information requires approval from H. Finn.
DATA QUALITY	
Lineage	All the surveyed data was supplied by Hugh Finn (0417 974 138), in a spreadsheet format. The surveys of dolphins in Cockburn Sound were conducted following a systematic spatial sampling protocol for the entire study area. The study area was divided into four habitat blocks. Within each block at least two transect areas were chosen, representing discrete habitat types within the block. The transect areas were 400 m wide and varied in length from 4.6 km to 10.5 km in length. **MCB Processing 20031201 - SWI** Spreadsheet was prepared and saved as a text file and table imported into ArcView. The points were then plotted as an add event theme.Spreadsheet was separated per transect numbers and saved as a text file and each transect table imported into ArcView. The points were then plotted separately (each transect) as an add event theme. Using Xtools (make one polyline from points) the points were joined to form the transect lines. Once all transect lines plotted as lines the datasets were then merged using Arcview3.2's geoprocessing wizard. **MCB Processing 20031201 - PKI** 1. MCB attribute structure applied and original spreadsheet renamed to match that of the dataset.
Positional	Positional accuracy is dependent on the accuracy of the coordinates in the original spreadsheet. GPS

Accuracy	coordinates are assumed to be WGS84 and to be accurate.
Attribute Accuracy	Attribute values are true to the data presented in the original spreadsheet supplied by Hugh Finn.
Logical Consistency	Attribute values were quickly compared to the spreadsheet, validated for consistency, and checked for logic in relation to attribute names. All attributes that require values have been assigned values.
Completeness	The dataset is complete as at the date of this metadata statement.
CONTACT INFORMATION	
Contact Organisation	Department of Conservation and Land Management, Marine Conservation Branch.
Contact Position	
Mail Address 1	47 Henry Street
Mail Address 2	
Suburb or Place or Locality	Fremantle
State or Locality 2	Western Australia
Country	Australia
Postcode	6160
Telephone	08 9336 0109
Facsimile	08 9430 5408
Electronic Mail Address	rayl@calm.wa.gov.au
METADATA DATE	
Metadata Date	28/06/2004
ADDITIONAL METADATA	
Additional Metadata	Data contained in spreadsheet supplied by Hugh Finn 200311. The tabs marked as SWI contain the post processing of coordinates undertaken by Stephen Widjaja : dolphin-transect_sis_20031201_ll_gda94.xls

Appendix V(h). Metadata for dolphins-survey-hf_s_20030704_II_gda94.shp

DATASET dolphins-survey-hf_s_20030704_ll_gda94	
Title	Bottlenose Dolphins (*Tursiops* sp.) in the Swan Estuary: A study by Hugh Finn
Custodian	Department of Conservation and Land Management (CALM)
Jurisdiction	Western Australia
DESCRIPTION	
Abstract	This dataset consists of GPS locations of Bottlenose Dolphins in the Swan River Estuary. The data were generated from information provided by experts. References include: i) Finn, H. (pers. comm.) The dataset contains the following fields : Descriptor (behaviour), Date/Time, location, nearest landmark, id's present, depth, feeding activity and the presence of tail slapping and boat begging.
Search Word(s)	foraging, feeding, resting, travelling, socialising, dolphins, GPS, Hugh Finn, Swan River
Geographic Extent	WA Coastal Waters adjacent to the Perth Metropolitan area. Central West Coast (CWC) IMCRA Region.
DATA CURRENCY	
Begin Date	27/10/2001
End Date	23/06/2003
DATASET STATUS	
Progress	Complete with respect to the availability of data from Hugh Finn.
Maintenance & Update Frequency	When and if required
ACCESS	
Stored Data Format	DIGITAL ArcView shapefile, geographical coordinates from Geocentric Datum of Australia 1994 (GDA94).
Available Format Type	DIGITAL ArcView 3.2 shapefile.
Access Constraint	Data available for use within CALM. Data not to be distributed outside CALM without permission from H. Finn. Publication of this information requires approval from H. Finn.
DATA QUALITY	
Lineage	All the surveyed data was supplied by Hugh Finn (0417 974 138), in a spreadsheet format. **Collection Methodology - Hugh Finn** A pilot study was conducted in November and December 2001 From February 2002 - June 2003, the Swan River was surveyed on 192 days. The surveys occurred at least weekly, but often they were performed on several days within a week. The surveys were conducted in several habitat blocks: 1) Port Blackwall Reach 2) Mosman Bay and Freshwater Bay 3) Melville Waters: Lucky Bay - South of Perth YC 4) Milyu 5) Matilida Bay 6) Meville Waters: pelican Point and Perth Flying Squadron Many of the survey days did not sample all habitat blocks as the sampling protocol was to stop the survey route if an appropriate focal animal was located (~50 focal follows over the study) or if sighting conditions were poor. The sampling effort was uneven across habitat blocks and was highest in the lower reaches of the Swan River. The majority of sampling occurred in the morning, particularly during summer (due to the sea breeze) **MCB Processing 20040706 - PKI**

