The Action Plan for

Australian Seals

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by

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Environment Australia
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Foreword

After a history of over-exploitation, seals are now benefiting from legal protection in Australian waters, and recovering in both numbers and range. The Australian population of the New Zealand fur-seal, for example, seems to be relatively healthy, after suffering a severe decline due to indiscriminate harvesting in the late 18th and early 19th centuries. Several breeding colonies have established or been discovered in recent decades, and some colonies are close to their carrying capacity.

Despite this encouraging response to the cessation of sealing, full recovery in numbers and distribution has not occurred for any previously harvested species, and new threats have displaced the commercial exploitation that caused such devastating declines in the past. Of the ten pinniped species inhabiting Australian waters, one, the Subantarctic fur-seal, is classified as *Endangered*, while another, the southern elephant seal, is classified as *Vulnerable*, according to the 1994 IUCN Red List criteria. Three other species depend on existing habitat-specific conservation measures and could become threatened if these were removed or weakened. Only four of the ten species are currently considered to be at low risk, largely because they favour the vast areas of Antarctic sea ice, and have been historically less available for exploitation. These species may not be so lucky in the future, as people exploit their environment even more energetically.

Marine and coastal environments now face a proliferation of human activities that may affect seals both directly and indirectly. This increased pressure on the oceans is recognised in the United Nations *Convention on the Law of the Sea* and the Commonwealth's recently launched *Australia's Oceans Policy*. As fisheries, oil exploration, transport and tourism expand in range and intensity, seals will be increasingly threatened by the associated disturbance, pollution, debris and disease, often with impacts far beyond their source. There will be increased interactions with seals, particularly with fisheries operations with which they may be perceived to compete. Awareness and management of these issues is critical if renewed seal decline is to be averted.

The Action Plan for Australian Seals reviews the conservation status of each of the 10 seal species inhabiting Australian waters, including the waters of the Australian Antarctic Territory. It summarises the current knowledge on their biology, abundance and distribution, identifies the threats and recommends research and management actions required for their conservation. It also notes deficiencies in our knowledge of seals; while we may have good information on the breeding locations of most species, there is little known about the major feeding areas for any of the species. Such information is essential if we are to ensure minimal impact in future uses of the marine environment.

This plan is the eighth in a series of action plans commissioned to assess the conservation status of major faunal groups. Previously published are those for birds, freshwater fishes, reptiles, rodents, cetaceans, marsupials and monotremes, and frogs. Action plans for bats, dugongs and butterflies are in preparation. Conservation overviews for non-vascular plants and non-marine invertebrates have also been published, while overviews for marine algae, invertebrates and fish have recently been commissioned by Environment Australia.

The Action Plan for Australian Seals will be an essential guide to the future conservation of Australian seals and to the management of activities that could potentially reverse the recent recovery of some species. A precautionary approach will be necessary to ensure that these important members of marine ecosystems endure and do not become relegated to myth and memory.

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Summary

There are ten pinniped species, or seals, regularly recorded in Australian waters. Three of them, the Australian sea-lion, New Zealand fur-seal and Australian fur-seal, breed on the coast of the Australian mainland (including Tasmania) and its nearshore islands. Another three species, the Antarctic fur-seal, Subantarctic fur-seal and southern elephant seal breed on Australia's Subantarctic islands (Macquarie, Heard and the McDonald Islands). The remaining four species breed in Antarctic waters: the leopard seal, crab-eater seal and Ross seal on pack ice, and the Weddell seal on fast ice adjacent to the Antarctic mainland. Elephant seals and leopard seals are frequent visitors to Tasmania. The first five species are eared seals (family Otariidae) and the last five are earless or true seals (family Phocidae). Only one species is endemic, the Australian sea-lion.

Australia has been interpreted in a broad sense to include the Australian Antarctic Territory, the Australian territory of Heard Island and the McDonald Islands, Macquarie Island (administratively and politically part of Tasmania), as well as mainland Australia and its inshore islands. It also includes the Exclusive Economic Zone, which extends beyond all of the above named areas to 200 nautical miles off-shore. When referring to seals on the coast of mainland Australia and its inshore islands, and in nearby waters, the expressions "Australian coast" and "Australian mainland waters" are used. This includes Tasmania, its islands (other than Macquarie Island) and its waters.

In waters up to 3 nautical miles off-shore and on land where seals haul-out, moult, rest and breed, management of seals is the responsibility of State nature conservation agencies under State legislation. The Commonwealth has responsibility for seals in the waters of the Continental Shelf outside State coastal waters and within the Australian Exclusive Economic Zone (EEZ) up to 200 nautical miles off-shore.

All ten seal species were assessed against the IUCN Red List Categories (IUCN 1994); these category names are used here in italics. Although the IUCN indicates that the criteria are most appropriately applied to whole taxa at a global scale, only the status of each species in Australia was taken into account, following advice from the Australian Nature Conservation Agency (ANCA).

On the basis of that assessment, one species, the Subantarctic fur-seal, is considered to be *Endangered* in Australian waters because of its small numbers (even though it is increasing). A positive step in the conservation of this species would be the declaration of a marine reserve around Macquarie Island to include the territorial sea to 12 nautical miles as a protected area with minimal human interference (see recommendations by Scott 1994). Such a reserve would provide safe access to the Subantarctic fur-seals' terrestrial breeding sites and protect a portion of its feeding grounds.

Another species, the southern elephant seal, is considered to be *Vulnerable*, on the basis of the sharp decrease in its numbers from about 1950 to the mid 1980s. The cause of the decrease is not known.

Neither of these species would fall into a threatened category if considered on a world-wide basis. Of the two, the southern elephant seal deserves attention because of its substantial population decrease since 1950.

