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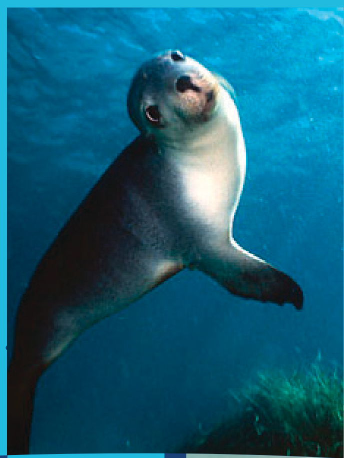
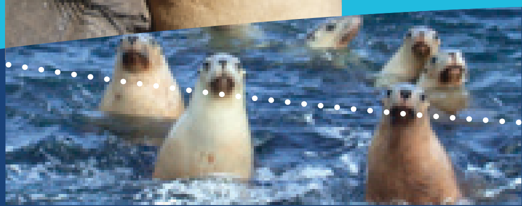
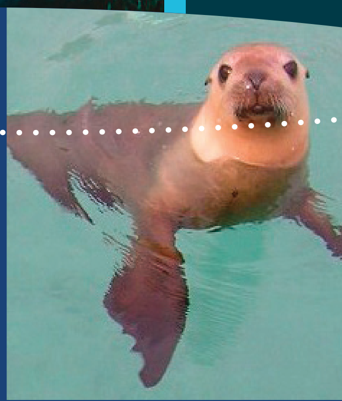

Issues Paper for the Australian Sea Lion (*Neophoca cinerea*)

2013

The recovery plan linked to this issues paper is obtainable from:
www.environment.gov.au/coasts/species/seals/index.html

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Images credits

Front cover left to right: entangled Australian sea lion, close up image of Australian sea lion, colony of Australian sea lions, Australian sea lion on the water's surface – Derek Hamer, Australian sea lion underwater – David Muirhead

Back cover left to right: Australian sea lion on a rocky shore, close up image of Australian sea lion, Australian sea lion on the water's surface – Derek Hamer

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Abbreviations

AFMA	Australian Fisheries Management Authority, Commonwealth
DSEWPaC	The Department of Sustainability, Environment, Water, Population and Communities, Commonwealth
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
IUCN	International Union for Conservation of Nature
MARPOL	International Convention for the Prevention of Pollution from Ships
SESSF	Southern and Eastern Scalefish and Shark Fishery
SLED	Sea Lion Exclusion Devices
WTO	Wildlife Trade Operation

1 SUMMARY

The Australian sea lion *(Neophoca cinerea)* was listed as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act 1999) in 2005 and as endangered on the International Union for Conservation of Nature (IUCN) Redlist in 2008.

The Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC), with the assistance of key stakeholders, has drafted a recovery plan for the species, which identifies a number of conservation priorities and articulates a number of associated actions that should be carried out to improve the conservation prospects of the species.

The Australian sea lion was hunted commercially during the 1700s and 1800s and has not recovered to occupy its former range since that time. It is expected that the lack of recovery of the species is a result of life history characteristics coupled with contemporary threats. The Australian sea lion exhibits low fecundity compared with other pinnipeds, due to a prolonged 17–18 month breeding cycle. Breeding populations are typically small and breeding colonies are unlikely to receive female immigrants due to breeding site fidelity (i.e. philopatry), suggesting that recolonisation of extinct breeding colonies is unlikely, and many breeding colonies (or clusters of colonies) have become genetically distinct as a result.

This issues paper has been developed to support the Recovery Plan for the Australian Sea Lion and is a summary of a more detailed Australian Sea Lion Technical Issues Paper, developed in 2010 (DEWHA, 2010). This issues paper summarises the biology and ecology of the Australian sea lion and details the immediate and identifiable threats to the species, and recommendations for future research.

A range of anthropogenic factors have been identified which may be impacting on the recovery of the Australian sea lion. The cumulative impact of many of these threats varies across the range of the species, with some threats having more prominence in certain areas. Fisheries bycatch and entanglement in marine debris appear to pose the greatest threat to the Australian sea lion at present. Secondary threats include habitat degradation and interactions with aquaculture operations; human disturbance to colonies; deliberate killings; disease; pollution and oil spills; noise pollution; prey depletion and climate change.

Considerable research and actions undertaken in recent times provide a clear step forward in our knowledge of the biology and ecology and in the conservation management of the Australian sea lion. Continuation of research into the ecology and biology, as well as into causes of anthropogenic mortality, will assist in developing programs to aid the long term recovery of this species.

This issues paper should be read in conjunction with the accompanying 2013 Recovery Plan for the Australian Sea Lion, which can be found at: www.environment.gov.au/coasts/species/seals/index.html

2 INTRODUCTION

2.1 Purpose

The purpose of this paper is to provide a summary of the biology, population ecology and current threats to the Australian sea lion in Australian waters and to make recommendations on the future research necessary to protect this species. This paper is an updated summary of a more detailed Australian Sea Lion Technical Issues Paper produced in 2010 (DEWHA, 2010). It has been written to inform the development of the Recovery Plan for the Australian Sea Lion and is designed to be read in conjunction with the Plan.

2.2 Objectives

The objectives of this paper are to:

- collate information on the distribution, abundance and trends of Australian sea lion populations and on the various natural and anthropogenic factors that impact on them
- identify gaps in the available information
- identify areas of further research to address the identified information gaps.

2.3 Scope

This document provides a contemporary picture of the biology and ecology of the Australian sea lion and identifies threats to its long-term persistence in the wild. This document is not a recovery plan and does not prescribe management actions necessary to address population declines.

2.4 Sources of information

This document summarises, synthesises and updates information included in a more detailed 2010 Australian Sea Lion Technical Issues Paper (DEWHA, 2010) which was prepared following a review of the literature and consultation with key stakeholders, including relevant agencies, researchers and interested organisations.

2.5 Recovery planning process

2.5.1 Purpose of recovery plans

The Australian Government minister responsible for the environment may make or adopt recovery plans for threatened fauna, threatened flora (other than conservation dependent species) and threatened ecological communities listed under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Recovery plans set out the research and management actions necessary to stop the decline of, and support the recovery of, listed threatened species or threatened ecological communities. The aim of a recovery plan is to maximise the long term survival in the wild of a threatened species or ecological community.

2.5.2 Objectives of the Recovery Plan for the Australian Sea Lion

The overarching objective of the 2012 Recovery Plan for the Australian Sea Lion is to halt the decline and assist the recovery of the Australian sea lion throughout its range in Australian waters by increasing the total population size, while maintaining the number and distribution of breeding colonies with a view to:

- improving the population status, leading to future removal of the Australian sea lion from the threatened species list of the EPBC Act
- ensuring that anthropogenic activities do not hinder recovery in the near future or impact on the conservation status of the species in the future.

3 BIOLOGY AND ECOLOGY

3.1 Species description

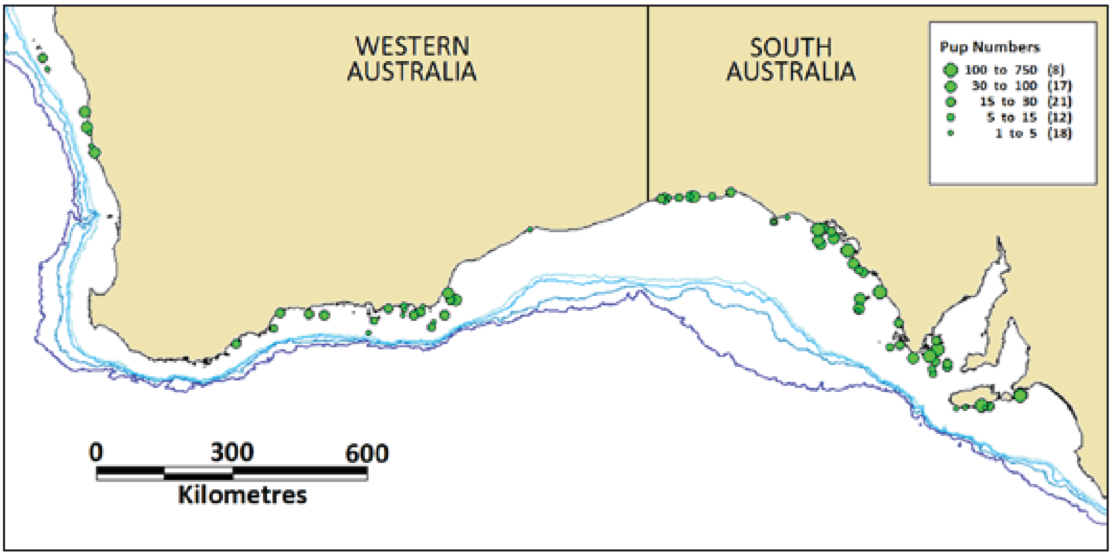
The Australian sea lion is one of seven extant sea lion species worldwide (Boness, 2009) and is Australia's only endemic pinniped species and one of the rarest otariids (Ling, 2002). The Australian sea lion shares Australia's southern coastline with the Australian fur seal *(Arctocephalus pusillus doriferus)*, which is a subspecies with the South African or cape fur seal *(Arctocephalus pusillus pusillus)* and the New Zealand fur seal *(Arctocephalus forsteri)*.

At birth, the pelage of pups is dark chocolate brown to charcoal grey in colour for the first five months, before changing to a grey-brown colour on the dorsal and lateral surfaces and cream on the chest and cheeks (Shaughnessy, et al., 2005). The females retain this colouration for life, although subadult males gradually develop a darker chest with evident scars from sparring with other subadult males and a darker face. The pelage colour of fully grown bulls becomes much darker brown, with the dorsal surface of the neck region (i.e. the mane) being light brown to cream. Pups are 62–68 cm long and weigh 6.4–7.9 kg at birth, while a pregnant female may be 132–181 cm long and weigh 61–105 kg, depending on the location (Ling, 2002; Hamer, et al., 2007). Bulls may attain lengths of 200 cm and weigh in excess of 200 kg (Ling, 2002).

3.2 Distribution, abundance and trends

The current distribution of Australian sea lion breeding colonies extends along approximately 3500 kilometres of Australia's southwest coastline, from the Houtman Abrolhos Islands on the west coast of Western Australia to The Pages Islands to the east of Kangaroo Island in South Australia (Figure 1; Appendix 1). The full historical extent of the Australian sea lions' geographic range is unclear, although seal harvesting activities may have caused the extirpation of several breeding colonies within the current range, plus range retraction from the Bass Strait islands some 650–1000 kilometres southeast of The Pages Islands (Gales, et al., 1994; Ling, 1999; Shaughnessy, et al., 2005).

Figure 1: Breeding distribution of the Australian sea lion, indicating the location and approximate pup number range of the 76 sites where Australian sea lion pups have been recorded. The number of sites with each pup number range is given in parentheses. Depth contours of 200, 500, 1000 and 2000 m (light to dark blue) are indicated (updated from DEWHA, 2010).