	1) Spreadsheet was prepared by massaging the supplied coordinates and creating a table (dbIV) for importing into ArcView. The massaged worksheet was saved in the supplied spreadsheet along with the raw data and renamed to match the dataset's name. 2) The points were then plotted as an event theme and converted to a shapefile. 3) The MCB attribute structure and naming convention was applied in addition to the tidying up of several field names etc.
Positional Accuracy	Positional accuracy is dependent on the accuracy of the coordinates in the original spreadsheet. GPS coordinates are assumed to be WGS84 and to be accurate.
Attribute Accuracy	Attribute values are true to the data presented in the original spreadsheet supplied by Hugh Finn.
Logical Consistency	Attribute values were quickly compared to the spreadsheet, validated for consistency, and checked for logic in relation to attribute names. All attributes that require values have been assigned values.
Completeness	The dataset is complete as at the date of this metadata statement.
CONTACT INFORMATION	
Contact Organisation	Department of Conservation and Land Management, Marine Conservation Branch.
Contact Position	
Mail Address 1	47 Henry Street
Mail Address 2	
Suburb or Place or Locality	Fremantle
State or Locality 2	Western Australia
Country	Australia
Postcode	6160
Telephone	08 9336 0109
Facsimile	08 9430 5408
Electronic Mail Address	rayl@calm.wa.gov.au
METADATA DATE	
Metadata Date	06/07/2004
ADDITIONAL METADATA	
Additional Metadata	The original spreadsheet supplied by Hugh Finn. dolphin-point_metro_20030704_ll_gda94.xls

Appendix V(i). Metadata for dolphinpods-survey-kw_s_1997_II_gda94.shp

DATASET dolphinpods-survey-kw_s_1997_ll_gda94.shp	
Title	Bottlenose Dolphin GPS locations between Fremantle and Yanchep during March 91 - June 93
Custodian	Department of Conservation and Land Management (CALM)
Jurisdiction	Western Australia
DESCRIPTION	
Abstract	This dataset consists of dot points representing locations of either single dolphins or groups of dolphins from March 1991- June 1993. **This dataset only contains the spatial positions of each sighting.** The original data provides baseline information on distribution of wild bottlenose dolphins on the coast between Fremantle and Yanchep. GPS coords were taken at the location of the sighting as well as information on group size, composition and behaviour of the dolphins. See Waples, K. 1997 The rehabilitation and release of bottlenose dolphins from Atlantis Marine Park Western Australia.
Search Word(s)	dolphin, GPS, Waples, K., survey
Geographic Extent	WA Coastal Waters adjacent to the Perth Metropolitan area. Central West Coast (CWC) IMCRA Region.
DATA CURRENCY	
Begin Date	18/03/1991
End Date	22/06/1993
DATASET STATUS	
Progress	Complete
Maintenance & Update Frequency	Complete
ACCESS	
Stored Data Format	DIGITAL ArcView shapefile, geographical coordinates from Geocentric Datum of Australia 1994 (GDA94).
Available Format Type	DIGITAL ArcView 3.2 shapefile.
Access Constraint	Data is not to be distributed without authorisation from CALM. Contact CALM's database administrator for further details
DATA QUALITY	
Lineage	**MCB PROCESSING : 200406 PKI** 1. Hardcopy map (pg 95), from Waples, K. 1997 The rehabilitation and release of bottlenose dolphins from Atlantis Marine Park Western Australia, supplied by Belinda Cannell was used to delineate areas utilized by wild bottlenose dolphins between Fremantle and Yanchep. Map showed "all recorded group sightings" for Dolphin locations recorded via GPS. 2. As there was no other spatial information ie no coordinates for each point, the points were "eyeballed" in over the hydro chart (Chart-a00334_200201_utm50_gda94.ecw). This process was complicated by the generalised nature of the coastline in the hardcopy map. Measurements were taken off the supplied map using common reference points in order to better locate several of the points. 3. The points were checked by comparing the visual pattern on the hardcopy map and on screen as well as ensuring that there were the same number of records. 4. The MCB preferred attribute structure was applied. The hardcopy map didn't supply any other aspatial information.
Positional Accuracy	Positional accuracy can be considered as low. The hardcopy map supplied the only spatial information and the coastline it contained was highly generalised. In order to locate the points on the base map (hydro chart), measurements were taken off the supplied map using common reference points.
Attribute Accuracy	Attribute values are true to the data presented in the hardcopy map provided by K. Waples via Belinda Cannell.

Logical Consistency	All attributes that require values have been assigned values.
Completeness	The dataset is complete at the date of this metadata statement.
CONTACT INFORMATION	
Contact Organisation	Department of Conservation and Land Management, Marine Conservation Branch.
Contact Position	
Mail Address 1	47 Henry Street
Mail Address 2	
Suburb or Place or Locality	Fremantle
State or Locality 2	Western Australia
Country	Australia
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Telephone	08 9336 0109
Facsimile	08 9430 5408
Electronic Mail Address	rayl@calm.wa.gov.au
METADATA DATE	
Metadata Date	06/07/2004
ADDITIONAL METADATA	
Additional Metadata	Waples, K. (1997) The rehabilitation and release of bottlenose dolphins from Atlantis Marine Park Western Australia. Dissertation Texas A & M University