The Australian sea-lion is considered to be *Lower Risk, near threatened* because the number of mature individuals is below the limit of 10,000. Three species, the New Zealand fur-seal, Australian fur-seal and Antarctic fur-seal, are considered to be *Lower Risk, conservation dependent* because the cessation of a "habitat-specific conservation programme" could lead to each of them qualifying for a threatened category if ready access by humans to breeding sites were permitted during the breeding season. Each of the four Antarctic phocid species, leopard seal, crab-eater seal, Weddell seal and Ross seal, is considered to be *Lower Risk, least concern*.

Critical habitat for Australian seals comprises breeding colonies of the terrestrially breeding species in Australian mainland waters (Australian sea-lion, New Zealand fur-seal, Australian fur-seal) and on Subantarctic islands (Antarctic fur-seal, Subantarctic fur-seal and southern elephant seal), waters adjacent to breeding colonies on the Australian mainland and waters adjacent to Subantarctic islands, favoured feeding places of seals, and the vicinity of fishing vessels and fishing nets.

Nine threatening processes are described. They are direct killing; interaction with fisheries; entanglement; oil spills and chemical contaminants; disturbance by aircraft, vessels and humans; tourism; disease; seismic survey activity; and climate change.

The major problem for seals in the waters of mainland Australia is conflict with fisheries. fur-seal populations are increasing and fishery interactions will increase concurrently. Conflicts between seals and fisheries pose problems for managers of nature conservation agencies and of fisheries agencies. Research and management actions to minimise impacts from threatening processes include:

- minimising interactions between seals and fishing gear
- encouraging fishers not to discard non-biodegradable material at sea
- aiming to understand ecological interactions between seals and fisheries
- establishing marine protected areas adjacent to seal colonies
- determining where seals feed and on what.

Biological characteristics of the ten seal species are described and a series of conservation actions covering both research and management are proposed. They include: following trends in abundance, determining the genetic source and genetic relatedness of populations, investigation of the feeding ecology of seals, and the recommendations summarised above relating to seals and fisheries. An underlying theme that is apparent in many of the proposed research actions (without being stated explicitly in the text) is that long-term studies are essential if good research data are to be collected for management purposes. Research on species in Australian mainland waters should be coordinated between Commonwealth and State nature conservation and fisheries agencies because of their combined management responsibilities.

Three flagship taxa are suggested for public education programs: the Australian sea-lion, southern elephant seal and leopard seal. The first of these is the only Australian endemic seal species, is picturesque and is relatively well known by the public as a result of opportunities to view it. The southern elephant seal and leopard seal frequently visit the Australian coast, particularly Tasmania, where they are the object of public attention. Each has a distinctive appearance and the leopard seal's reputation as a fearsome predator of warm blooded animals focuses attention on it.

The report notes the proliferation of seal marking schemes, as well as problems associated with it. Formation of a central (national) seal marking registry is recommended, similar to that maintained by the Australian Bird and Bat Banding Scheme by Environment Australia, Biodiversity Group. A central registry would be a point of reference to avoid duplication of marks in concurrent marking programs, would provide information and contacts in regard to assessments of marking and attachment techniques, and would assist in directing recovery information to taggers.

Breeding colonies of the three species that breed on the Australian coast, the Australian sea-lion, New Zealand fur-seal and Australian fur-seal, are listed, along with the land classification of each colony and the pertinent management agency. Nearly all breeding colonies are managed by State nature conservation agencies. One island in Western Australia that supports breeding colonies of both Australian sea-lions and New Zealand fur-seals is vacant crown land (Hauloff Rock); action should be taken to include it in the reserve system of the Department of Conservation and Land Management.

Acknowledgements

Many people assisted in the preparation of this Action Plan by commenting on a draft that was circulated in March 1995; they are listed in Appendix I.1, and their assistance is acknowledged here. Bob Warneke, Nick Gales and David Pemberton, in particular, provided detailed comments on the draft report.

Advice on how to interpret the rules for threatened categories in IUCN (1994) was obtained from John Croxall, a member of one of the groups of the IUCN Species Survival Commission. Greg Hood applied the RANGES package for the determination of the extent of occurrence of some species for the application of IUCN's guidelines for threatened species.

Bruce Male, Lyn Meredith, Jamie Pook, Stephanie Maxwell, Sally Stephens and especially Geoff Larmour of the Threatened Species and Communities Section of Environment Australia, Biodiversity Group are thanked for their guidance in the preparation of this report.

1 Introduction

1.1 Background

A number of seal species were hunted by Aboriginal people in coastal southern Australia beginning at least 8,000 years ago (Stockton 1982). Species taken included Australian fur-seals, New Zealand fur-seals, southern elephant seals and leopard seals. There are many archaeological sites with prehistoric seal remains on the Tasmanian coast, particularly in the north-west. Evidence from these includes teeth of juvenile elephant seals and indicates that a breeding colony was nearby.

Seals were important in the economy of the early European settlement of Australia because of their availability, the ready markets for seal products in China and later in London, the low level of capital and skill required to establish the industry, and the ready supply of unskilled labour. There were no effective controls to inhibit the sealers and their commercial masters. Consequently the seals were heavily over-harvested.

Seals received legal protection in the southern States of Australia at different times: 1889 in Tasmania, 1891 in Victoria, 1892 in Western Australia, and 1919 in South Australia (Warneke 1982), and 1918 in New South Wales (L. Llewellyn, *in litt.*). Some sealing did continue after these dates though. In Tasmania, residents of Cape Barren Island were permitted to harvest seals on islands in eastern Bass Strait. Most of this activity ceased around 1923 when the open season changed from summer to winter.

In Western Australia, sealing was permitted in 1920 (Serventy 1953), and in Victoria it was permitted in 1948-49. In the latter case, permits were issued to licensed professional fishermen and culling was restricted to two colonies, Seal Rocks and Lady Julia Percy Island. Carcasses were utilised for oil, meat-meal and leather (Warneke 1966). Seals have also been killed at fishing vessels (Warneke and Shaughnessy 1985).