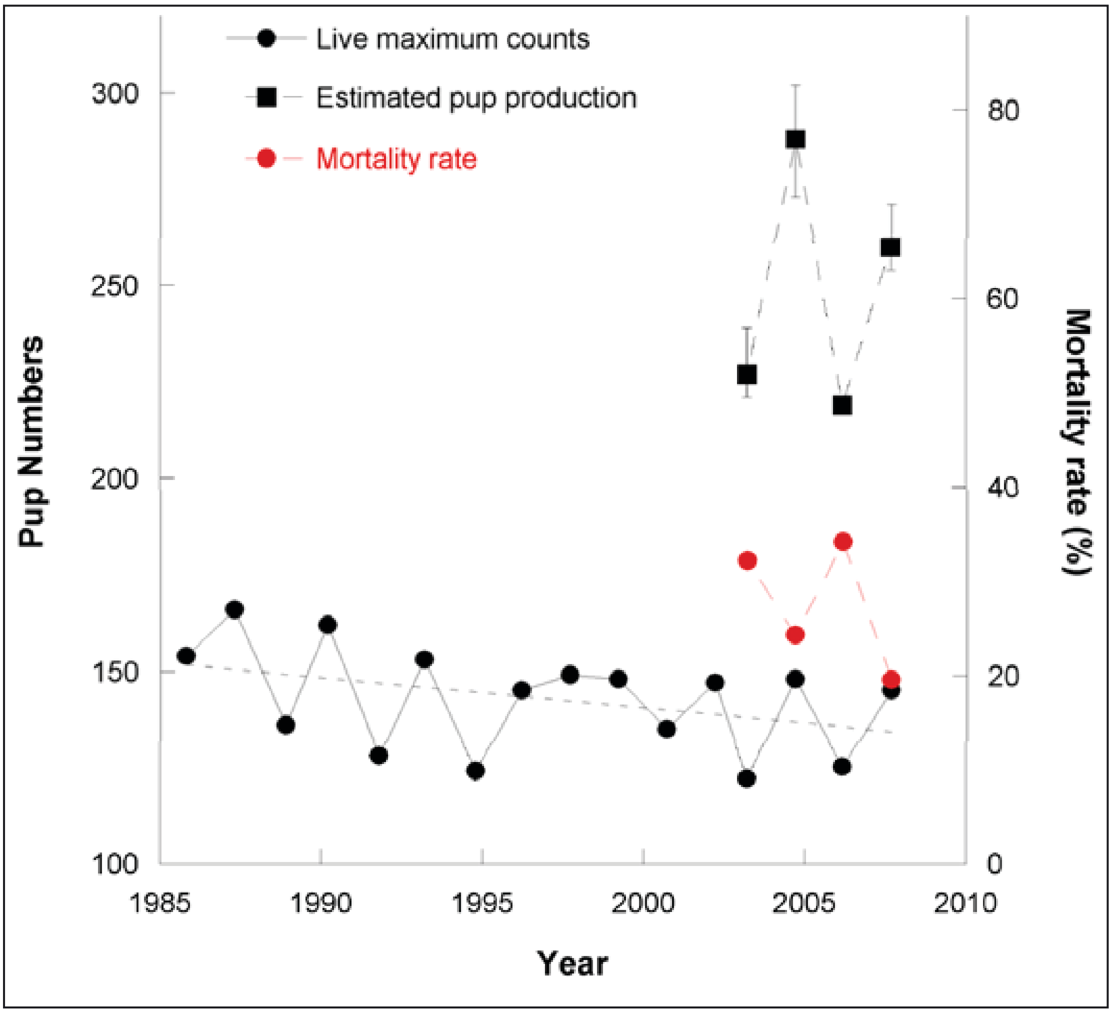
There are 76 known breeding sites for the Australia sea lion, with 28 in Western Australia and 48 in South Australia, of which 58 are known as regular breeding colonies (i.e. sites at which five or more pups per breeding cycle have been recorded; Shaughnessy, et al., 2011; Appendix 1) and 18 are sites where the presence of pups has been occasionally recorded (i.e. have fewer than five pups per breeding cycle; Shaughnessy, et al., 2011; Appendix 1). The 58 breeding colonies are considered as habitat critical to the survival of the species because they are used to meet essential life cycle requirements (i.e. breeding).

The most recent pup abundance surveys indicate that an estimated 3622 pups are born per breeding cycle across the species range (Shaughnessy, et al., 2011). Pup numbers are used as the most reliable basis for determining population size. They are the age group most likely to be on shore because they have not developed at-sea foraging skills and are confined to breeding sites for at least the first five weeks of their life (McIntosh, et al., 2011; Shaughnessy, et al., 2011). The latest figure exceeds previous estimates of 2495 pups per breeding cycle during the early 2000s (McKenzie, et al., 2005) and 2432 pups per breeding cycle during the early 1990s (Gales, et al., 1994), although this increase is most likely due to increased survey effort and the inclusion of a few newly discovered breeding sites since the early 1990s, rather than a true increase in population size. From recent surveys, it was calculated that 3119 pups per breeding cycle were born in South Australia (86 per cent of all pups) and 503 pups per breeding cycle were born in Western Australia (14 per cent of all pups; Shaughnessy, et al., 2011). Pup numbers exceeded 100 individuals at nine sites (representing 12 per cent of all breeding sites), all of which are located in South Australia and account for 63 per cent of all pups recorded in that season (DEWHA, 2010; Shaughnessy, et al., 2011). Pup numbers were 30 or fewer at 51 sites (66 per cent of all breeding sites), accounting for 571 pups (16 per cent of all pups recorded in that season). An additional 151 locations have been identified as haul-out sites, 61 in Western Australia and 90 in South Australia. The number of haul-out sites is expected to be higher because records of haul-out sites are based largely on opportunistic observation (Shaughnessy, et al., 2011).

Population estimates have been calculated using a 'pup multiplier' of 4.08, which allows the recorded number of pups in a pinniped population to infer overall population size, based on population demographic data (Berkson & DeMaster, 1985). However, limited population demographic data is available for the Australian sea lion, originating from only one breeding site at Seal Bay (Kangaroo Island, South Australia), which may not be representative of the situation at other colonies (McIntosh, 2007; McIntosh, et al., 2011). Nonetheless, these currently available parameters suggest there are approximately 14 780 Australian sea lions across the species' entire geographic range (Shaughnessy, et al., 2011).

Long-term population monitoring through which trends can be determined has only occurred at a few breeding sites, although population monitoring at other sites has also been described in the 2010 Australian Sea Lion Technical Issues Paper (DEWHA, 2010). Seal Bay provides the most comprehensive account, with reliable estimates of pup abundance available since the mid-1980s (Shaughnessy, et al., 2006). Subsequent pup counts have indicated a general decline of 0.54–0.67 per cent per year between 1985 and 2010 (Shaughnessy, et al., 2006; Goldsworthy, et al., 2008a; Goldsworthy, et al., 2010; Goldsworthy, et al., 2011; Figure 2). Oscillations between years are attributable to the extended 17.6 month breeding cycle for this species (further explained in Section 3.4 of this document), with higher levels of pup mortality occurring when breeding occurs over winter months (McIntosh, 2007; Goldsworthy, et al., 2008a). Explanations for the long-term trend have focused on bycatch and entanglement of individuals in fishing gear (Page, et al., 2004).

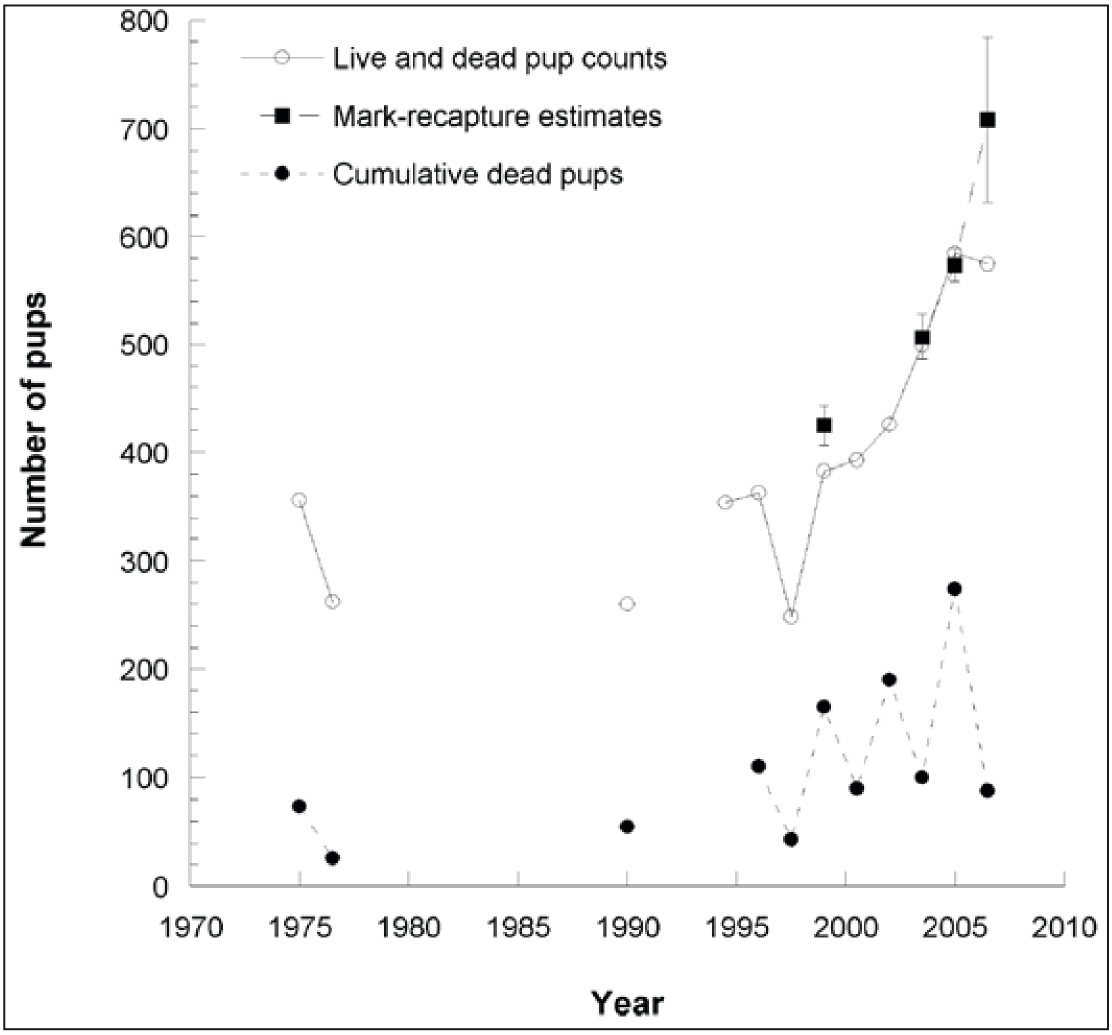
Figure 2: Trends in Australian sea lion pup abundance at Seal Bay (Kangaroo Island, South Australia), for 18 consecutive breeding seasons between 1985 and 2010



(Source: Goldsworthy, et al., 2011, updated from Shaughnessy, et al., 2006).