Appendix V(j). Metadata for sealions_s_20040531_II_gda94.shp

DATASET sealions_s_20040531_ll_gda94.shp	
Title	Sea lions (*Neophoca cinerea*) in Perth Metropolitan Coastal Waters
Custodian	Department of Conservation and Land Management (CALM)
Jurisdiction	Western Australia
DESCRIPTION	
Abstract	This dataset consists of polygons representing the areas of seal lion haul out sites in the Metropolitan area. Included in the attribute structure is a descriptor (site type), site name e.g. Dyer Island, relative location information (Rltnshp) e.g. northern beach, comments and site fidelity. The data was generated from anecdotal information provided by experts, and from published information gathered during a literature review of sea lions in the region. References include: i) Campbell, R. (pers. comm. 2004.) ii) Orsini, J-P. (pers. comm. 2004.) iii) Edwards,J (pers. comm. 2004.) iv) Gales et al. 1992
Search Word(s)	Sea Lion, Neophoca cinerea, haulout, metropolitan
Geographic Extent	WA Coastal Waters adjacent to the Perth Metropolitan area (Yanchep to Mandurah). Central West Coast (CWC) IMCRA Region.
DATA CURRENCY	
Begin Date	12/2003
End Date	12/2003
DATASET STATUS	
Progress	Complete with respect to the collection exercise by Belinda Cannell
Maintenance & Update Frequency	Complete
ACCESS	
Stored Data Format	DIGITAL ArcView shapefile, geographical coordinates from Geocentric Datum of Australia 1994 (GDA94).
Available Format Type	DIGITAL ArcView 3.2 shapefile.
Access Constraint	Data available for external use subject to transfer fee and license conditions. Data is not to be distributed without authorisation from CALM. Contact CALM's database administrator for further details.
DATA QUALITY	
Lineage	**MCB Processing 200405 : PKI** i) Relevant experts were consulted to determine Sea Lion haulout areas. Blank hard copy maps were taken to John Edwards and Richard Campbell who, in turn, drew/annotated areas utilised by sealions (where known). ii) the paper base maps were then digitised by PKI in Arcview 3.2 over the ortho (Airphoto-orthorectified_mar+sis+sie_200208_utm50_gda94.ecw) and a poly dataset was created with the attributes as per the CALM Marine Conservation's Branch's attribute and naming standards. iii) The polygons and attributes were checked and edited on screen by PKI under the direction of John Edwards 20040531. A 10m buffer was created around the DLI coastline 20010228 in the areas of Warnbro Sound that JED pointed out. The areas around MMP were digitised on screen and clipped using the HWM polygon created from the same coastline. iv) MCB attribute and naming conventions were applied.
Positional Accuracy	Positional accuracy can be considered as medium due to the anecdotal nature of the supplied information. Each polygon's spatial extent is however a good representation of the information collected by Belinda Cannell and further reiterated by John Edwards.
Attribute Accuracy	Attribute values are true to the data collected by Belinda Cannell.

Logical Consistency	Attribute values were quickly compared to the annotated collector sheets (maps supplied to experts), validated for consistency, and checked for logic in relation to attribute names. All attributes that require values have been assigned values.
Completeness	The dataset is complete as at the date of this metadata statement.
CONTACT INFORMATION	
Contact Organisation	Department of Conservation and Land Management, Marine Conservation Branch.
Contact Position	
Mail Address 1	47 Henry Street
Mail Address 2	
Suburb or Place or Locality	Fremantle
State or Locality 2	Western Australia
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Postcode	6160
Telephone	08 9336 0109
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Electronic Mail Address	rayl@calm.wa.gov.au
METADATA DATE	
Metadata Date	12/07/2004
ADDITIONAL METADATA	
Additional Metadata	1. Gales, N., J., A. Cheal, J., G. Pobar, J., and P. Williamson. 1992. Breeding biology and movements of Australian sea-lions, *Neophoca cinerea*, off the west coast of Western Australia. Wildlife Research 19:405-416.

Appendix V(k). Metadata for birds-penguin_s_20040420_II_gda94.shp

DATASET birds-penguin_s_20040420_ll_gda94	
Title	Little Penguin (*Eudyptula minor*) breeding, foraging and travelling areas in the Perth metropolitan area between Yanchep and Mandurah.
Custodian	Department of Conservation and Land Management (CALM)
Jurisdiction	Western Australia
DESCRIPTION	
Abstract	This dataset consists of: 1. Polygons for known breeding areas of Little Penguins in coastal waters between Yanchep and Mandurah, namely on Penguin, Carnac and Garden Islands. 2. Polygons within Cockburn Sound representing sightings of Little Penguins during the day between Sept 2000 and March 2001. From daily activity budgets of Little Penguins it can be inferred that they were either foraging, travelling or resting in this area. The data were generated from anecdotal information provided by experts, from published literature and from maps contained within unpublished and published reports. References include: i) Bradley *et al.* 1997 ii) Cannell 2004. iii) Cannell, B. pers. comm. iv) Dunlop & Storr 1981 v) Watterson 2001 vi) Wooller *et al.* in review The dataset contains the following fields : Descriptor (tracking type), Date/Time, Source_a of attribute and Source_plp. The data were generated from anecdotal information provided by experts and from maps contained within unpublished reports.
Search Word(s)	Radio Tracking, Little Penguins, breeding, foraging, travelling
Geographic Extent	WA Coastal Waters adjacent to the Perth Metropolitan area, Yanchep to Mandurah. Central West Coast (CWC) IMCRA Region.
DATA CURRENCY	
Begin Date	Penguin Island breeding area: 1982 Garden Island breeding area: May 2001 Cockburn Sound: Sept 2000
End Date	Penguin Island breeding area:- ongoing Garden Island breeding area: Feb 2004 Cockburn Sound: March 2001
DATASET STATUS	
Progress	Complete with respect to the availability of data from Belinda Cannell as at 08/07/2004.
Maintenance & Update Frequency	When and if required.
ACCESS	
Stored Data Format	DIGITAL ArcView shapefile, geographical coordinates from Geocentric Datum of Australia 1994 (GDA94).
Available Format Type	DIGITAL ArcView 3.2 shapefile.
Access Constraint	Data for Little Penguin breeding areas on Garden Island are available for use within CALM. Data not to be distributed outside CALM without permission from B. Cannell. Publication of this information requires approval from B. Cannell. Contact CALM's database administrator for further details.
DATA QUALITY	
Lineage	**MCB Processing : 200406 PKI** Polygons were created and attributed by the following methods: Little Penguin breeding areas on Islands and presence in Cockburn Sound