The habitats of seals in Australia have not been greatly modified by sealing or other activities. In particular, their terrestrial habitats have suffered little interference from people since sealing ceased. The marine habitat close to Australia has been altered by many human activities including fishing, shipping and oil exploration and extraction. These alterations are small relative to those that have occurred in terrestrial Australia, however, where 18 mammalian species have become extinct (Kennedy 1990a, Shaughnessy 1994).

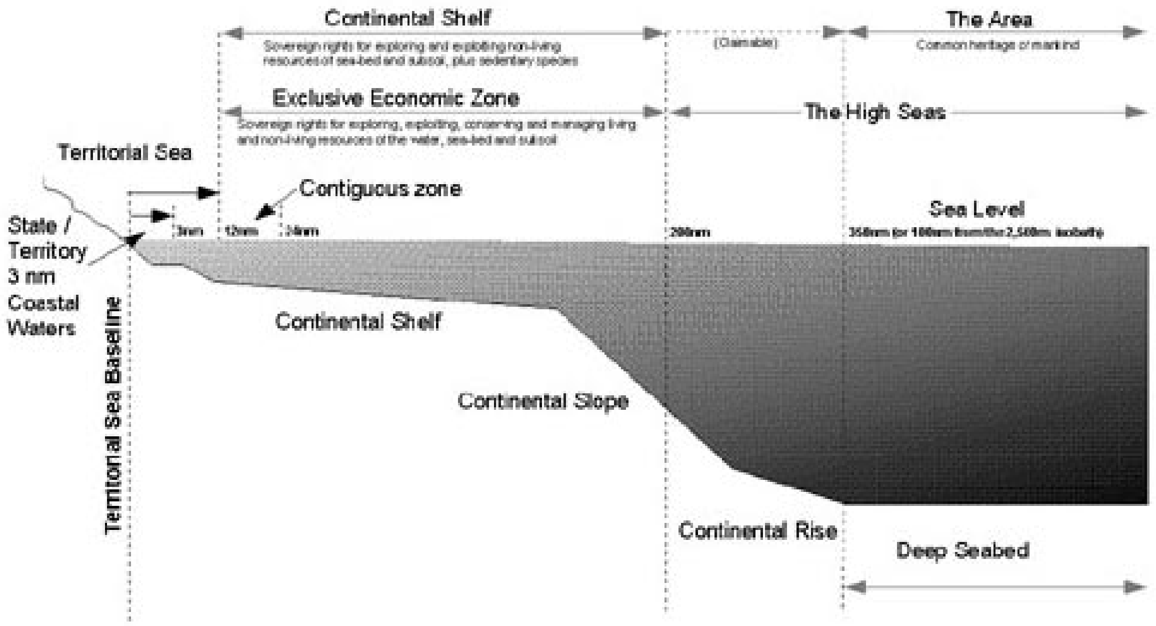
Although early sealing in Australia was an example of the tragedy of the commons (Daly 1994), numbers of most of our seal species have increased since exploitation ceased. Thus we have a second chance to conserve seals in Australian waters.

Increases in seal populations of Australia are likely to provide opportunities for tourism but also to result in conflicts with commercial and recreational fishing. In addition, calls for sustainable harvesting of wildlife resources may increase as the policy of ecologically sustainable development is implemented by resource managers. In this situation wildlife managers need information to make sound judgements about the conservation and management of seal populations.

1.2 Management responsibilities

In waters up to 3 nautical miles off-shore and on land where seals haul-out, moult, rest and breed, management of seals is the responsibility of State nature conservation agencies under State legislation (see Appendix III). The Commonwealth has responsibility for seals in the waters of the Continental Shelf outside State coastal waters and within the Australian Exclusive Economic Zone (EEZ) up to 200 nautical miles off-shore (Figure 1). All members of the Order Pinnipedia are protected under Schedule 1 of the National Parks and Wildlife Regulations in force under the National Parks and Wildlife Conservation Act 1975, which is administered by Environment Australia (EA). Thus an integrated Commonwealth/State approach to their management is essential.

Figure 1. Australia's maritime zones



(J. Gillies, G. Anderson, Environment Australia)

Two States have addressed similar issues to those discussed in this Action Plan. New South Wales has published the *Management manual for marine mammals* (Smith 1997), following a workshop held in Sydney in June 1995. A pinniped plan is being produced in Western Australia, based on discussions at a workshop held in Perth in September 1996.

At the time of writing the Commonwealth Government was developing an Oceans Policy for Australia via a consultative process. Amongst the stated goals for the policy are "to understand, monitor and conserve Australia's marine biological diversity, the ocean environment and its resources and ensure that oceans uses are ecologically sustainable" (Commonwealth of Australia 1998). Particular management problems related to pinnipeds were recognised in *Background Paper 1* (Commonwealth of Australia 1997).

1.3 Species reviewed

This Action Plan is concerned with ten pinniped species (Table 1.1). They belong to two families, the Otariidae (eared seals) and the Phocidae (true seals or earless seals). Three of these species are otariids found in the southern States of Australia: Western Australia, South Australia, Tasmania, Victoria and New South Wales, together with their inshore islands. Two otariid and one phocid species breed on Subantarctic islands. The remaining four phocid species breed on pack ice of the Southern Ocean and on fast ice attached to Antarctica. The only other seal species recorded from Australia is Hooker's sea-lion *Phocarctos hookeri*, which breeds primarily on the subantarctic Auckland Islands (New Zealand). Vagrants have been recorded at Macquarie Island but it is not a regular visitor and so is not included here.

A review of information on each species, presented in Chapter 5, was developed in order to provide some of the basic data for other sections of the Action Plan. This was particularly pertinent for Chapter 2 where IUCN's threatened categories were used to assess species' conservation status.

1.4 Definition of region

In reviewing information on pinniped species, Australia has been interpreted in a broad sense to include the Australian Antarctic Territory (AAT), the Australian territory of Heard Island and the McDonald Islands, Macquarie Island (administratively and politically part of Tasmania), as well as mainland Australia. It also includes the EEZ, which extends beyond all of the above named areas to 200 nautical miles off-shore. Figure 2 shows the External Territories and illustrates Australia's marine jurisdictional zones.