Regular population monitoring has also occurred at Dangerous Reef (Spencer Gulf, South Australia), with pup abundance estimates available for 12 of the 22 breeding cycles between 1975 and 2007 (Goldsworthy, et al., 2007a). The population there showed a moderate increase of 1.8 per cent per year until 1999, whereupon the rate of population growth increased to 4.6–6.5 per cent per year (Goldsworthy, et al., 2007a; Figure 3). As with Seal Bay, oscillation in pup abundance due to increased pup mortality during winter breeding seasons was evident. The increase in the population growth rate is thought to be attributable to a ban on shark gillnetting in Spencer Gulf in 2001. The associated theory is that the impediment to growth was removed, with fewer or no lactating Australian sea lion females with dependent pups becoming bycaught and drowning in demersal shark gillnets after that time (Goldsworthy, et al., 2007a).

Figure 3: Trends in Australian sea lion pup abundance at Dangerous Reef (Spencer Gulf, South Australia), for 12 of 22 breeding seasons between 1975 and 2007.



(Note the marked increase in pup numbers after about 2000, around the time that demersal gillnetting for sharks was banned in Spencer Gulf (Source: Goldsworthy, et al., 2007a)).

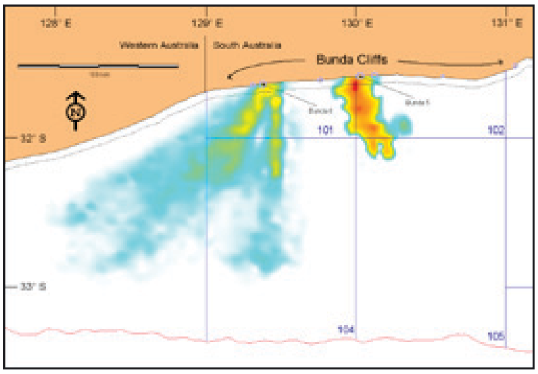
3.3 Foraging ecology and diet

It is difficult to identify the attributes of critical marine habitat for the Australian sea lion. Nonetheless, determination of geographic distribution of foraging effort and of vertical dive profiles provides some clues as to where individuals focus their time when at sea and when foraging. About 180 satellite transmitters have been deployed on individual Australian sea lions across their range, many being lactating females with dependent pups ashore, mostly across South Australian waters (Hamer, et al., 2007; Goldsworthy, et al., 2009b; Campbell, 2011). These studies identified marked individuality in foraging effort within and between the breeding sites from which the animals were tracked, with a variety of coastal and offshore habitats being utilised. The mean maximum foraging distances achieved from each colony ranged from 28 ± 18 km at Dangerous Reef in Spencer Gulf to 189 ± 25 km at Bunda Cliffs in exposed waters near the Western Australian border (Fowler, et al., 2007; Hamer, et al., 2013). For 115 lactating females tracked in South Australian waters, at-sea foraging effort covered 27.9 per cent of the approximately 178 000 km2 area of South Australian shelf waters, from coastal areas out to the shelf break (Hamer, et al., 2013; Figure 4). These results suggest the utilisation of shelf waters in South Australia — and across the entire range of the species generally — is likely to be extensive, although variable depending on the environmental conditions in the local marine environment.

Foraging capacity of the Australian sea lion develops with age, with 15 month old pups foraging nearer their natal colony (mean distance 20.8 ± 4 km) when compared with adults (67.9 ± 3.5 km; Fowler, et al., 2007). However, several marked pups have been shown to move from Dangerous Reef to English Island, some 20 km to the north, at approximately three months of age (Goldsworthy, et al., 2009b). This suggests that the development of at-sea foraging behaviours may vary between breeding colonies and may also depend on localised environmental conditions.

Figure 4: Geographic distribution of foraging (at-sea) effort of 115 tracked lactating female Australian sea lions across South Australian shelf waters (high: red, medium: orange, low: blue)

In (a) the Great Australian Bight, (b) Nuyts Archipelago, (c) southern Eyre and (d) Kangaroo Island regions (Source: Hamer, et al., 2013).



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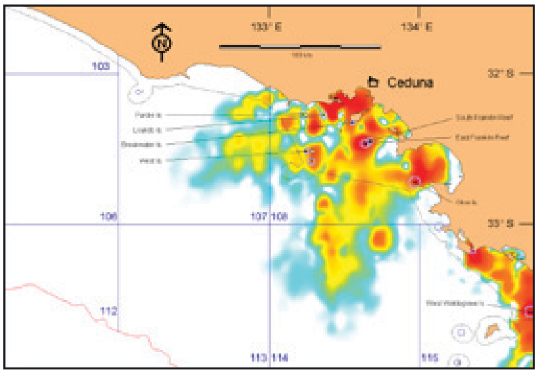

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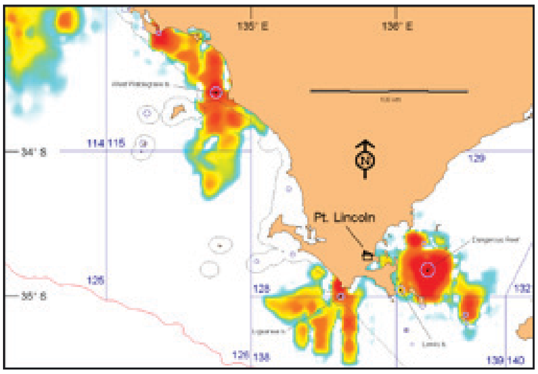

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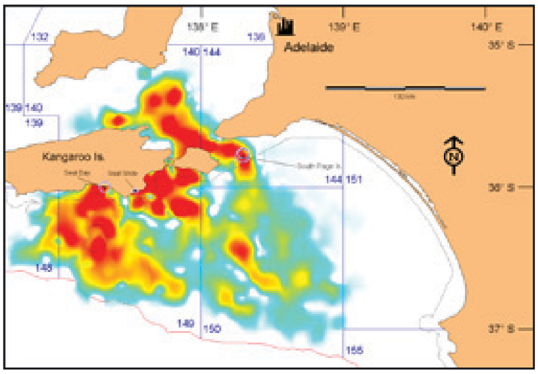

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Unlike the sympatric New Zealand fur seal that will forage predominantly in the pelagic zone (Harcourt, et al., 2002), the Australian sea lion spends around 35 per cent of its time at or close to the sea floor (Costa & Gales, 2003). Adults tend to travel at the surface for a short distance, then commence repeated dives to the benthos (Goldsworthy, et al., 2009b). The descent and ascent appear to be rapid, presumably to maximise the time spent on the sea floor. Diving capacity also develops with age, with the mean depth and duration of dives continuing to increase from six months of age (7 ± 1 m and 0.4 ± 0.2 min) to adulthood (71 ± 4 m and 3.3 ± 0.2 min; Fowler, et al., 2006). Similar to geographic distribution of foraging, dive behaviour is likely to vary between regions according to sea floor depth and topography, with adults foraging to depths of 17 m at the Abrolhos Islands on the west coast of Western Australia and to depths of 110 m at Investigator Island on the south coast of Western Australia (Campbell & Holley, 2007).

The diet of the Australian sea lion comprises mostly benthic species. Unlike fur seals, from which hard part remains in scats such as fish otoliths and squid beaks can be used to determine dietary composition, Australian sea lion scats seldom contain identifiable prey remains. However, feeding trials of captive animals and stomach analysis of opportunistically collected deceased animals have facilitated the identification of many benthic and bentho-pelagic prey (Walker & Ling, 1981; Gales, et al., 1992; Ling, 1992; McIntosh, et al., 2006; Table 1). More recent studies of stomach remains confirmed octopus and giant cuttlefish as the most numerically abundant prey items at Seal Bay, although diet at other sites may differ (McIntosh, et al., 2006). Fatty acid and DNA analyses have confirmed the presence of the prey groups outlined in Table 1 at a molecular level, using milk and scat samples. Fatty acid analysis has also suggested that inshore foragers had fish and shark-dominated diets, while offshore foragers had fish-dominated diets (Peters, et al., 2007; Baylis, et al., 2009). The seagrass meadows in South Australia are some of the largest in the world (Shepherd & Robertson, 1989) and are likely to offer an important habitat to many of these prey species. Given that the Australian sea lion spends a considerable amount of time foraging in them, the loss of seagrass beds due to climate change may have negative ramifications for the Australian sea lion (Goldsworthy, et al., 2009b; Lowther, et al., 2011; refer: section 5.2.10).

Table 1: Prey species identified in the diet of Australian sea lions, derived from feeding trials of captive animals and from stomach analysis of opportunistically collected carcasses.

The most numerically abundant prey (*) are marked.

Common name	Scientific name
Fishes	
King George whiting	*Sillaginodes punctata*
eastern school whiting	*Sillago flindersi*
Australian salmon	*Arripis sp.*
leatherjacket	*Monacanthidae*
flathead	*Platycephalus sp.*
swallowtail	*Centroberyx lineatus*
bigscale bullseye	*Pempheris multiradiata*
yellowtail scad	*Trachurus novaezelandiae*
Squids	
octopus	*Octopus sp.* *
giant cuttlefish	*Sepia apama* *
southern calamari	*Sepioteuthis australis*
arrow squid	*Nototodarus gouldi*
Sharks	
school shark	*Galeorhinus galeus*
gummy shark	*Mustelus antarcticus*
Port Jackson shark	*Heterodontus portusjacksoni*
Crustaceans	
rock lobster	*Jasus sp.*
swimming crab	*Ovalipes australiensis*
Birds	
little penguin	*Eudyptula minor*

(Source: Walker & Ling, 1981; Gales, et al., 1992; Ling, 1992; McIntosh, et al., 2006).

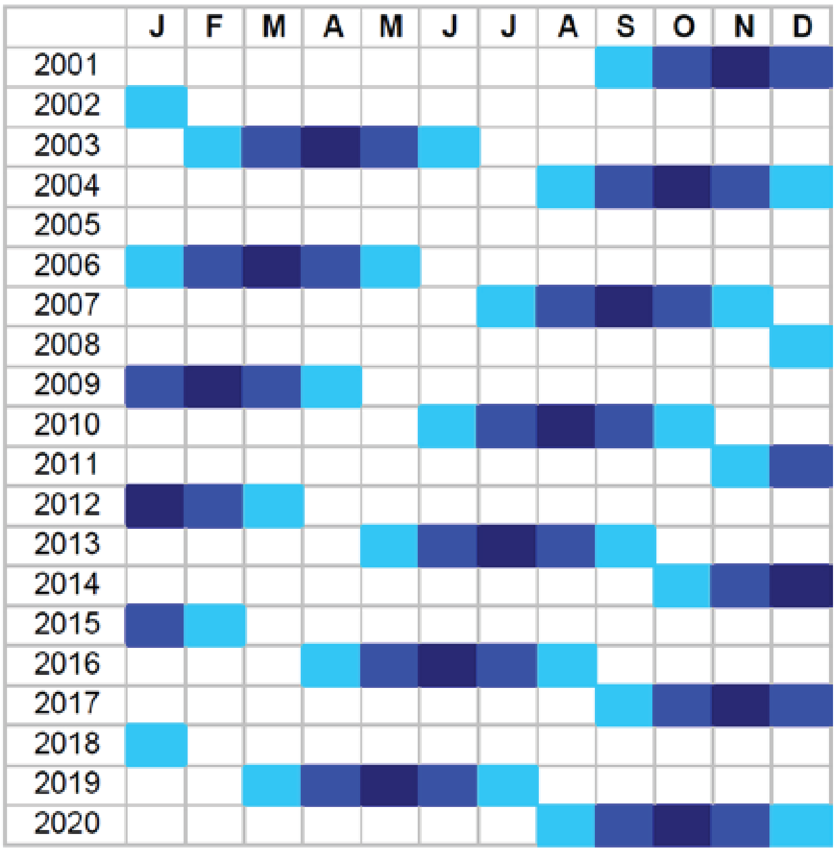
3.4 Life history, breeding strategies and population genetics

The Australian sea lion is a large-bodied marine mammal that is slow to mature, with females having few young over their lifetime, to which they commit extended maternal care (Gales & Costa, 1997). Females become sexually mature at 3.5–6 years of age (Higgins, 1993; McIntosh, 2007), which is similar to most other otariids (Wickens & York, 1997; Dickie & Dawson, 2003). The maximum age at which a female has been observed giving birth is 24 years (McInstosh, 2007), which is also similar to other otariids, such as the New Zealand fur seal (McKenzie, et al., 2007). However, Australian sea lion breeding cycles are atypically extended, being 17.4–17.8 months in duration (Shaughnessy, et al., 2006), which reduces reproductive opportunities by approximately one third when compared with other annually breeding pinnipeds. Breeding is expected to occur at all times of the year across a 24 year period, based on a 4.6 month pupping season (Shaughnessy, et al., 2006; Figure 5), inferring that prey availability must be relatively stable throughout the year (Lowther, et al., 2011). Pups are typically nursed for 15–18 months, typically being weaned one month prior to the birth of the next pup (Higgins & Gass, 1993). There is evidence that pups learn to forage during this time, suggesting that pups are able to make a slow transition to nutritional independence, which may be necessary for learning the skills to survive in an environment where prey are patchy and scarce (Lowther, et al., 2011).