	i) Relevant experts/papers were consulted to delineate areas of Little Penguin breeding directly on screen. Digitising was undertaken over the ortho image (Airphoto-orthorectified_mar+sis+sie_200208_utm50_gda94.ecw) at a large-scale under the direction of Belinda Cannell and Dunlop, J. N., and G. M. Storr. 1981a. SEABIRD ISLANDS. No.111. Carnac Island, Western Australia. Corella 5:71-74. ii) Relevant experts/papers were consulted to delineate the area utilized by the penguins in Cockburn Sound. iii) The polygons were attributed as per the MCB preferred structure. iv) The maps were checked for consistency by Belinda Cannell (relevant expert for Little Penguins) in June 2004 and relevant changes were made by Phil Kindleysides in 200406.
Positional Accuracy	Positional accuracy can be considered as medium due to the anecdotal nature and currency (Carnac Island) of the supplied information. Each polygon's spatial extent is however a good representation of the information collected by Belinda Cannell.
Attribute Accuracy	Attribute values are true to the data supplied and collected by Belinda Cannell.
Logical Consistency	All attributes that require values have been assigned values.
Completeness	The dataset is complete as at the date of this metadata statement.
CONTACT INFORMATION	
Contact Organisation	Department of Conservation and Land Management, Marine Conservation Branch.
Contact Position	
Mail Address 1	47 Henry Street
Mail Address 2	
Suburb or Place or Locality	Fremantle
State or Locality 2	Western Australia
Country	Australia
Postcode	6160
Telephone	08 9336 0109
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Electronic Mail Address	rayl@calm.wa.gov.au
METADATA DATE	
Metadata Date	09/07/2004
ADDITIONAL METADATA	
Additional Metadata	Bradley, J. S., B. Cannell, and R. D. Wooller. 1997. A radio-tracking study of the movements at sea and diet of Little Penguins Eudyptula minor. Report by Murdoch University, Perth, Western Australia for Bowman Bishop Gorham, Perth, Western Australia. Cannell, B. 2001. Status of little penguins in Western Australia: A management review. Department of Conservation and Land Management, Perth, Western Australia. Cannell, B. L. 2004 Little Penguins, Eudyptula minor, on Garden Island 2001 – 2003: A final report on their ecology and recommendations for management. Report for the Royal Australian Navy Connard, M. N. 1995. Patterns of foraging by Little Penguins Eudyptula minor from Penguin Island, Western Australia. Biological Sciences. Murdoch University, Perth, Western Australia. Dunlop, J. N., and G. M. Storr. 1981a. SEABIRD ISLANDS. No.111. Carnac Island, Western Australia. Corella 5:71-74. Dunlop, J. N., N. I. Klomp, and R. D. Wooller. 1988. Penguin Island, Shoalwater Bay, Western Australia. Corella 188:93-98. Klomp, N. I. 1987. The breeding biology and diet of the Little Penguin *Eudyptula minor* (Forster) on Penguin Island, Western Australia. Biology. Murdoch University, Perth. Klomp, N. I., and R. D. Wooller. 1988. Diet of little penguins *Eudyptula minor* from Penguin Island

Western Australia. Australian Journal of Marine & Freshwater Research 39:633-640.

Klomp, N. I., Meatheral, C. E., Wienecke, B. C and Wooller, R.D. 1991. Surface nesting by Little Penguins on Penguin Island, Western Australia. Emu 91:190-193.

Watterson, P.J. 2001. Distribution and foraging ecology of seabirds and dolphins in Cockburn Sound, and implications for environmental management. Biological Sciences. Murdoch University, Perth.

Wienecke, B. C. 1989. The breeding patterns of Little Penguins on Penguin Island, Western Australia, in relation to dietary and oceanographic factors. Biological Sciences. Murdoch, Perth, Western Australia.

Wienecke, B. C. 1993. The size and breeding patterns of Little Penguins *Eudyptula minor* in Australia: a comparative study. Biological Sciences. Murdoch, Perth, Western Australia.

Wooller, R. D., J. N. Dunlop, N. I. Klomp, C. E. Meathrel, and B. C. Wienecke. 1991. Seabird abundance, distribution and breeding patterns in relation to the Leeuwin Current. Journal of the Royal Society of Western Australia 74:129-132.

Wooller, R. D., Cannell, B. L., Bradley, J. S., Valesini, F. J., Lenanton, R.C. J., and Connard, M. in review. Do the needs of little penguins at sea limit their breeding sites.