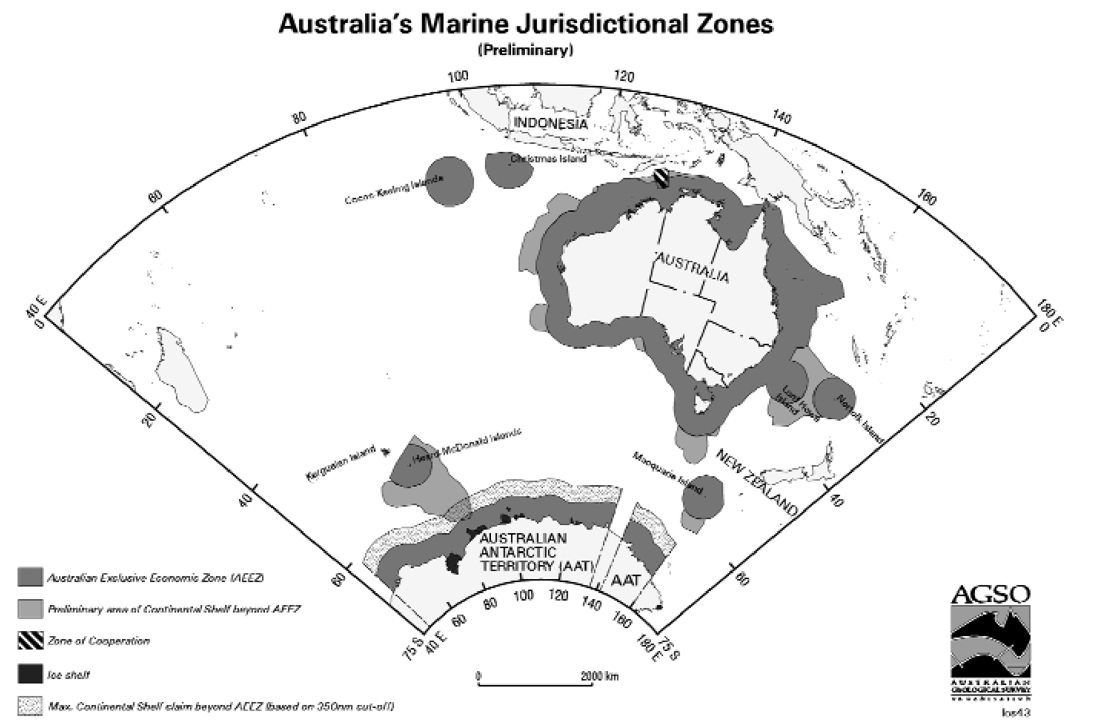
When referring to seals on the coast of mainland Australia and its inshore islands, and in nearby waters, the expressions "Australian coast" and "Australian mainland waters" are used. This should be interpreted as including Tasmania, its islands (other than Macquarie Island) and its waters. The expression "Australian waters" is used in a broader sense to include the Antarctic and Subantarctic regions.

Table 1.1 The ten species of pinniped regularly found in the Australian region.

Family	Scientific name	English name	Breeding area
Otariidae	*Neophoca cinerea*	Australian sea-lion	Mainland Australia
	Arctocephalus forsteri	New Zealand fur-seal	Mainland Australia
	A. pusillus doriferus	Australian fur-seal	Mainland Australia
	A. gazella	Antarctic fur-seal	Subantarctic islands
	A. tropicalis	Subantarctic fur-seal	Subantarctic islands
Phocidae	*Mirounga leonina*	Southern elephant seal*	Subantarctic islands
	Hydrurga leptonyx	Leopard seal*	Sea ice
	Lobodon carcinophagus	Crab-eater seal	Sea ice
	Leptonychotes weddellii	Weddell seal	Sea ice
	Ommatophoca rossii	Ross seal	Sea ice

* The southern elephant seal and the leopard seal also occur frequently in Tasmanian waters.

Figure 2. Australia's Marine Jurisdictional Zones (Preliminary).



Map provided by Australian Geological Survey Organisation, Department of Agriculture, Fisheries and Forestry – Australia

2 Conservation Status

2.1 Introduction

In recent years the International Union for the Conservation of Nature and Natural Resources (IUCN) has revised definitions of its categories of threat (IUCN 1993) and has also provided new sets of definitions, which aim to be “an explicit, objective framework for the classification of species according to their extinction risk” (IUCN 1994, p. 1). Both sets are discussed briefly here, but only the latter was applied to Australian pinnipeds. The results are summarised in Tables 2.1 to 2.5.

2.2 Application of IUCN categories to Australian pinnipeds

Application of IUCN’s 1993 categories in the ‘1994 IUCN Red List of Threatened Animals’ led to only one of the Australian pinnipeds being included in a Threatened category: the Australian sea-lion was listed as Rare. In addition, the same set of criteria was used by the Seal Specialist Group of the IUCN Species Survival Commission (Reijnders *et al.* 1993). They also classified the Australian sea-lion as Rare, but did not list any of the remaining nine taxa of Australian pinnipeds.

IUCN’s listings (or non-listings) of Australian pinnipeds using their 1993 categories are indicated in the species synopses (Chapter 5, at item 5.2, for each species). In November 1994, IUCN proposed a new set of definitions for Red List categories (IUCN 1994). The new definitions and associated criteria are applied in this Action Plan. They are included in Appendix II.

2.3 Interpretation of 1994 IUCN criteria

This section summarises how several of the criteria were calculated or interpreted to evaluate the conservation status of Australian pinnipeds.

2.3.1 Generation time (A.1 & C.1)

These criteria call for an investigation of the population decline “over the last 10 years or three generations, whichever is the longer” (for A.1), or “within 3 years or one generation, whichever is the longer” (for C.1). The age of first reproduction in pinnipeds is about four to five years. For example, the model for the Australian sea-lion used by Gales *et al.* (1994) assumed that females had their first pup at age 4.5 years. Similarly, for the Subantarctic fur-seal, Bester (1995) indicated that females started ovulating at age four years and that all six year old females were sexually mature. Therefore, for analyses of A.1, three generations or 15 years is taken as the time line, since this exceeds 10 years. For analyses of C.1, five years is taken as the time line.