The only genetic investigation into the population structure of the Australian sea lion utilised mitochondrial (mtDNA) and nuclear (microsatellite) DNA markers to investigate the degree of population sub-structuring and sex-biased dispersal throughout most of its range. Samples were collected from eight colonies in Western Australia (Abrolhos Islands, Beagle Island, North Fisherman Island, Buller Island, Hauloff Rock, Red Islet, Six Mile Island and Spindle Island) and from two colonies in South Australia (Dangerous Reef and Seal Bay; Campbell, 2003; Campbell, et al., 2008a). This study provided evidence of strong sex-biased dispersal in the populations, manifested primarily in extreme female natal site fidelity (or philopatry). This means that females will typically breed in the same colony in which they were born, with genetic differences in the female line being evident in colonies as close as 20 kilometres apart.

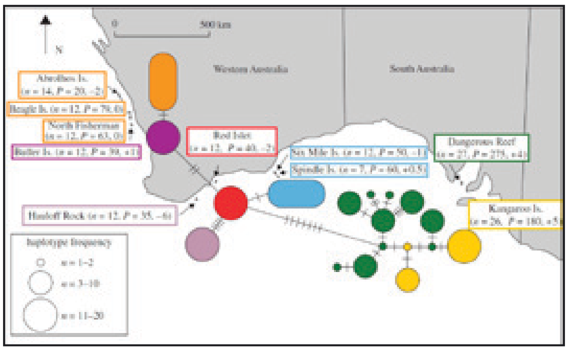
The marked foraging site fidelity recently observed in lactating Australian sea lions (Lowther, et al., 2011), may explain the exhibition of breeding site fidelity, which appears to be prevalent in the species across its range (Campbell, et al., 2008b; Lowther, et al., 2012). Philopatry involves the continued return of a pregnant female to her natal breeding colony to give birth. There are two consequences to this strategy, which are clearly evident in the Australian sea lion. Firstly, breeding isolation appears to have resulted in the drift and asynchrony of breeding cycles, with the peak in breeding seasons among breeding colonies being several months apart, even between those in close proximity where foraging ranges overlap (Shaughnessy, et al., 2011). Secondly, effective decoupling in the timing of breeding has resulted in a temporal barrier to female immigration, because the short window of oestrus (i.e. seven days immediately after giving birth; Higgins, 1990) may not be synchronised with adjacent colonies. Consequently matrilineal genetic separation (involving mitochondrial or maternally inherited DNA) has occurred at the colony or regional (i.e. clusters of colonies) level (Campbell, et al., 2008b; Lowther et al. 2012; Figure 6). In essence, some breeding colonies, or clusters of breeding colonies, are unique populations.

Figure 5: Predicted timing of breeding for the Australian sea lion, depicting the seasonal drift in the peak of breeding across the entire year at Seal Bay between 2001 and 2020.



(Source: DEWHA, 2010).

Figure 6: Geographic representation of genetic differentiation among Australian sea lions depicting mitochondrial DNA differentiation between sampled colonies, by halotype distribution and proportion. (a) Minimum spanning tree, where distribution is colour coded with colony name, size is related to their frequency of occurrence, and extended circles indicate sharing between colonies.



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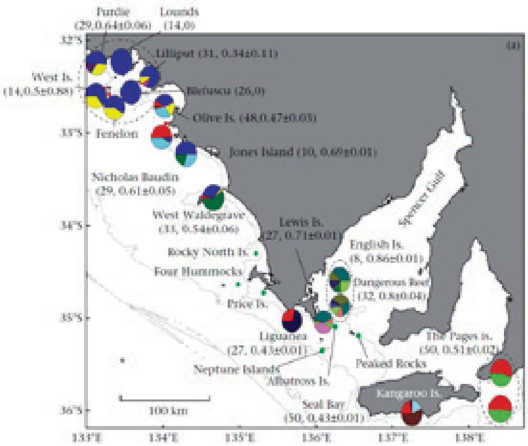
(b) Pie charts depict relative frequency/proportion in sampled colonies, with dotted lines indicating clusters of colonies where halotype combinations are statistically similar



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(Source: Campbell, et al., 2008a [a]; Lowther, et al., 2012 [b]).

4 CONSERVATION STATUS

The Australian sea lion was listed as endangered under the IUCN Red List in 2008 (Goldsworthy & Gales, 2008).

In Australia, the Australian sea lion was listed as vulnerable under the EPBC Act in 2005. For information on the basis for this listing under the EPBC Act refer to the 2013 Recovery Plan for the Australian Sea Lion at: www.environment.gov.au/coasts/species/seals/index.html. This listing protects the Australian sea lion from intentional harm in Commonwealth waters and requires all development projects that may impact on the Australian sea lion in Commonwealth and state waters to be assessed through the referrals process as part of the Matters of National Environmental Significance legislation in the EPBC Act. The EPBC Act threatened species listing also requires all Commonwealth and state fisheries to report any interactions to the Australian Government Department of Sustainability, Environment, Water, Population and Communities . In addition, Commonwealth fisheries that export product must have management arrangements in place that ensure that all reasonable steps are taken to ensure individuals of the species are not killed or injured as a result of fishing activities. As part of the Commonwealth marine bioregional planning process, the Australian sea lion has been identified as a regional priority for the South-west Marine Region. In addition, Schedule 2 of the Commonwealth South-west Marine Bioregional plan includes guidance for people planning to undertake actions which have the potential to impact on Australian sea lions within the region. Further information on Commonwealth marine bioregional planning is available at: www.environment.gov.au/coasts/marineplans/index.html.

In South Australia, the Australian sea lion was listed in 2008 as a threatened species and is protected under the South Australian *National Parks and Wildlife Act 1972* and the South Australian *Fisheries Management Act 2007*. In Western Australia, the Australian sea lion is specially protected as threatened fauna under the *Wildlife Conservation Act 1950 — Wildlife Conservation (Specially Protected) Fauna Notice 2003*. A number of breeding and haul out islands are protected as nature reserves, and existing marine parks further protect marine areas of Australian sea lion habitat. The current conservation status of the Australian sea lion in Australia is detailed in Table 2.

Table 2: Current conservation listings for the Australian sea lion in Australia

Listing	Conservation status
Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)	Listed as Vulnerable in 2005
National Parks and Wildlife Act 1972 (South Australia)	Listed as a protected species in 2008
Fisheries Management Act 2007 (South Australia)	Protected
Wildlife Conservation Act 1950 — Wildlife Conservation (Specially Protected) Fauna Notice (Western Australia)	Specially protected as threatened fauna in 2003

5 IMMEDIATE AND KNOWN CONSERVATION THREATS

Historically, the main anthropogenic threat to the Australian sea lion was hunting and overharvest through sealing activities during the 1700s, 1800s and early 1900s. Although this activity was stopped in the 1920s, the Australian sea lion population has not recovered to pre-exploitation levels (AFMA, 2010).

Life history characteristics of the Australian sea lion are suspected to have contributed to lack of recovery of the species post-commercial sealing. Slow maturation and low fecundity, an extended breeding cycle and philopatry are all indicative of adaptations to improve breeding and foraging success in a nutrient poor environment, where benthic prey availability is low but stable,. These are also characteristics that make this species highly vulnerable to extinction.

The prevalence of philopatry among female Australian sea lions is especially problematic for the species, because it effectively negates dispersal. In situations where breeding colonies are very small or have gone extinct, immigration of pregnant or sexually mature females to facilitate growth or recolonisation is not possible. In instances where extinction has occurred, it is possible the Australian sea lion will not recolonise those sites. The extirpation and non-recovery of several breeding sites within, and to the east, of the current geographic range of the species are cases in point. Given the genetic diversity recently demonstrated among populations of the Australian sea lion, it is likely that historical and future extinctions may irreversibly diminish matrilineal genetic diversity.

A range of anthropogenic factors have been identified which may be impacting on the recovery of the Australian sea lion. The cumulative impact of many of these threats varies across the range of the species. Fisheries bycatch and entanglement in marine debris appear to pose the greatest threat to the Australia sea lion at present, while secondary threats include habitat degradation and interactions with aquaculture operations; human disturbance to colonies; deliberate killings disease; pollution and oil spills; noise pollution; prey depletion and competition and climate change.

5.1 Primary threats

5.1.1 Fishery bycatch

5.1.1.1 Demersal gillnet fishing for shark

Recent research confirms that interactions with commercial gillnetting operations have been a significant cause of mortality of Australian sea lions and are likely to be limiting population growth (Goldsworthy, et al., 2010). Gillnets are mesh nets that are designed to target a particular fish species through the use of net size in which target species get stuck while smaller species swim through.Species too large to push their heads through the mesh as far as their gills are not retained.

Shark gillnetting in southern Australia commenced in the late 1960s, firstly to target school shark *(Galeorhinus galeus)* and later gummy shark *(Mustelus antarcticus)*, and has remained largely unchanged since that time (Kailola, et al., 1993; Larcombe & McLoughlin, 2007). The most significant demersal gillnet fishery is the Commonwealth managed gillnet sector of the Southern and Eastern Scalefish and Shark Fishery (SESSF), which operates from the Western Australia-South Australia border to the Victorian-New South Wales border. In South Australia, a bilateral agreement between the Commonwealth and South Australian governments permits fishing across shelf waters under both jurisdictions, from near shore coastal waters to a depth of 183 m. Annual fishing effort peaked in 1987 at 43 000 km of net-lifts, declining to and remaining steady at about 17 000 km of net-lifts since 2000 (DSEWPaC, 2010). In 2009/10 and 2010/11, gillnetting effort increased again to around 37 000 km net-lifts and 40 000 km net-lifts in each year, respectively (Woodhams, et al., 2011). In South Australia, effort has been concentrated along the west coast of the Eyre Peninsula and along the south coast of Kangaroo Island (DSEWPaC, 2010). A lower level of demersal gillnetting for sharks also occurs across Western Australian shelf waters under similar bilateral agreements between the Australian and Western Australian governments, managed by the Western Australian government (McAuley & Leary, 2010).