Appendix V(l). Metadata for birds-penguin_s_20031203_II_gda94.shp

DATASET birds-penguin_s_20031203_ll_gda94	
Title	Little Penguin (*Eudyptula minor*) foraging and travelling areas in Warnbro Sound and Comet Bay.
Custodian	Department of Conservation and Land Management (CALM)
Jurisdiction	Western Australia
DESCRIPTION	
Abstract	This dataset consists of points representing the daytime distribution of Little Penguins in Warnbro Sound and Comet Bay as observed during radio tracking (from air and land) surveys conducted within the metro area on the following dates: November 1996 (air and land), April 1997 (air and land), June 1997 (land), August 1997 (land), and November 1997 (land). The dataset contains the following fields : Descriptor (tracking type), Date/Time, Source_a of attribute and Source_plp. The data were generated from anecdotal information provided by experts and from maps contained within unpublished reports. References include: i) Bradley, J. S., Cannell, B. L. and Wooller, R. D. 1997. A radio-tracking study of the movements at sea and diet of Little Penguin *Eudyptula minor* breeding on Penguin Island, Western Australia. Final report by Murdoch University, Perth, Western Australia for Bowman Bishaw Gorham.
Search Word(s)	Radio Tracking, Little Penguins, foraging, travelling
Geographic Extent	WA Coastal Waters adjacent to the Perth Metropolitan area. Central West Coast (CWC) IMCRA Region.
DATA CURRENCY	
Begin Date	11/1996
End Date	11/97
DATASET STATUS	
Progress	Complete with respect to the availability of data from Belinda Cannell.
Maintenance & Update Frequency	When and if required
ACCESS	
Stored Data Format	DIGITAL ArcView shapefile, geographical coordinates from Geocentric Datum of Australia 1994 (GDA94).
Available Format Type	DIGITAL ArcView 3.2 shapefile.
Access Constraint	Data are available for use within CALM. Data not to be distributed outside CALM without permission from Wooller, Cannell and Bradley. Publication of this information requires approval from Wooller, Cannell and Bradley. Contact CALM's database administrator for further details
DATA QUALITY	
Lineage	Points were created and attributed by the following methods: Belinda Cannell supplied all base maps containing individual points obtained from radio-tracking penguins. Each survey period was depicted on a separate map. **MCB Processing 20031202 - SWI** 1. Each month's survey data sets was digitised separately. As there was no other spatial information ie no coordinates for each point, the points were "eyeballed" in over the DLI coastline 20010228 and the ortho (Airphoto-orthorectified_mar+sis+sie_200208_utm50_gda94). Measurements were taken off the supplied map using common points of reference in order to better locate several of the points. 3. The points were checked by comparing the visual pattern on the hardcopy map and on screen as well as ensuring that there were the same number of records. Several points falling over the land were moved into the ocean under the direction of B. Cannell. 4. A table was then created with relevant columns and used throughout the 7 surveys for consistency. 5. The datasets were then merged using Arcview3.2's geoprocessing wizard.

Positional Accuracy	Positional accuracy can be considered as low. The hardcopy map supplied the only spatial information.
Attribute Accuracy	Attribute values are true to the data presented in the original hardcopy maps supplied by Belinda Cannell.
Logical Consistency	All attributes that require values have been assigned values.
Completeness	The dataset is complete as at the date of this metadata statement.
CONTACT INFORMATION	
Contact Organisation	Department of Conservation and Land Management, Marine Conservation Branch.
Contact Position	
Mail Address 1	47 Henry Street
Mail Address 2	
Suburb or Place or Locality	Fremantle
State or Locality 2	Western Australia
Country	Australia
Postcode	6160
Telephone	08 9336 0109
Facsimile	08 9430 5408
Electronic Mail Address	rayl@calm.wa.gov.au
METADATA DATE	
Metadata Date	08/07/2004
ADDITIONAL METADATA	
Additional Metadata	**Collection Methodology - Belinda Cannell** Bradley, J. S., B. Cannell, and R. D. Wooller. 1997. A radio-tracking study of the movements at sea and diet of Little Penguins *Eudyptula minor* breeding on Penguin Island, Western Australia. Report by Murdoch University, Perth, Western Asutralia for Bowman Bishaw Gorham, Perth, Western Australia. Wooller, R. D., Cannell, B. L., Bradley, J. S., Valesini, F. J., Lenanton, R.C. J., and Connard, M. in review. Do the needs of little penguins at sea limit their breeding sites.

Appendix V(m). Metadata for birds-sea-survey_s_20040604_II_gda94.shp

DATASET **birds-sea-survey_s_20040604_ll_gda94**	
Title	Seabird breeding and roosting sites in Perth Metropolitan waters between Mandurah and Yanchep
Custodian	Department of Conservation and Land Management (CALM)
Jurisdiction	Western Australia
DESCRIPTION	
Abstract	This dataset consists of points representing areas of seabird roosting and breeding in the Perth metropolitan coastal waters, from Yanchep to Mandurah. This area includes the Marmion, Swan Estuary and Shoalwater Islands Marine Parks. Species included in the data set are: • Bridled Terns *Sterna anaethetus* • Brown Noddy *Anous stolidus* • Caspian Terns *Hydroprogne caspia* • Crested Terns *Sterna bergii* • Fairy Terns *Sterna nereis* • Great Pied Cormorants *Phalacrocorax varius* • Little Pied Cormorants *Phalacrocorax melanoleucos* • Little Shearwaters *Puffinus assimilis* • Ospreys *Pandion haliaetus* • Pelicans *Pelecanus conspicillatus* • Roseate Terns *Sterna dougallii* • Sooty Tern *Sterna fuscata* • Wedgetailed Shearwaters - *Puffinus pacificus* • White faced storm petrel *Oceanites marinus* The data were generated from anecdotal information provided by experts, and from published information gathered during a literature review of marine wildlife in the region. See Additional Metadata section for references used. Dunlop, N. pers. comm. (2003) Goodale, B. pers. comm. (2004) Delamare, C, pers. comm. (2003) Lamont, C. pers. comm. (2004) The dataset contains the following fields : descriptor of behaviour (descriptor), common name (name_cmmn), scientific name (name_scntfc), site name (site), number of pairs (pairs_), period of behaviour (period), nest site fidelity (nest_site), foraging grounds/ prey (range_prey), source_a, source_plp and comments. The data is referenced to geographical coordinates from Geocentric Datum of Australia 1994 (GDA94).
Search Word(s)	Perth Metropolitan Area, Sea Bird, behaviour, nesting, foraging, breeding, display
Geographic Extent Name(s)	Perth Metropolitan Area, Perth, Western Australia Central West Coast (CWC) IMCRA region
DATA CURRENCY	
Begin Date	1978