2.3.2 Extent of occurrence (B)

For the three species on the coast of mainland Australia, the Australian sea-lion, New Zealand fur-seal and Australian fur-seal, the extent of occurrence has been calculated with minimum convex polygons using the RANGES 5 package. Its input requires X, Y coordinates; these have been calculated in km from the latitude and longitude for each breeding colony in the following manner.

X For each breeding colony, the distance from the Greenwich meridian (0°) has been calculated using the following formula:

Longitude (degrees and hundredths of a degree) x 60 x 1.853 x cosine (latitude).

Y For each breeding seal colony, the distance from the equator (0°) has been calculated using the following formula:

Latitude (degrees and hundredths of a degree) x 60 x 1.853.

For the three species at Australia’s Subantarctic islands, the Antarctic fur-seal, Subantarctic fur-seal and southern elephant seal, the extent of occurrence has been taken as the total area of the islands.

For the three Antarctic pack ice phocids, leopard, crab-eater and Ross seals, the extent of occurrence has been taken as the mean sea ice extent when each species breeds using Figure 6 of Jacka (1983), together with the proportion of the sea ice within the sectors that extends beyond the Australian Antarctic Territory (AAT). The latter was taken as 0.42, this being the proportion of Antarctica that comprises the AAT.

For the Weddell seal, insufficient information is available on breeding sites or on the extent of the fast ice zone (where the seals breed) to determine its extent of occurrence.

2.3.3 Area of occupancy (B)

For the three species on the coast of mainland Australia, this has been determined using quarter-degree grid cells, ie cells that are half a degree along each side. Such cells are sized about 2,500 km2 on the southern coast of Australia. Their size was calculated as follows:

(0.5 x 60 x 1.853 x cosine (latitude)) km by (0.5 x 60 x 1.853) km.

For the Australian sea-lion and the New Zealand fur-seal, the latitude of most of the colonies is about 34°S. This leads to an area for a quarter-degree grid square of 46.1 x 55.6 = 2,500 km^2.

For the Australian fur-seal, the latitude of most of the colonies is about 39°S. This leads to an area for a quarter-degree grid square of 43.2 x 55.6 = 2,400 km^2.

For the Antarctic and Subantarctic fur-seals, and the southern elephant seal breeding at Heard, McDonald and Macquarie Islands, area of occupancy has been determined using a grid of size 2.5 minutes of latitude and 5 minutes of longitude. Their size (km^2) was calculated as follows:

(2.5 x 1.853) km in a north - south direction
(5 x 1.853 x cosine (latitude)) km in an east - west direction.

The latitude was taken as 53°S. This leads to grid cells of size 4.6 by 5.6 km, with an area of 25.8 km^2.

The area of occupancy has not been calculated for the four Antarctic phocids: leopard, crab-eater, Weddell and Ross seals.

2.3.4 Population size: number of mature individuals (C & D)

For the colonially breeding species, the otariids and elephant seals, estimates of population size have been determined from pup numbers. A population with pup production of 5,000 or more is assumed to contain at least 10,000 mature individuals for criterion C in the *Vulnerable* listing. This is based on the litter size for pinnipeds being one (ie they produce a single pup), and assumes that there are more than 5,000 mature females (since the reproductive rate is less than 1.0) and nearly 5,000 mature males (the sex ratio is presumably less than 1 male to 1 female for mature individuals due to a higher mortality rate for male pinnipeds).

Similarly, for criteria C2a and D in the *Vulnerable* listing, if pup production in a colony is 500 or more, the number of mature animals is assumed to exceed 1,000.

For the four Antarctic phocids, leopard, crab-eater, Weddell and Ross seals, population estimates are based on counts of all age-classes. None is directed specifically at the area of pack ice contained within the Australian Antarctic Territory (AAT); rather they refer to the circumpolar area. For the purposes of these analyses, it has been assumed that the density of the Antarctic phocids is uniform, in the sense that 42% of the population of each species is assumed to be within the sectors of pack ice that extend beyond the AAT (and 58% of it is beyond the AAT).

2.3.5 Probability of extinction

Criterion E has not yet been assessed for any of the species. This work is planned for several otariid species by A. Nicholls and P. Shaughnessy, based on serial pup counts from breeding localities. In the meantime, the assessment conducted here assumes that criterion E is satisfied for all species. If this is later demonstrated not to be the case, assessments in this Action Plan may need revision.

2.4 Application of the 1994 IUCN categories to Australian pinnipeds

All ten seal species were assessed against the IUCN Red List Categories approved on 30 November 1994 (IUCN 1994). Although the IUCN indicates that the criteria are most appropriately applied to whole taxa at a global scale, only the status of each species in Australia was taken into account, following advice from the Australian Nature Conservation Agency (ANCA).

Table 2.1. Summary of the analysis of the conservation status of Australian otariid pinnipeds based on descriptions of the categories in IUCN (1994).

'No' or numbers that exceed the threshold indicate that the species does not satisfy the requirements for that criterion (or part of a criterion) for the listing of *Vulnerable*, and 'Yes' indicates that it does satisfy the criterion.