The gillnets used across the range of the Australian sea lion typically involve a mesh size that can also entangle large species, including the Australian sea lion. Once caught, Australian sea lions often drown before the nets are retrieved or may tear out a section of the net or be cut free by fishers (Gales, et al., 1994; Page, et al., 2004). Concerns about the impact of demersal gillnetting on the Australian sea lion are longstanding and were initially motivated by the regular occurrence of entanglements observed on individuals ashore at breeding colonies and haul-out sites (Shaughnessy & Dennis, 2001; Shaughnessy & Dennis, 2002; Page, et al., 2004). Two anecdotal reports from shark fishers indicate high levels of bycatch by individual gillnetters, with one report of 20 animals being killed each year during the 1990s (Shaughnessy, et al., 2003).

Reliable estimates of Australian sea lion mortality from gillnetting operations have only recently become available, as fishers have not historically been required to keep records of interactions with this species. Together with limited observer coverage of commercial fishing operations, this has led to only small numbers of interactions being reported and it is likely that reporting has under-represented the actual bycatch (Hamer, 2007; DEWHA, 2010). Achieving a reliable estimate of bycatch is further complicated by drowned animals dropping out of gillnets, due to being minimally entangled and subsequently not being detected by the operator or observers (Goldsworthy, et al., 2010). For example, in a study of bycatch mortality rates undertaken over 24 months in South Australia, Goldsworthy, et al. (2010) reported that 10 (83 per cent) of the 12 Australian sea lion bycatch mortalities dropped out of the gillnet before or on making contact with the net roller, as the net was hauled out of the water. In addition, other animals may escape and die later from injuries (Hamer, et al., 2011).

A study undertaken by the South Australian Research and Development Institute (Goldsworthy, et al., 2010) estimated that Australian sea lion mortality off South Australia, as a result of interactions with the gillnet fishing sector, was around 374 animals per breeding cycle (17.5 months) of which, it was estimated, approximately 197 would be female. The study concluded that this level of mortality equated to about 3.9 per cent of the overall female population being removed as bycatch mortality each breeding cycle, which was further estimated to be an approximate 35 per cent increase from natural mortality levels.

Fisheries closures around Dangerous Reef (South Australia) provide a case study of what might happen if gillnets are removed from the foraging range of Australian sea lion colonies. As previously noted, the Dangerous Reef population is the only Australian sea lion population known to have undergone a recent recovery in numbers and the explanation for this is likely to be linked to the restriction of gillnet fishing in the region following closures in 2001 (Goldsworthy, et al., 2007b).

The majority of the Australian sea lion population found in waters offshore of South Australia is contained within the boundaries of the Shark Gillnet and Shark Hook Sectors of the SESSF. The SESSF, including these commercial gillnetting operations, is an approved Wildlife

Trade Operation (WTO) under the EPBC Act (until 28 February 2013) and is accredited for interactions with protected species. The first environmental assessment of the SESSF was conducted in 2003 and highlighted the potential for operational interactions between Australian sea lions and demersal gillnetting. This prompted the Australian Government environment department (currently DSEWPaC) to recommend that the Australian Fisheries Management Authority (AFMA), the managers of the SESSF, to (i) *"establish a robust reporting system"* and (ii) *"if necessary, trial and implement appropriate mitigation measures such as spatial closures"* (Commonwealth of Australia Gazette, 2010). As such, a number of research activities were initiated, funded mainly by the Fisheries Research and Development Corporation and DSEWPaC.

Perhaps most importantly, independent monitoring of fishing effort from 2006 to 2007 reported levels of observed bycatch that were higher than anticipated. Specifically 12 bycaught and drowned animals were reported from a total of 994 km of gillnet observed hauled from 234 fishing events or sets (i.e. 2.9 per cent of the combined length of gillnets set across South Australian waters during the two year monitoring period; Goldsworthy, et al., 2010). Based on the calculated annual length of gillnet set in the fishery (i.e. 17 355 ± 852 km) and the bycatch rate observed from monitored fishing, it was estimated that 293–324 Australian sea lions were becoming bycaught and drowning each breeding cycle across South Australian shelf waters (Hamer, et al., 2013). The bycatch rate is likely to be similar, or at least at the same order of magnitude, across a substantial portion of South Australian shelf waters because the absolute minimum overlap between Australian sea lion foraging and fishing effort has been estimated to be 68.7 per cent (Hamer et al., 2013). Thus, a simple extrapolation based on kilometres of net and observed interactions is appropriate. Based on a more sophisticated 'equal sample size' approach, a similar estimate was obtained of 374 (272–506 ± 95 per cent confidence limit) Australian sea lions being bycaught and drowning each breeding cycle across South Australian shelf waters (Goldsworthy, et al., 2010).

Although 12 drowned animals were observed, 10 (83 per cent) dropped out of the fishing gear as they were raised to and above the surface of the water, raising concerns about the proportion of drowned animals that go unobserved and unreported, and are thus excluded from calculated estimates of bycatch (Hamer, et al., 2013). The two animals that were hauled aboard the vessel were small juveniles, suggesting the weight of larger animals may cause structural failure of the gillnet meshes as the dead animal is hauled through the water, or as the full effect of gravity occurs as they are hauled from the water. Additionally, others may drop out of the net as it is hauled off the benthos, or may become temporarily bycaught and then escape with an entanglement. Whatever the case, the mortality estimates based on observed bycatch should be viewed as a minimum. The fact that entangled animals are frequently observed on land (refer: section 5.1.2) further supports this conclusion.

Formal measures to protect the Australian sea lion are stipulated in the SESSF WTO approval, with closures and an Australian Sea Lion Management Strategy for the fishery implemented by AFMA as conditions of this approval. Further information regarding management of the SESSF is available at: www.afma.gov.au/managing-our-fisheries/fisheries-a-to-z-index/southern-and-eastern-scalefish-and-shark-fishery

Recent research on the interaction between commercial fisheries and the Australian sea lion (Goldsworthy, et al., 2010) has informed deliberations on what measures are required to afford a sufficient level of protection to the Australian sea lion within the area of impact of the SESSF. Following this research and further work undertaken by AFMA, revised management arrangements have been put in place for the SESSF, including modified zone boundaries, lowered maximum bycatch trigger limits for each management zone, increased observer coverage and new identification and reporting requirements. The revised triggers permit a maximum bycatch level of 15 Australian sea lions per fishing season. Consistent with these measures, as of February 2012, areas of the fishery that have exceeded the Australian sea lion bycatch trigger for their zone have been closed for 18 months, so that the period of closure will encompass one full breeding cycle for that zone. More information on Australian sea lion bycatch is available at:www.afma.gov.au/australian-sea-lion-management-strategy-reset-maximum-bycatch-trigger-limits

An observer program is not currently in place in the Western Australian temperate demersal gillnet fisheries, therefore the impacts of possible bycatch off the Western Australian coastline are currently unquantified. However, an observer program that operated from 1994 to 1999 recorded only one dead Australian sea lion over the six years of the program (McAuley & Simpfendorfer, 2003). While there is less demersal gillnet fishing effort in Western Australia than in South Australia, Campbell (2011) reviewed information on Australian sea lion foraging effort and gillnetting activity in Western Australia and found there is almost complete spatial overlap. The Western Australian Department of Fisheries is currently reviewing the monitoring arrangements for Australian sea lions in its temperate demersal gillnet fisheries.

Fisheries bycatch (including in demersal gillnet fisheries and rock lobster fisheries) has been assessed in the Commonwealth's marine bioregional plans as a pressure 'of concern' for the Australian sea lion in the South-west Marine Region. More information on the South-west Marine Region is available at: www.environment.gov.au/coasts/marineplans/index.html

5.1.1.2 Pot fishing for rock lobster

The diet of juvenile Australian sea lions includes rock lobsters (Gales & Cheal, 1992; Ling, 1992; McIntosh, et al., 2006). The use of rock lobster pots in areas close to Australian sea lion breeding colonies, or in areas where animals forage, may result in occasional bycatch related mortality, as the animals may become caught inside the lobster pots as they attempt to depredate on the caught lobsters. Quantitative studies are scarce, although in Western Australia, annual surveys provided estimates of zero to 12 interactions over five years, in waters less than 20 m deep and within 30 km of breeding colonies (Campbell, et al., 2008b). Satellite tracking of animals from colonies in areas where rock lobster fishing occurred indicated that the foraging area of the tracked animals overlapped spatially with the rock lobster fishing effort (Campbell, et al., 2008).

No quantitative data on bycatch rates are available from the South Australian Rock Lobster Fishery (Goldsworthy, et al., 2010). However, Goldsworthy, et al., (2010) suggested that the bycatch impact from the South Australian Rock Lobster Fishery was likely to be smaller than from the SESSF because there was less overlap in fishing effort with Australian sea lion foraging effort (i.e. two-thirds of the fishing effort occurred in areas with little foraging); fishing was restricted to eight months of the year and bycatch was likely to be restricted to pups and juveniles. In addition, the use of sea lion exlusion devices (SLEDs) provides a relatively simple management solution for sea lion interactions with rock lobster pots, while management solutions for gillnet fishing are more complex.

In Western Australia, mitigation was effected by modifying rock lobster pots to include a spike (an upright steel rod attached to the base of the pot, rising up towards the centre of the opening at the top of the pot) or a batten (a steel bar straddling the opening at the top of the pot; Campbell, et al., 2008b). The SLED is designed to exclude individuals that may attempt to enter the pot via the neck opening to depredate (i.e. remove) rock lobsters within the pot. The mandatory use of SLEDS in the West Coast Rock Lobster Fishery was implemented in the 2006/07 season in the mid-west region in waters less than 20 m deep. The area was designed to include most of the habitat utilised by pups, which comprised most of the bycatch (Campbell, et al., 2008b). Since then, two new SLED zones for the Abrolhos Islands have been introduced. From the 2011/12 rock lobster season, fishers are required to use a SLED of either design within these specified SLED zones. More information on SLEDs is available at: www.fish.wa.gov.au/Documents/recreational_fishing/additional_fishing_information/sea_lion_exclusion_devices.pdf

In South Australia, anecdotal reports suggest spikes have been used for some time by fishers to exclude depredating Australian sea lions and New Zealand fur seals. However, there is no formal management framework that regulates the use of spikes in areas close to Australian sea lion colonies, in waters of a certain depth, or in any other critical marine habitat. Nonetheless, the effectiveness of the spike in deterring depredating Australian sea lions and their effect on commercial catch rates has been explored to determine the practicality of implementing or regulating their use in South Australia.

Experimental trials were carried out in South Australia to determine the most effective height at which to set spikes to prevent Australian sea lions from entering lobster pots (Goldsworthy, et al., 2010; Hamer, et al., in preparation). In addition, an industry based trial was conducted to determine the impact of using spikes on rock lobster catch rates and catch size distribution. The findings of these studies indicate that the use of a spike that is level with the bottom of the neck is most effective in deterring depredating individuals from entering the pot and putting themselves at risk of becoming incidently caught and drowning, while having little or no economic impact on the fishery.