End Date	Currency of these data varies for species and place, from 1978 to 2004. Information for Bridled Terns is current and ongoing. Each summer research is carried out on the Shoalwater Islands and whilst most of the effort is concentrated on Penguin Island, the other islands are regularly checked. Therefore, the data available for the species on the Shoalwater Islands is current.
DATASET STATUS	
Progress	In Progress
Maintenance & Update Frequency	As required
ACCESS	
Stored Data Format	DIGITAL ArcView shapefile, geographical coordinates from Geocentric Datum of Australia 1994 (GDA94).
Available Format Type	DIGITAL ArcView 3.2 shapefile
Access Constraint	Data available for external use subject to transfer fee and license conditions. Data is not to be distributed without authorisation from CALM. Contact CALM's database administrator for further details.
DATA QUALITY	
Lineage	PROCESSING 20040601: 1. Relevant experts/papers were consulted to delineate areas of seabird roosting and breeding. The information was entered into a spreadsheet, along with any available information of numbers of pairs at each site, foraging areas and preferred prey. Spreadsheet supplied to MCB 20040108. 2. A record (point) was added for each combination of species, behaviour and site name. Sites were located and digitised on screen using operator knowledge, the nomenclature dataset (geonoma-mf-dep_wa_20011113_ll_gda94) and airphoto-orthorectified_mar+sis+sie_200208_utm50_gda94.ecw. 3. Hardcopy maps were produced and reviewed by Nic Dunlop and Belinda Cannell on 20040317. The digitised points were attributed with the rest of the information in the original spreadsheet and manually moved to specific parts of the "Site", e.g.. the N or S of on island or a particular beach, with Belinda Cannell's input based on the afore mentioned review (PKI). 4. Where specific spatial information was not available to move the point, the point was left central to the "Site" e.g. in the centre of an island, and anecdotal spatial information was included in the "comments" field. An extra field (TYPE) was added to show if the data is indicative or absolute for mapping purposes. 5. The "source_a" is a concatenation of the spreadsheet's "source of position" and "source of attribute" columns. 6. A final review of the maps was made onscreen by NDU and BCA on 20040611 and spatial and aspatial changes were made by PKI.
Positional Accuracy	Positional accuracy is dependent on the process of using on screen placement of points over an orthorectified aerial image, to represent the areal entities relating to Seabird behavioural patterns. The spatial error in the DALSE ortho image (Airphoto-orthorectified_mar+sis+sie_200208_utm50_gda94.ecw) is negligible compared to the anectodal/expert knowledge aspect of the source positional information.
Attribute Accuracy	Attribute values are true to the data summarised in the data sheet collected by Belinda Cannell, derived from personal conversations with experts and available literature.
Logical Consistency	Attribute values have been checked and validated for consistency, and checked for logic in relation to attribute names. All attributes that require values have had values assigned.
Completeness	The dataset will be upgraded as priorities, time and resources permit. Further work needs to be undertaken on ground-truthing as some of the sightings are several years old.
CONTACT INFORMATION	
Contact Organisation	Department of Conservation and Land Management, Marine Conservation Branch
Contact Position	Marine GIS Co-ordinator
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METADATA DATE	
Metadata Date	23/07/2004
ADDITIONAL METADATA	
Additional Metadata	Additional metadata CANNELL, B.L - Marine Fauna in the Perth Metropolitan Area Dunlop, J. N., and G. M. Storr. 1981. SEABIRD ISLANDS. No.111. Carnac Island, Western Australia. Corella 5:71-74. Dunlop, J. N. 1985a. The relationship between molt and the reproductive cycle in a population of crested terns Sterna bergii. Australian Wildlife Research 12:487-494. Dunlop, J. N. 1985b. Reproductive periodicity in a population of crested terns Sterna bergii in southwestern Australia. Australian Wildlife Research 12:95-102. Dunlop, J. N. 1987. Social behavior and colony formation in a population of crested terns sterna-bergii in south-western Australia. Australian Wildlife Research 14:529-540. Dunlop, J. N., and M. J. Bamford . 1987a. THE SEABIRDS OF PENGUIN ISLAND, WESTERN AUTRALIA. Bridled Tern. Report for The Department of Conservation & Land Management, PERTH. Dunlop, J. N., N. I. Klomp, and R. D. Wooller. 1988. SEABIRD ISLANDS No.188. Penguin Island, Western Australia. Corella 12:93-98 Dunlop, J. N., and J. Jenkins. 1992. Known-age birds at a subtropical breeding colony of the bridled tern (Sterna anaethetus): A comparison with the sooty tern. Colonial Waterbirds 15:75-82. Dunlop, J. N., and J. Jenkins. 1994. Population dynamics of the Bridled Tern Sterna anaethetus colony on Penguin Island, south-western Australia. Corella 18:33-36. Garavanta, C. A. M., and R. D. Wooller. 2000. Courtship behaviour and breeding biology of Bridled Terns Sterna anaethetus on Penguin Island, Western Australia. Emu 100:169-174. Saunders, D., and P. de Rebeira 1985. The birdlife of Rottnest Island. DAS and CPdeR. Storr, G. M., and R. E. Johnstone. 1988. Birds of the Swan Coastal Plain. Records of the Western Australian Museum. Supplement No. 28. Watterson, P. 2001. Distribution and foraging ecology of seabirds and dolphins in Cockburn Sound, and implications for environmental management. Biological Sciences. Murdoch University, Perth. Wooller, R. D., and J. N. Dunlop. 1981. Itinerant breeding in Pied Cormorants on Carnac Island, Western Australia. Corella 5:97. Wykes, B. J., D. Pearson, and J. Maher. 1999. Fauna Survey of Garden Island, WA, 1996-1997. Royal Australian Navy, HMAS Stirling.