Criteria	Requirement for *Vulnerable*	Australian sea-lion	New Zealand fur-seal	Australian fur-seal	Antarctic fur-seal	Subantarctic fur-seal
A. Population reduction	>20% in 3 generations	No	No	No	No	No
B. Extent of occurrence (km²)	<20,000	1.05×10^6	1.1×10^6	132,000	497 Yes	496 Yes
B. Area of occupancy (km²)	<2,000	90,000	45,000	19,000	258 Yes	52 Yes
B1. No. breeding locations	<10	60+	31	10	15	3 Yes
B2. Continuing decline	Any of 5 parameters	No	No	No	No	No
B3. Extreme fluctuations	Any of 4 parameters	No	No	No	No	No
Summary of B requirements	Either of two Bs & two of B1, B2, B3	No	No	No	No	No
C. No. mature animals	< 10,000	Yes	> 10,000 No	>10,000 No	15,000 No	<100 Yes
C1. Decline in numbers	>10% in 3 generations	No	No	No	No	No
C2a. No. mature animals in largest colony	<1,000	1,350	>1,000	>1,000	<1,000 Yes	<100 Yess
C2b. Single sub-population?	Yes	Many No	Many No	Several No	No	No
Summary of C requirements	C & one of C! or C2 (either C2a or C2b)	No	No	No	No	No
D. Population size restricted						
D1. No. mature animals in population	<1,000	>1,000	>1,000	>1,000	>1,000	<1,000 Yes
D2. Restriction in area of occupancy or no. locations	<100 km² <5 No	No 60+	No 31	No 10	258 Yes 15	52 Yes 3 Yes
Summary of D requirements	Either D1 or D2	No	No	No	No	Yes
E. Probability of extinction	>10% within 100 years	To be calculated	To be calculated	To be calculated	To be calculated	To be calculated
Conclusion	Any of A to E	Not *Vulnerable* *Lower Risk, near threatened*	Not *Vulnerable* *Lower Risk, conservation dependent*	Not *Vulnerable* *Lower Risk, conservation dependent*	Not *Vulnerable* *Lower Risk, conservation dependent*	*Vulnerable* on criteria C & D Further analysis in Table 2.2

Table 2.2. Summary of the analysis of the conservation status of the Subantarctic fur-seal based on descriptions of the categories in IUCN (1994).

'No' or numbers that exceed the threshold indicate that the species does not satisfy that criterion for the listing of *Endangered*, and 'Yes' indicates that it does satisfy the criterion.

Criteria	Requirement for *Endangered*	Does species satisfy requirement for *Endangered*?	Requirement for *Critically endangered*	Does species satisfy requirement for *Critically Endangered*?
A. Population reduction	>50% over 3 generations	No	>80% over 3 generations	No
B. Extent of occurrence (km²)	<5,000	496 Yes	<100	496 No
B. Area of occupancy (km²)	<500	52 Yes	<10	52 Yes
B1. No. breeding locations	<5	3 Yes	1	3 No
B2. Continuing decline	Any of 5 parameters	No	Any of 5 parameters	No
B3. Extreme fluctuations	Any of 4 parameters	No	Any of 4 parameters	No
Summary of B requirements	Either of two Bs & two of B1, B2, B3	No	Either of two Bs & 2 of B1, B2, B3	No
C. Number of mature animals	< 2,500	<100 Yes	< 250	<100 Yes
C1. Decline in numbers	>20% in 3 generations	No	25% in 3 generations	No
C2a. No. mature animals in				

Table 2.3. Summary of the analysis of the conservation status of Australian phocid pinnipeds based on descriptions of the categories in IUCN (1994).

'No' or numbers that exceed the threshold indicate that the species does not satisfy the requirements for that criterion (or part of a criterion) for the listing of *Vulnerable*, and 'Yes' indicates that it does satisfy the criterion.

Criteria	Requirement for Vulnerable	Southern elephant seal	Leopard seal	Crab-eater seal	Weddell seal	Ross seal
A. Population reduction	>20% over 3 generations	ca 25% Yes	Insufficient data	Insufficient data	No	Insufficient data
B. Extent of occurrence (km²)	<20,000	497 Yes	7.1×10^6	7.6×10^6	Insufficient data	6.7×10^6
B. Area of occupancy (km²)	<2,000	851 Yes	>2,000	>2,000	Insufficient data	>2,000
B1. No. breeding locations	<10	Many No	Continuous No	Continuous No	Many No	Continuous No
B2. Continuing decline	In 5 parameters	In mature individuals Yes	No	No	No	No
B3. Extreme fluctuations	In 4 parameters	No	No	No	No	No
Summary of B requirements	Either of two Bs & two of B1, B2, B3	No	No	No	No	No
C. No. mature animals	<10,000	>10,000 cows	>10,000	>10,000	>10,000	>10,000
C1. Decline in numbers >	10% in 3 generations	ca 25% Yes	No	Insufficient data	No	No
C2a. No. mature animals in largest colony	<1,000	>1,000	Continuous No	Continuous No	Insufficient data	Continuous No
C2b. Single sub-population?	Yes	Many No	Continuous No	Continuous No	Many No	Continuous No
Summary of C requirements	C & one of C1 or C2 (Either C2a or C2b)	No	No	No	No	No
D. Population size restricted						
D1. No. mature animals in population	<1,000	>1,000	>1,000	>1,000	>1,000	>1,000
D2. Restriction in area of	<100 km²	851 No	No	No	No	No
occupancy or no.locations	<5	>5	Continuous No	Continuous No	Many No	Continuous No
Summary of D requirements	Either D1 or D2	No	No	No	No	No
E. Probability of extinction	>10% within 100 years	No plans known to calculate	Insufficient data	Insufficient data	Insufficient data	Insufficient data
Conclusion	Any of A to E	*Vulnerable* on criterion A	Not *Vulnerable*	Not *Vulnerable*	Not *Vulnerable*	Not *Vulnerable*
		Further analysis in Table 2.4	*Lower Risk, least concern*	*Lower Risk, least concern*	*Lower Risk, least concern*	*Lower Risk, least concern*

Table 2.4. Summary of the analysis of the conservation status of the southern elephant seal based on descriptions of the categories in IUCN (1994).

'No' indicates that the species does not satisfy the requirements for that criterion (or part of a criterion) for the listing of *Endangered*, and 'Yes' indicates that it does satisfy the critierion.