5.1.1.3 Other fishing

Interactions between Australian sea lions and the recreational or Indigenous fishing sectors have not been quantified. Thus, it is not known whether these fishing sectors pose a threat to Australian sea lion populations. Further information is needed to determine the level of interaction these sectors may have with Australian sea lions and the potential impacts to the species.

5.1.2 Entanglement in marine debris

A number of studies have shown that entanglement in marine debris is likely to be a significant source of mortality for Australian sea lion populations and may be contributing to their lack of recovery across certain parts of their range (Page, et al., 2004; Shaughnessy, et al., 2006). Entanglement in marine debris has been assessed in the Commonwealth's marine bioregional plans as a pressure 'of concern' for the Australian sea lion in the South-west Marine Region. More information on the South-west Marine Region is available at: (www.environment.gov.au/coasts/marineplans/index.html Surveys have indicated high levels of entanglement and identified that most of the debris is likely to have originated from the fishing sector. A study at Seal Bay during the 1990s and early 2000s found that about 1.3 per cent of the overall population was likely to have entanglements, one of the highest rates reported for any species of pinniped (Page, et al., 2004). Monofilament polyamide or polypropylene gillnet, identical to that used by the demersal shark gillnet fishery in southern Australia, was responsible for 55 per cent of all observed entanglements. Other material included trawl netting (either demersal or pelagic: 11 per cent), packing tape (used in wrapping frozen bait boxes in the rock lobster and longline fisheries: 11 per cent), monofilament fishing line (used by recreational fisheries and by commercial longline and dropline fisheries: 6 per cent) and tyre inner tube (rings used to secure structures in intertidal oyster aquaculture: 3 per cent; Page, et al., 2004). The study was unable to ascertain whether the netting entanglement was obtained when the individual encountered active fishing gear, or originated from already discarded or lost fishing gear. However, techniques such as those used in the net identficiation kit developed by the World Wide Fund for Nature (WWF) Australia for northern Australia (White, et al., 2004) could potentially be used to identify the origin of marine debris entangling Australian sea lions.

Given the synthetic and typically durable nature of the materials involved in entanglements, they are unlikely to biodegrade in the short-term. The constant movement of these typically active animals and the growth of younger animals suggest that entanglement material effectively becomes abrasive, eventually becoming embedded in the skin and flesh and causing extensive wounds (Pemberton, et al., 1992; Page, et al., 2004; Figure 7). Although the only published account is for Seal Bay, the occurrence of entanglement has been observed in both South Australia and Western Australia (e.g. Mawson & Coughran, 1999; Page, et al., 2004). Based on the work at Kangaroo Island, Page, et al., (2004) estimated that approximately 64 Australian sea lions die each year from marine debris entanglement across their range.

Earlier studies of pinniped entanglement in the northern hemisphere suggest that entanglement rates may be up to 35 times higher than can be determined from land-based observations alone, because entangled animals either die from injury or exhaustion at sea before they can return to land; need to stay at sea for much longer periods to forage to compensate for inefficiencies associated with the entanglement or haul-out in locations away from breeding colonies to avoid stress and further injury associated with the interactive nature of colonial life (Fowler, 1987; Fowler, et al., 1990).

Figure 7: Australian sea lions observed entangled at breeding colonies.

(a) Juvenile at Seal Bay entangled in monofilament demersal gillnet identical to that used by the shark fisheries operating along Australia's southern coastline, which appears to be firmly lodged around its neck in the typical manner of most entanglements on pinnipeds. (b) Adult female at English Island nursing a brown pup, exhibiting an extensive neck injury caused by the cutting effect of thin and non-biodegradable demersal gillnet material (removed two days prior to taking this picture).

(Source: [a] Nick J. Gales; [b] Derek J. Hamer).

a

b

In the early 1980s, the Commonwealth Government introduced the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*, which prohibits the disposal of plastic in Australian and international waters, in recognition of the International Convention for the Prevention of Pollution from Ships (MARPOL) ratified in the late 1980s. Additionally in the early 2000s, the Australian and some state governments developed or implemented bycatch action plans for a number of fisheries that, among other things, was designed to mitigate situations where non-target species were "killed as a result of interaction with fishing gear (including lost fishing gear)… described as unaccounted mortality resulting from fishing" (AFMA, 2001; Page, et al., 2004). The fishing industry is developing ways to reduce the impact of bait packaging that uses strapping. For example, the Western Australian Department of Fisheries introduced the prohibition of "at sea" possession of bait bands from 15 November 2011, making it illegal to carry plastic bait bands on board recreational fishing vessels after this date. More information is available in the Recreational Fishing From Boat Licence 2011/2012 brochure published by the Western Australian Department of Fisheries, available at: www.fish.wa.gov.au.

Although a recent quantitative assessment of the impacts of these measures has not occurred, entanglements are still regularly observed at breeding colonies. Therefore, further efforts to reduce Australian sea lion entanglement in fishing gear may be necessary, given that it is likely to be a significant conservation threat, in addition to the threat directly attributable to observed bycatch mortality.

In addition, the Commonwealth Threat Abatement Plan for the Impact of Marine Debris on Vertebrate Marine Life notes that the Australian sea lion has been "documented as negatively impacted by ingestion of, or entanglement in, harmful marine debris" (DEWHA, 2009). Objective 2 of the threat abatement plan is to "remove existing harmful marine debris from the marine environment". As such, the implementation of this threat abatement plan, through activities to remove bait bands and fishing lines from beaches, rocky shores and the water, would also assist in reducing the impacts of marine debris on Australian sea lions.

5.2 Secondary threats

5.2.1 Marine aquaculture

The primary potential impact from marine aquaculture is due to loss of habitat for the Australian sea lion. A minor impact is entanglement in subsurface equipment and subsequent drowning.

Finfish aquaculture activities may result in the alteration of water chemistry due to nutrient influxes caused by precipitation of effluent from the farmed fish and of unconsumed feed pellets or bait fish, resulting in significant changes to the abundance and diversity of benthic flora and fauna (Brown, et al., 1987), although the impact is generally thought to be localised (Brown, et al., 1987; Cheshire, et al., 1996). Australia's largest tuna aquaculture industry near Port Lincoln in South Australia underwent sustained growth during the 2000s. Although the impact on Australian sea lion populations is currently unknown, it seems to have had little impact on the nearby breeding colony at Dangerous Reef, which underwent sustained population growth during the 2000s (Goldsworthy, et al., 2007a; Goldsworthy, et al., 2009b).

In addition, the use of rack and line structures for sub-tidal and intertidal mussel and oyster farming tends to occur in shallow waters close to the coast, which often results in the loss of seagrass beds (Wear, et al., 2004; Bryars, et al., 2007). This outcome may have deleterious, albeit localised, consequences for the Australian sea lion, as foraging habits for this species indicate that seagrass beds are an important habitat (Goldsworthy, et al., 2009b; Lowther, et al., 2011).

There has been no formal observer program to record deaths of Australian sea lions as a result of aquaculture operations. A small number of Australian sea lion deaths have been recorded as a result of animals drowning in the anti-predator nets used by this industry (Kemper & Gibbs, 1997). The use of these nets has now been reduced and husbandry practices related to repairing holes in nets and removing dead fish that attract Australian sea lions have improved. Collision or entanglement with infrastructure, including marine aquaculture infrastructure, has been assessed in the Commonwealth's marine bioregional plans as a pressure 'of potential concern' for the Australian sea lion in the South-west Marine Region.

Without recent reliable estimates on the number of Australian sea lion deaths due to aquaculture operations the extent of the problem remains unknown, but is likely to be minor. The aquaculture industry is expected to expand across the range of the Australian sea lion and this issue will need to be continually monitored.

5.2.2 Habitat degradation

Habitat degradation may occur as a result of land based run-off or impacts of developments such as aquaculture operations. Direct impacts on Australian sea lion survival may occur from these sources if they alter prey availability or impact on the feeding substrate. There is some evidence that localised impacts may occur from aquaculture cages (Brown, et al., 1987), but little evidence to suggest that impacts are widespread and affecting survival or reproductive success.

5.2.3 Human disturbance

The definition of human disturbance used here is restricted to any occasion when humans deliberately or accidentally place themselves in close proximity to Australian sea lions, on land or at sea. In these situations, individual Australian sea lions may display outward signs of fright, vigilance, aggression, reduced pup suckling time and/or relocation of females to suboptimal habitat (Orsini, 2004, Lovasz, et al., 2008). Land and boat based wildlife tourism, commercial and recreational boating activities and aircraft all have the potential to cause some level of disturbance that will elicit these responses. Disturbance at colonies during the breeding season may be particularly detrimental. Pups are likely to be the most affected, when their mothers flee a perceived or real threat and thus disrupt or end a feeding attendance session, or when the entire colony stampedes toward the sea for the same reason and tramples pups in the process. Similar situations for other pinniped species are known to contribute to shorter attendance times by mothers, which results in a reduced growth rate in their pups (Lidgard, 1996). Studies on California sea lions *(Zalophus californianus)* have indicated that weekly human disturbance can result in permanent relocation of many females with their pups to adjacent sites (Richardson, et al., 1995).

Human presence at sensitive sites has been assessed in the Commonwealth's marine bioregional plans as a pressure 'of potential concern' for the Australian sea lion in the South-west Marine Region. Over the last 15 years, pinniped tourism has experienced rapid growth in the Southern Hemisphere, particularly in Australia and New Zealand where at least four sites, including Seal Bay, South Australia, attract more than 100 000 visitors per year (Orsini, 2004). Tourism based activities are known to occur at 10 Australian sea lion breeding colonies and haul-out sites, three in South Australia and seven in Western Australia (Orsini, 2004). The level of human disturbance in South Australia is managed at popular tourist sites (i.e. Seal Bay, Point Labatt and Jones Island) through guided tours, the accreditation and licensing of tour operators, and through restricting access through viewing platforms. However, unregulated and unmonitored access occurs at many other haul out and breeding sites, including independent bushwalkers/sightseers and researchers. In these situations, the onus is on the tour operator or general public to ensure their presence has minimal impacts, although visitor awareness of and appreciation for these issues is minimal (Orsini, 2004; Orsini & Newsome, 2005).

The Seal Bay breeding colony on Kangaroo Island is a major tourist attraction and was visited by 100 000 tourists each year during the mid 1990s to mid 2000s (DSEWPaC, 2010). Determining limits to the numbers of people permitted to visit Seal Bay (or other colonies) each year and minimum approach distances has been difficult, as there are no baseline studies available for periods prior to tourism with which to compare them. Nonetheless, one recent behavioural study at Seal Bay concluded that the minimum approach distance of six metres in place during the early 2000s should be extended to a minimum of 10 metres (Lovasz, et al., 2008), which has since been adopted.

Mitigation to prevent undue disturbance to Australia sea lions at Seal Bay from tourism exists in the form of a tour accreditation for commercial tour operators. This is assessed by the South Australian Department of Environment, Water and Natural Resources.