Appendix V(n). Metadata for birds-wader-survey_s_20040608_II_gda94.shp

DATASET **birds-wader-survey_s_20040608_ll_gda94**	
Title	Migratory Wader Activity Areas in the Perth Metropolitan Area
Custodian	Department of Conservation and Land Management (CALM)
Jurisdiction	Western Australia
DESCRIPTION	
Abstract	This dataset consists of points representing migratory wader roosting and foraging in the Perth metropolitan coastal waters, from Yanchep to Mandurah. The area includes the Swan River Estuary from the coast up to Canning Bridge and the Mt Henry Bridge. The data were generated from anecdotal information provided by experts, and from published information gathered during a literature review of migratory waders in the region. The species of waders identified in this dataset include: Bar-tailed Godwit *Limosa lapponica* Common Greenshank *Tringa nebularia* Common Sandpiper *Tringa hypoleucos* Curlew Sandpiper *Calidris ferruginea* Great knot *Calidris tenuirostris* Grey Plover *Pluvialis fulva* Grey-tailed Tattler *Tringa brevipes* Red Knot *Calidris canutus* Red-necked Stint *Calidris ruficollis* Ruddy Turnstone *Arenaria interpres* Sanderling *Calidris alba* Sharp-tailed Sandpiper *Calidris acuminata* References include: i) Bamford and Bamford 1999 ii) Bamford, M. pers. comm. iii) Davis, C. (bird count coordinator for W.A. Bird Notes) pers. comm. iv) Bamford et al. 2003 v) Bamford 1999 vi) Wykes et al. 1999 vii) Storr and Johnstone 1988 viii) Saunders and De Rebeira 1985 ix) Various W.A. Bird Notes The dataset should be used with the dataset that contains M. Bamford's activity versus habitat polygons in the SEMP.
Search Word(s)	Perth Metropolitan Area, Swan Estuary Marine Park, migratory wader, foraging, roosting
Geographic Extent Name(s)	Swan Estuary Marine Park, Perth, Western Australia Central West Coast (CWC) IMCRA region
DATA CURRENCY	
Begin Date	1985
End Date	2003
DATASET STATUS	
Progress	Finished with respect to the information supplied by Belinda Cannell.
Maintenance & Update Frequency	As required
ACCESS	
Stored Data Format	DIGITAL ArcView shapefile, geographical coordinates from Geocentric Datum of Australia 1994 (GDA94).
Available Format Type	DIGITAL ArcView 3.2 shapefile

Access Constraint	Data available for external use subject to transfer fee and license conditions. Data is not to be distributed without authorisation from CALM. Contact CALM's database administrator for further details.
DATA QUALITY	
Lineage	PROCESSING 20040608: 1. Relevant experts/papers were consulted to delineate areas of wader roosting and breeding. The information was entered into a spreadsheet, along with any available information of numbers of pairs at each site etc. Spreadsheet supplied to MCB 200406. 2. A record (point) was added for each combination of species, behaviour and site name. Sites were located and digitised on screen using operator knowledge, the nomenclature dataset (geonoma-mf-dep_wa_20011113_ll_gda94) and airphoto-orthorectified_mar+sis+sie_200208_utm50_gda94.ecw. 3. In the majority of records, specific spatial information was not available to better position the point, therefore the point was left central to the "Site" e.g. in the centre of an island, and anecdotal spatial information was included in the "comments" field.
Positional Accuracy	Positional accuracy is dependent on the process of using on screen placement of points over an orthorectified aerial image, to represent the areal entities relating to migratory wader behavioural patterns. Agian it should be noted that the majority of the points are not spatially specific. The spatial error in the DALSE ortho image (Airphoto-orthorectified_mar+sis+sie_200208_utm50_gda94.ecw) is negligible compared to the anectodal/expert knowledge aspect of the source positional information.
Attribute Accuracy	Attribute values are true to the data summarised in the data-sheet collected by Belinda Cannell, derived from personal conversations with experts and available literature.
Logical Consistency	Attribute values have been checked and validated for consistency, and checked for logic in relation to attribute names. All attributes that require values have had values assigned.
Completeness	The dataset will be upgraded as priorities, time and resources permit. Further work needs to be undertaken on ground-truthing (see positional accuracy statement).
CONTACT INFORMATION	
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METADATA DATE	
Metadata Date	22/07/2004
ADDITIONAL METADATA	
Additional Metadata	Bamford, M. (1999) Movements of waders on the Swan Estuary. W.A. Bird Notes, 89, 10-11. Bamford, M.J. and Bamford, A.R. (1999) Ecological Research Consultancy - Monitoring Programme to Determine Whether Use of Personal Watercraft is Affecting Wildlife. Report for Department of Transport. Bamford, M.J. Bamford, A.R and .Bancroft., W. (2003) Social (human use) monitoring programme for the Swan Estuary Marine Park. Report for CALM. Western Australian Bird Notes (1998) W.A. mid Summer Wader Survey Feb 1998. 87: 9.

Western Australian Bird Notes (1999) W.A. mid summer wader count Feb 1999. 91: 10.

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Wykes, B.J., Pearson, D. and Maher, J. (1999) Fauna Survey of Garden Island, WA, 1996-1997.