Criteria	Requirement for *Endangered*	Does species satisfy requirement for *Endangered*?	Requirement for *Critically Endangered*	Does species satisfy requirement for *Critically Endangered*?
A. Population reduction	>50% over 3 generations	No	>80% over 3 generations	No
B. Extent of occurrence (km²)	<5,000	497 Yes	<100	497 No
B. Area of occupancy (km²)	<500	851 No	<10	851 No
B1. No. breeding locations	<5	Many No	1	Many No
B2. Continuing decline	Any of 5 parameters	In mature individuals Yes	Any of 5 parameters	In mature individuals Yes
B3. Extreme fluctuations	Any of 4 parameters	No	Any of 4 parameters	No
Summary of B requirements	Either of two Bs & two of B1, B2, B3	No	Either of two Bs & two of B1, B2, B3	No
C. Number of mature animals	< 2,500	>10,000 cows No	< 250	>10,000 cows No
C1. Decline in numbers	>20% in 3 generations	Yes	>25% in 3 generations	Just
C2a. No. mature animals in	<250	>1,000 No	<50	>1,000 No

Of the detailed criteria for listing species as *Critically Endangered*, *Endangered* and *Vulnerable*, those for the least extreme case (*Vulnerable*) were examined here in the first instance for each of the ten Australian pinnipeds. The procedure adopted follows the steps in the IUCN document. This is summarised and presented with the results of the analyses in Tables 2.1 to 2.4. Much of the information used in the analyses is provided in the species synopses in Chapter 5.

2.5 Conclusions

All ten species of seal in the Australian region have been assessed against the IUCN Red List Categories approved on 30 November 1994 (IUCN 1994). Results of the assessment are summarised in Table 2.5.

The Subantarctic fur-seal is considered to be *Endangered* in Australian waters, on the basis of its small numbers (even though they are increasing). The southern elephant seal is considered to be *Vulnerable*, on the basis of the sharp decrease in its numbers from about 1950 to the mid 1980s. Neither species would fall into a threatened category if assessed on a world-wide basis, because each is numerous and a major population of southern elephant seal (at South Georgia) is not decreasing (Hindell *et al.* 1994, Hofmeyr *et al.* 1997). Of the two, the southern elephant seal in Australian waters deserves attention because of its substantial population decrease since 1950. The cause of the decrease is not known. One suggestion is that the population overshot equilibrium levels (which are still to be attained). Other suggestions are that changes in the environment of the Southern Ocean may have adversely affected the abundance or availability of their prey, or that predation by killer whales is important.

The Australian sea-lion is considered to be *Lower Risk, near threatened*, because the number of mature individuals is below the limit of 10,000. The New Zealand fur-seal, Australian fur-seal and Antarctic fur-seal are considered to be *Lower Risk, conservation dependent* because the cessation of a “habitat-specific conservation programme” could lead to each of them qualifying for a *Threatened* category if ready access by humans to breeding sites were permitted during the breeding season. Each of the four Antarctic phocids, leopard seal, crab-eater seal, Weddell seal and Ross seal, is considered to be *Lower Risk, least concern*.

Table 2.5. Conservation status of Australian pinniped species as assessed against IUCN (1994) categories.

Scientific name	Common name	Conservation status (IUCN 1994)
Arctocephalus tropicalis	Subantarctic fur-seal	*Endangered (EN)*
Mirounga leonina	Southern elephant seal	*Vulnerable (VU)*
A. forsteri	New Zealand fur-seal	*Lower Risk, conservation dependent (LR,cd)*
A. pusillus doriferus	Australian fur-seal	*Lower Risk, conservation dependent (LR,cd)*
A. gazella	Antarctic fur-seal	*Lower Risk, conservation dependent (LR,cd)*
Neophoca cinerea	Australian sea-lion	*Lower Risk, near threatened (LR,nt)*
Hydrurga leptonyx	Leopard seal	*Lower Risk, least concern (LR,lc)*
Lobodon carcinophagus	Crab-eater seal	*Lower Risk, least concern (LR,lc)*
Leptonychotes weddellii	Weddell seal	*Lower Risk, least concern (LR,lc)*
Ommatophoca rossii	Ross seal	*Lower Risk, least concern (LR,lc)*

3 Key critical habitats

3.1 Terrestrial habitat

The terrestrial habitat of pinnipeds is where they come ashore to breed, moult and rest. On the Australian coast, the terrestrial habitat used by seals is largely untouched and most areas have some protection. These sites are the responsibility of State nature conservation agencies (listed in Appendix I). Nevertheless, human disturbance is still a threat at some island colonies, particularly during the breeding season.

Most disturbance is caused by visitation, for example by professional and amateur photographers, commercial tourism ventures (including those by the white shark viewing industry which often involve berleying to attract predators), private boat owners, inappropriately timed servicing of navigational aid equipment by the Australian Maritime Safety Authority (AMSA), and scientists. There has also been direct harassment at haul-out sites, where seals have been shot or taken for bait (see Chapter 4). Animals can also be disturbed by low flying aircraft, particularly helicopters. If there were ready access to the species’ breeding sites during the breeding season, even though it is illegal, seal numbers could fall rapidly. For that reason, breeding colonies should be considered as critical habitat. Breeding colonies are listed in the Tables in Appendix VII.

For seals on subantarctic Macquarie, Heard and McDonald Islands, their terrestrial habitat could be considered secure. Macquarie Island is a national park administered by the Tasmanian Parks and Wildlife Service. McDonald Island is a designated Wilderness Reserve administered by the Australian Antarctic Division of the Commonwealth Department of the Environment. Nevertheless, these colonies are susceptible to disturbance by people and they should be considered as critical habitat for the same reason as are breeding colonies on the Australian coast.

For seals occupying the Southern Ocean, the “terrestrial habitat” is represented by pack ice or fast ice. Pagophilic species - leopard, crab-eater, Weddell and Ross seals - rely on sea ice to haul-out for rest and to raise pups. The sea ice environment used by these seals covers a vast area and little of it is subject to direct human interference, and so it cannot be considered as a critical habitat. Nevertheless, global warming could pose a threat to pagophilic seals if it were to reduce greatly the area available for haul-out.