5.2.4 Direct killing

There have been numerous records of instances of direct killing of Australian sea lions, along with anecdotal reports of fishers and aquaculture operators shooting animals that are perceived to be a threat to their operations (Kemper, et al., 2003). In South Australia, around the Port Lincoln area, five carcasses that had been shot were retrieved between 1995 and 2000 (Kemper, et al., 2003). In Western Australia between 1980 and 1996 there were 14 recorded instances of Australian sea lion mortality as a result of being shot, and a further four due to spearing, shooting with arrows or clubbing (Mawson & Coughran, 1999). It is unlikely that a reliable estimate of overall mortality due to direct killings can be established as most deaths go unreported.

5.2.5 Disease

The degree and manner in which disease interacts with body condition, immune response and fertility rates in sea lion species is largely unknown and hence it is very difficult to estimate its contribution in limiting Australian sea lion population growth. However, several lines of evidence suggest disease is a significant cause of mortality in sea lion populations.

McIntosh (2007) undertook necropsies on 128 Australian sea lion pups to identify the cause of mortality. The causes were found in about half of these cases — with factors such as trauma, emaciation, still-birth and possible shark attack being identified — but no factor was identified in the other half of cases. It is likely that disease and pathogens played a role in these unattributed deaths.

In support of this idea, hookworm (Beveridge, 1980) and tuberculosis (Mawson & Coughran, 1999; Cousins, et al., 2003) have been recorded in sea lion colonies and linked to the marked seasonal fluctuations in mortality that appear to occur between summer and winter breeding seasons. Overseas evidence suggests that hookworm can cause significant mortalities in some years in sea lion colonies but the extent that it is limiting growth in Australian sea lion populations is currently unknown.

Mass disease outbreaks are also of particular concern. Overseas, thousands of pinnipeds have died in short periods of time through disease outbreaks (Baker, 1999). Although this has not occurred in Australian sea lion populations, small colonies would be particularly susceptible to an outbreak. The prevalence of disease and disease outbreaks is an area identified for ongoing research.

5.2.6 Pollution

As the Australian sea lion is a higher order predator, there is the possibility that persistent organic contaminants may accumulate in their bodies and have a long-term impact on health. To date there is no evidence of this, although research has been limited.

5.2.7 Oil spills

Oil spills pose a threat to all pinniped populations, especially those near major shipping lanes (Shaughnessy, 1999). Oiling of pinnipeds may lead to hypothermia if the fur is affected and to poisoning if toxic hydrocarbons are ingested, resulting in reduced foraging and reproductive fitness or death. Worldwide in the past four decades, there have been 26 oil spill events that are known to have affected pinnipeds (St. Aubin, 1990). In Australia, two oil spills have been known to have affected seals. The first occurred in 1991 when the bulk ore carrier MV Sanko Harvest wrecked off the south coast of Western Australia and spilled approximately 700 tonnes of fuel oil into the sea. Some of the oil washed onto two nearby New Zealand fur seal breeding colonies at Hood Island and Seal Rocks, in the Recherche Archipelago and at least 64 New Zealand fur seal pups were observed oiled at those two sites (Gales, 1991). Two Australian sea lions were also observed oiled at Figure of Eight Island, a possible Australian sea lion breeding colony, some 50 km to the northwest. The overall impact at the time and in the long-term on New Zealand fur seal and Australian sea lion populations in the area remains unclear. The second oil spill occurred in Tasmania in 1995 when the bulk ore carrier MV Iron Baron ran aground and spilled approximately 300 tonnes of fuel oil, affecting waters around the Australian fur seal colony on Tenth Island (Pemberton, 1999). At least 20 seals of various age groups were observed oiled and the number of pups born in the following breeding season was reduced (Pemberton, 1999). Again, the overall long-term impact on Australian fur seals at Tenth Island remains unclear.

A long-term biological study spanning 14 years, following the ‘Exxon Valdez’ oil spill in Alaska, indicates the persistence of sub-surface oil contamination at sub-lethal levels, which continues to affect wildlife populations (Peterson, et al., 2003). With increasingly busy transport shipping activity in waters at the western and eastern ends of the range of the Australian sea lion (i.e. from Perth along the southwest and south coasts of Western Australia and from Adelaide along the east of Kangaroo Island and the south coast of the Eyre Peninsula), the risk and impacts of further oil spills have also increased. Oil pollution has been assessed in the Commonwealth’s marine bioregional plans as a pressure ‘of potential concern’ for the Australian sea lion in the South-west Marine Region.

5.2.8 Noise

Although research into the vulnerability of the Australian sea lion to noise disturbance has not been undertaken, studies of similar species (e.g. harbour seal and grey seal) in the Northern Hemisphere indicate that pinnipeds are likely to be susceptible to increased noise levels or noise pollution,for example, from seismic surveys, construction or operation activities (Gordon, et al., 2003). Exposure to sharp, short sounds of moderate intensity for extended periods may cause avoidance behaviour and/or hearing threshold changes in pinnipeds (Gordon, et al., 2003). In addition, although indirect effects of noise on marine mammals (e.g. through impacts on their prey) has not been investigated, studies on the effects of seismic noise on bony fish (e.g. Turnpenny & Nedwell, 1994) indicate that seismic pulses may affect marine mammal prey species (Gordon, et al., 2003). Noise pollution has been assessed in the Commonwealth's marine bioregional plans as a pressure 'of potential concern' for Australian sea lions in the South-west Marine Region.

5.2.9 Competition and prey depletion

Australian sea lions may compete for food with humans and other marine predators. Across much of their range, Australian sea lion populations occur in waters shared with the New Zealand fur seal and, to a lesser extent, with the Australian fur seal. Given this broad scale range overlap in the species distributions, there has been speculation over the degree of inter-specific competition for prey resources, especially as populations of both fur seal species are currently increasing.

Current knowledge of the foraging ecology and diet of the Australian sea lion and of the distribution and abundance of its prey is insufficient to determine the degree to which the Australian sea lion competes with fur seals for food resources. However, given that all three species once coexisted at greater population densities before the advent of sealing (Shaughnessy & Warneke, 1987), niche differentiation is expected to be well developed. Anatomical and physiological differences between the Australian sea lion and fur seals (such as body size of adults) also suggest that the three species are able to exploit different food resources. However, the recent establishment of an Australian fur seal colony at North Casuarina Island (southwest of Kangaroo Island, at the eastern end of the geographic range of Australian sea lions) may result in localised competition for mutually targeted benthic prey species, which may become a larger problem over time if seals at this colony continue with westward expansion of their range (Shaughnessy, et al., 2010).

Little is known about the trophic interactions between fisheries and pinnipeds in Australian waters, either through direct competition for the same stocks or through more subtle competition through alteration of trophic structure. In South Australia, there are several significant commercial fisheries that may be exploiting several species that are also important prey for the Australian sea lion. The stocks of school shark and several other species that are present in the diet of Australian sea lions declined during the 1980s, possibly due to overexploitation (BRS, 2004; Walker, et al., 2005; Woodhams, et al., 2011). Similarly, the commercial rock lobster fishery in South Australia is showing signs of being overfished, with declines in catch rate and many critical measures of stock health (i.e. egg production, puerulus settlement, unit weight, biomass estimate, catch per unit effort) over the last one to three decades (Ward, et al., 2004; Linnane, et al., 2011a; Linnane, et al., 2011b). Extraction of living resources has been assessed in the Commonwealth's marine bioregional plans as a pressure 'of potential concern' for the Australian sea lion in the South-west Marine Region..

Incidental observations of Australian sea lions at colonies in South Australia indicated that animals are healthy and in good condition. However, the removal or reduction of several species important as prey to the Australian sea lion may reduce foraging and thus reproductive success, possibly over long periods if the effect is subtle.

5.2.10 Climate change

The definition of climate change used here is confined to sea level rise and 'wave wash' events associated with extreme weather patterns. The effect of ocean acidification due to carbon emissions and introduction into the marine environment on food production is also likely to have some level of impact in the future, although the process and extent remain unclear. In addition, increasing ocean temperatures may change ocean productivity and have been linked to lower pup survival (Goldsworthy, et. al., 2010). The Austrailan government's marine bioregional plans assessed climate change as a pressure 'of concern' with respect to changes in sea surface temperature and 'of potential concern' with respect to sea level rise; changes in oceanography and changes in ocean acidification for the Australian sea lion in the South-west Marine Region.

There has been a prolonged warming in the earth's atmosphere since the industrial revolution commenced in the mid 1700s (Levitus, et al., 2001).Global average surface temperature increased by about 1°C between 1961 and 1990 alone, presumably due to greenhouse gas effects (IPCC, 2007). Increased temperatures have caused polar ice caps to melt, with sea level rise occurring as a result. It is projected that sea level may rise by up to 88 cm by 2100 from 1990 levels (Rahmstorf, et al., 2007; Garnaut, 2011). Associated with these climatic changes is an increased frequency and likelihood of extreme weather events, which at sea are increasingly associated with unusually strong winds and large swells in shelf and coastal regions (IPCC, 2007). At present, it is unclear what the impact of sea level rise and wave wash events may have had or will have on Australian sea lion colonies. However, most breeding colonies are on very low lying islands, with Dangerous Reef, hosting one of the largest breeding colonies, being only several metres above sea level at the highest point. Assuming the projected sea level rise becomes reality, several smaller breeding colonies — such as the one on Nicholas Baudin Island — will become completely submerged. There are many anecdotal reports of pups being washed off rocks during bad weather, especially at fur seal breeding colonies. Although the impacts on Australian sea lions remains unclear, the combination of big wave events and sea level rise is likely to impact on small breeding populations that reside on low lying islands.

6 SUMMARY OF ISSUES

This issues paper has been developed to support the Recovery Plan for the Australian Sea Lion. It summarises the biology and ecology of the Australian sea lion and details the immediate and identifiable threats to the species. Specifically, those threats and priority ongoing issues are outlined in brief below.

- **Fishery bycatch in demersal gillnets.** This is a significant source of mortality for Australian sea lions. Estimated bycatch is in the low hundreds in waters adjacent to South Australia based on observed bycatch rates, with the possibility of more going unobserved. Considerable inroads have been made by AFMA and the associated fishery to mitigate the threat, including through high levels of observer coverage and year-round spatial closures. Much larger closures are implemented if mandated bycatch limits—which are reflective of the prevalence of small breeding populations—are reached. The effectiveness of the recent mitigation mechanisms requires ongoing assessment.
- **Fishery bycatch in rock lobster pots.** While considered a much smaller threat than bycatch in demersal gillnets, relatively simple gear changes that have little impact on rock lobster catch can be made to mitigate Australian sea lion bycatch. While mitigation measures have been implemented by some fishers throughout the range of the Australian sea lion, mandated use in close proximity to breeding colonies has only been implemented on the west coast of Western Australia.
- **Entanglement in marine debris.** An entanglement survey at one breeding colony and several anecdotal reports indicate that Australian sea lions are regularly entangled in monofilament gillnet material, which is likely to result in eventual death. Although the extent of this threat is uncertain, it is thought that many entangled individuals may go unobserved. Although pups may become entangled in lost material, juveniles and adults may acquire entanglements when they incidentally collide with active gillnets, or when they escape after becoming bycaught while attempting to depredate caught fish. Further measures are required to mitigate the impacts of entanglement in marine debris.
- **Human disturbance.** The arid islands along the south and west coast of Australia are important breeding sites for Australian sea lions. Visitors (e.g. tourists and researchers) may disturb Australian sea lions and elicit responses such as fright, vigilance, aggression, reduced pup suckling time and/or relocation of females to suboptimal habitat. The rapid increase in marine aquaculture may also disrupt breeding activities, or may destroy seagrass beds, which is a key foraging habitat. The impacts of human interactions on Australian sea lion colonies need to be monitored and mitigation measures developed.