Appendix V(o). Metadata for birds-wader_s_20040722_II_gda94.shp

DATASET **birds-wader_s_20040722_ll_gda94**	
Title	Migratory Wader Areas in the Perth Metropolitan Area (Swan Estuary Marine Park)
Custodian	Department of Conservation and Land Management (CALM)
Jurisdiction	Western Australia
DESCRIPTION	
Abstract	This dataset consists of polygons representing areas of migratory wader roosting and foraging in each of the reserves that comprise the Swan Estuary Marine Park. Habitat and activity polygon delineation was adapted from Bamford *et al.* (2003) Social (human use) monitoring programme for the Swan Estuary Marine Park. 60. Whilst each record is not species specific, the species of waders known to use the area's habitat for foraging and roosting include : Bar-tailed Godwit *Limosa lapponica* Common Greenshank *Tringa nebularia* Common Sandpiper *Tringa hypoleucos* Curlew Sandpiper *Calidris ferruginea* Great knot *Calidris tenuirostris* Grey Plover *Pluvialis fulva* Grey-tailed Tattler *Tringa brevipes* Red Knot *Calidris canutus* Red-necked Stint *Calidris ruficollis* Sharp-tailed Sandpiper *Calidris acuminata* The dataset should be used with the point dataset that contains the relative locations of waders by species in the Perth Metropolitan Area.
Search Word(s)	Perth Metropolitan Area, Swan Estuary Marine Park, migratory wader, foraging, roosting
Geographic Extent Name(s)	Swan Estuary Marine Park, Perth, Western Australia Central West Coast (CWC) IMCRA region
DATA CURRENCY	
Begin Date	2003
End Date	2003
DATASET STATUS	
Progress	Finished with respect to the study undertaken by Mike Bamford.
Maintenance & Update Frequency	As required
ACCESS	
Stored Data Format	DIGITAL ArcView shapefile, geographical coordinates from Geocentric Datum of Australia 1994 (GDA94).
Available Format Type	DIGITAL ArcView 3.2 shapefile
Access Constraint	Data available for external use subject to transfer fee and license conditions. Data is not to be distributed without authorisation from CALM. Contact CALM's database administrator for further details.
DATA QUALITY	
Lineage	PROCESSING 20040722: 1. Hardcopy maps supplied by Belinda Cannell from Bamford's report (see additional metadata) pages 39-41. The maps showed the areas of mud flats (used for foraging) and sandbars (used for roosting) and the study's zones for Milyu, Alfred Cove and Pelican Point. 2. The maps were recreated using the chart (chart-898-dpi_swan_utm50_gda94) and ortho (Airphoto-orthorectified_ses_200201_utm50_gda94.ecw). If objects e.g. a sandbar, were not present in the ortho, their location was measured from points common to the ortho and the hardcopy maps and manually digitised. It would appear that the hardcopy map is somewhat generalised and the ortho is taken at a different tide height to when the study took place. 3. The polygons were attributed according to the information present in the hardcopy maps and the

	MCB attribute structure. 4. Belinda Cannel requested the removal of the zone (which were study specific) boundaries, this left wader activity versus habitat type. Still to do : 1. Have maps checked by Bamford for accuracy via BCA.
Positional Accuracy	The habitat/activity polygons are an interpretation of the hardcopy maps supplied. A better image with respect to tide level could provide a more accurate delineation of the mud flats and sand shoals indicated in the hardcopy maps.
Attribute Accuracy	Attribute values are true to the data presented in the hardcopy maps from Bamford's report (see additional metadata).
Logical Consistency	Attribute values have been checked and validated for consistency, and checked for logic in relation to attribute names. All attributes that require values have had values assigned.
Completeness	The dataset will be upgraded as priorities, time and resources permit. Further work needs to be undertaken on ground-truthing (see positional accuracy statement).
CONTACT INFORMATION	
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METADATA DATE	
Metadata Date	22/07/2004
ADDITIONAL METADATA	
Additional Metadata	1. Bamford, M.J., Bamford, A.R and Bancroft, W. (2003) Social (human use) monitoring programme for the Swan Estuary Marine Park. Report for CALM.

APPENDIX VI. ACRONYMS

BT Butyltin

CALM Department of Conservation and Land Management

CAMBA Agreement between the Government of Australia and the Government of the Peoples' Republic of China for the Protection of Migratory Birds and their Environment

CITES Convention on International Trade in Endangered Species of Wild Flora and Fauna

CWR Centre for Whale Research

DBT Dibutyltin

DEP Department of Environmental Protection

ENSO El Nino Southern Oscillation

EPBC Environmental Protection and Biodiversity Conservation Act 1999

GIS Geographical Information System

IUCN International Union for the Conservation of Nature and Natural Resources – 2000 Red List of Threatened Species

JAMBA Agreement between the Government of Japan and the Government of Australia for the Protection of Migratory Birds, Birds in Danger of Extinction and their Environment.

MARPOL International Convention for the Prevention of Pollution from Ships

MBT Monobutyltin

MCB Marine Conservation Branch, Department of Conservation and Land Management

OC Organochlorine

PAHs Polycyclic Aromatic Hydrocarbons

PCB Polychlroinated biphenyl

PWC Personal Watercraft

RAN Royal Australian Navy

SEMP Swan Estuary Marine Park

SIMP Shoalwater Islands Marine Park

TBT Tributyltin

UNEP United Nations Environmental Program

WAWCA Western Australian Wildlife Conservation Act 1950

WWR Western Whale Research Pty. Ltd.

APPENDIX VII. COMPLETE BIBLIOGRAPHY OF ALL REFERENCES COLLECTED DURING REPORT PRODUCTION

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