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8 APPENDICES

Appendix 1. Known breeding sites for the Australian sea lion and range of pup counts

Table 3: The location of known breeding sites for the Australian sea lion and range of pup counts over the 23 years from 1985.

Locations are given in decimal degrees. Local names are noted by quotation marks. States are indicated as SA (South Australia) and WA (Western Australia). The year and method used for the most recent pup count for each location are given. Estimation methods are: (1) Mark-recapture (Petersen), (2) Direct count, (3) Cumulative mark and count, (4) Partial count from a boat or cliff. Methods range in decreasing order of accuracy from: 1 (most accurate) to 4 (highly inaccurate). 'UK' indicates timing of breeding season unknown. Sources of pup count data are: (1) Shaughnessy (2005b), Shaughnessy & Goldsworthy (2007), (2) Goldsworthy et al. (2008b), (3) Goldsworthy et al. (2008a), (4) Gales et al. (1994), (5) Goldsworthy et al. (2009b), (6) Goldsworthy et al. (2007a), (7) Shaughnessy et al. (2005), (8) Robinson et al. (2008), (9) Dennis (2005), (10) Shaughnessy (2005a), (11) Shaughnessy (2008), (12) Goldsworthy et al. (2007b), (13) S. Goldsworthy (unpublished data), Shaughnessy et al. (2011), (14) Goldsworthy et al. (2003)*, (15) Campbell & Gales (unpublished), (16) Shaughnessy et al. (2009), (17) Dennis & Shaughnessy (1996), (18) Dennis & Shaughnessy (1999), (19) N. Gales (unpublished data), (20) Goldsworthy et al. (2009a). The 58 breeding sites with five or more pups (i.e. those known as 'breeding colonies') are considered as habitat critical to the survival of the species.

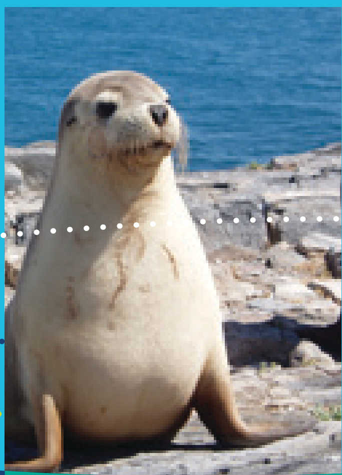
**** 26 pups from haul-out sites (Dennis & Shaughnessy, 1996) were apportioned to B1-B6, B8, B9 on the basis of the proportion of pups at each site.***

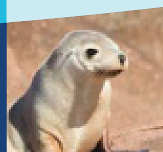
Status	State	Site	Lat.	Long.	Breeding seasons surveyed (1985–2008)	Pup count range (1985–2008)	Best available recent pup survey			
							Year	Method	Pup count	Source
Breeding colonies — habitat critical to the survival of the species										
	SA	North Pages Island	-35.7590	138.3011	13	177-312	2005	1	258	1
	SA	South Pages Island	-35.7771	138.2917	13	197-331	2005	1	331	1
	SA	'Seal Slide' (Kangaroo Is)	-36.0257	137.5361	11	1-16	2007	1	16	2
	SA	Seal Bay (Kangaroo Is)	-35.9965	137.3270	16	122-260	2007	1	260	3
	SA	Peaked Rocks	-35.1868	136.4830	2	15-24	1990	3	24	4
	SA	North Island	-35.1207	136.4761	3	1-28	2005	3	28	5
	SA	Dangerous Reef	-34.8170	136.2170	11	248-709	2007	1	709	6
	SA	English Island	-34.6379	136.1958	6	4-27	2005	2	27	5
	SA	Albatross Island	-35.0686	136.1814	2	12-15	2005	4	15	5
	SA	South Neptune (Main) Islands	-35.3303	136.1118	6	0-6	2008	3	6	13
	SA	North Neptune (East) Islands	-35.2301	136.0683	2	11-14	2005	3	14	5
	SA	Lewis Island	-34.9570	136.0317	2	78-131	2007	1	131	2
	SA	Liguanea Island	-34.9984	135.6199	3	1-43	2004	2	43	5
	SA	Price Island	-34.7076	135.2895	1	-	1996	3	25	7
	SA	Rocky Island (North)	-34.2587	135.2605	1	-	1996	3	16	7
	SA	Four Hummocks (North) Island	-34.7577	135.0421	1	-	1996	3	12	7
	SA	West Waldegrave Island	-33.5962	134.7615	4	79-157	2003	2	157	7
	SA	Jones Island	-33.1853	134.3671	7	5-15	2007	1	15	2
	SA	Ward Island	-33.7409	134.2850	3	2-45	2006	3	45	8
	SA	Pearson Island	-33.9486	134.2614	7	1-35	2005	3	35	9
	SA	Point Labatt	-33.1523	134.2607	8	1-6	2005	4	6	10

Status	State	Site	Lat.	Long.	Breeding seasons surveyed (1985–2008)	Pup count range (1985–2008)	Best available recent pup survey			
							Year	Method	Pup count	Source
	SA	Nicolas Baudin Island	-33.0157	134.1330	5	49-98	2006	2	98	11
	SA	Olive Island	-32.7191	133.9698	8	12-206	2006	1	206	12
	SA	Lilliput Island	-32.4486	133.6685	3	(62-69	2008	1	64	13
	SA	Blefuscu Island	-32.4623	133.6392	3	92-106	2008	1	84	13
	SA	Gliddon Reef	-32.32	133.56	2	7	2005	3	7	5
	SA	Breakwater Island	-32.3217	133.5613	4	6-17	2005	1	17	5
	SA	Lounds Island	-32.2730	133.3657	4	4-34	2008	3	34	20
	SA	Fenelon Island	-32.5810	133.2817	5	10-40	2008	3	40	20
	SA	West Island	-32.5108	133.2513	3	14-56	2005	2	56	5
	SA	Purdie Island	-32.2698	133.2284	5	34-132	2005	3	132	5
	SA	Nuyts Reef (west)	-32.1186	132.1314	1	-	2004	3	12	7
	SA	'Bunda Cliffs B1'	-31.5175	131.0611	2	11-15	1995	3	15	14
	SA	'Bunda Cliffs B2'	-31.5862	130.5808	3	1-5	1995	4	5	14
	SA	'Bunda Cliffs B3'	-31.5823	130.1259	4	5-31	1995	4	31	14
	SA	'Bunda Cliffs B5'	-31.5851	130.0306	3	1-43	1995	4	43	14
	SA	'Bunda Cliffs B6'	-31.6094	129.7618	3	3-12	1995	4	12	14
	SA	'Bunda Cliffs B8'	-31.6396	129.3810	3	2-38	1995	4	38	14
	SA	'Bunda Cliffs B9'	-31.6467	129.3114	2	7-17	1995	4	17	14
	WA	Spindle Island	-33.7630	124.1610	1	-	1990	3	53	4
	WA	Ford (Halfway) Island	-33.7660	124.0410	1	-	1990	2	24	4
	WA	Six Mile Island	-33.6400	123.9680	3	40-43	2000	2	40	15
	WA	Round Island	-34.1050	123.8880	1	-	1990	3	20	4

Status	State	Site	Lat.	Long.	Breeding seasons surveyed (1985–2008)	Pup count range (1985–2008)	Best available recent pup survey			
							Year	Method	Pup count	Source
	WA	Salisbury Island	-34.3600	123.5520	1	-	1990	3	14	4
	WA	Stanley (Wickham) Island	-34.0200	123.2910	1	-	1989	3	18	4
	WA	Glennie Island	-34.0960	123.1050	2	21-24	1999	2	21	15
	WA	Taylor Island	-33.9200	122.8730	UK	-	1992	3	7	4
	WA	Kimberley Island	-33.9490	122.4690	3	27-42	2001	2	27	15
	WA	MacKenzie Island	-34.2000	122.1115	1	-	1992	3	5	4
	WA	Rocky Island	-34.0833	120.8667	1	-	1989	3	17	4
	WA	West Island	-34.0820	120.4850	1	-	1991	3	20	4
	WA	Red Islet	-34.0400	119.7800	3	23-30	2001	2	23	15
	WA	Middle Doubtful Island	-34.3747	119.6070	1	-	1989	3	10	4
	WA	Haul Off Rock	-34.7020	118.6610	3	13-29	2001	2	19	15
	WA	Buller Island	-30.6565	115.1150	9	32-49	2004	1	42	15
	WA	North Fisherman Island	-30.1297	114.9440	9	43-66	2004	1	48	15
	WA	Beagle Island	-29.8080	114.8770	9	47-79	2004	1	58	15
	WA	Abrolhos Islands, Easter Group (Serventy, Suomi, Alexander, Gilbert Is.)	-28.6667	113.8167	3	11-17	2004	2	17	15

Status	State	Site	Lat.	Long.	Breeding seasons surveyed (1985–2008)	Pup count range (1985–2008)	Best available recent pup survey			
							Year	Method	Pup count	Source
Haul-out sites with occasional pupping										
	SA	'Black Point', Cape Gantheaume Wilderness Area (Kangaroo Island)	-36.0382	137.4063	2	1-1	2002	4	1	16
	SA	Cave Point, Cape Bouguer Wilderness Area (Kangaroo Island)	-36.0258	136.9574	2	1-3	1990	3	3	16
	SA	Cape Bouguer, main site (Kangaroo Island)	-36.0416	136.9088	6	0-3	1999	3	3	16
	SA	North Casuarina Island	-36.0682	136.7025	4	1-3	1996	3	3	16
	SA	Dorothee Island	-33.9969	134.2487	UK	-	1996	3	1	7
	SA	Point Fowler ('Camel-foot Bay')	-32.0108	132.4378	1	-	1994	3	1	17
	SA	Nuyts Reef (middle)	-32.1386	132.1414	UK	-	1990	3	3	4
	SA	'Bunda Cliffs B4'	-31.5856	130.0611	2		1995	4	2	14
	SA	'Bunda Cliffs B7'	-31.6250	129.5105	UK		1994	4	3	14
	WA	'Bunda Cliffs B10'	-32.2790	126.0117	2	2-4	1996	4	4	18
	WA	Cooper Island	-34.2310	123.6070	2	3-4	1999	2	4	19
	WA	SW Rock (Twin Peaks Island)	-33.9833	122.9000	UK	-	1990	3	1	4
	WA	Kermadec (Wedge) Island	-34.0880	122.8340	1	-	1992	3	4	4
	WA	Poison Creek Island	-33.9167	123.3300	UK	-	1988	3	2	4
	WA	Little Island	-34.4570	121.9900	UK	-	1990	3	1	4
	WA	North Cervantes Island	-30.52	115.04	1		2004	3	1	15
	WA	Sandland Island	-30.24	114.98	1		2004	3	1	15
	WA	Abrolhos Islands, Southern Group (Square Is.)	-28.9022	113.9442	3	2-3	2004	2	2	15





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