3.2 Marine habitat

The second major habitat component of seals is the sea, where they feed and spend a large proportion of their life. This area is the responsibility of nature conservation and fisheries agencies of the States and, beyond State waters, of the Commonwealth.

A weakness in our knowledge of pinnipeds is our ignorance of major feeding areas for any of the species. Seals in Australian mainland waters are at times attracted to fishing vessels and to fishing nets as an opportunistic source of food, and they may suffer as a consequence. In that sense, the vicinity of fishing vessels and fishing nets should be considered as risky habitat for seals, and effort should be devoted to improving our understanding of the interaction between seals and fishing activities. This is dealt with more appropriately under the topic “threatening processes” in Chapter 4.

Fisheries have the potential for depleting food resources available for pinnipeds. If marine areas become known as important feeding habitat for pinnipeds, they should be considered critical habitats and as candidates for inclusion in a system of marine protected areas.

The waters adjacent to fur-seal and sea-lion breeding colonies in Australian mainland waters are also critical habitat in the sense that they are traversed frequently, particularly by mothers at the beginning and end of each feeding bout. Waters adjacent to colonies are also used by seals for resting and for refuge when their colony is disturbed. They may also be important for feeding. Marine protected areas around breeding colonies lessen the interaction between humans (including fishers) and seals and for that reason they are valuable. This need has been recognised by several State nature conservation agencies.

3.3 Marine protected areas

In Western Australia there are two marine protected areas within the range of seals, Marmion Marine Park and Shoalwater Islands Marine Park. There are plans to extend the latter to include waters around Carnac Island (D. Coughran, pers. comm.). A plan for a representative system of marine reserves in Western Australia has been prepared (Marine Parks and Reserves Selection Working Group 1994) and the recommendations include protection of waters around many breeding sites of the Australian sea-lion and New Zealand fur-seal.

In South Australia there are marine protected areas in waters associated with several sea-lion sites. Waters within 2 km of Dangerous Reef in Spencer Gulf are gazetted under the *National Parks and Wildlife Act 1972* as part of a Conservation Park, and Aquatic Reserves have been proclaimed under Fisheries legislation at Seal Bay on Kangaroo Island and at Point Labatt on Eyre Peninsula. The Great Australian Bight Marine Park (GABMP) in South Australian waters (to 3 nautical miles offshore) includes a sanctuary zone of one nautical mile width along the coast that includes nine sea-lion breeding sites.

In 1998 the Commonwealth proclaimed a Marine Park in the Bight consisting of two areas, the Marine Mammal Protected Area and the Benthic Protected Area. The Marine Mammal Protected Area is adjacent to that proclaimed by South Australia and is specifically designed to protect the Australian sea-lion and the southern right whale *Eubalena australis*. Although the area provides an additional buffer to the existing State sanctuaries and aims to allow for integrated management over the whole of the combined protected areas, activities permitted there include fishing.

In Victoria there are several marine protected areas relevant to Australian fur-seals. There are two contiguous areas at Wilsons Promontory Marine Park and Wilsons Promontory Marine Reserve. They extend from Shallow Inlet in the west to Entrance Point, at the entrance to Corner Inlet, in the east. fur-seals occur on Kanowna Island and adjacent Anderson Islets in the Anser Group, within the Marine Reserve. The reserve boundaries extend to 300 m around the islands (Department of Conservation, Forests and Lands, 1989). In Port Phillip Bay transient Australian fur-seals visit the Annulus (Pope's Eye) Marine Reserve. The reserve boundary extends to a radius of 100 m from the centre of the annulus. In Westernport a marine reserve is under consideration for Seal Rocks. Other marine protected areas are proposed for the waters around The Skerries and Lady Julia Percy Island (M. Kitchell, *in litt.* 8 June 1995).

In Tasmania a marine protected area has been proposed around Deal Island in Bass Strait that would include the colony of Australian fur-seals at Judgement Rock (D. Pemberton *in litt.* 31 October 1997). A marine protected area around Macquarie Island has been proposed (Scott 1994, Copson *et al.* 1994) and a proposal has been initiated by the Tasmanian Government (D. Rounsevell, *in litt.*).

The value of the existing marine protected areas on the Australian coast should be assessed, particularly in relation to foraging behaviour of pups before weaning (to about 18 months for sea-lions and 10 months or even longer for fur-seals) and soon after weaning. Pups spend time in the shallows near their breeding colonies. It would be valuable to document the amount of time they spend there and their activities. At Seal Bay, Kangaroo Island, young sea-lions pursue mullet in the shallows close to the colony. If juvenile seals are dependent or even semi-dependent on resources in waters adjacent to their colonies, existing protected areas should be expanded to provide adequate protection for these areas too.

Marine protected areas around seal colonies in Australia are managed by nature conservation agencies or by fisheries agencies. Since seals are managed ashore by nature conservation agencies, it is appropriate that they be managed by the same agency when at sea in order to avoid inconsistencies and maintain an adequate level of protection. It is logical therefore that such marine protected areas should be established under nature conservation legislation rather than fisheries legislation. Another source of variation in marine protected areas is their width from the shore. For ease of management they should be of consistent width, unless there is a good ecological reason for selecting a specific width.

Little is known of where seals feed at sea. If there are favoured feeding places, they should be included in marine protected areas. This is especially important because the otariid seals on the coast of mainland Australia and at the Subantarctic islands nurse their pups for many months. Other marine predators would also benefit from the establishment of protected areas at feeding 'hotspots'.

3.4 Species' critical sites

The two species considered in this Action Plan as threatened are the Subantarctic fur-seal (*Endangered*) and the southern elephant seal (*Vulnerable*). Both breed at Macquarie Island and Heard Island where, as indicated above, colonies are in protected areas. Individuals of both species occasionally come ashore in coastal Australia, but this cannot be considered critical habitat because such behaviour is uncommon. Their critical habitat appears to be in the sea and it is important to know more of their biology there, especially for the elephant seal, which is accorded *Vulnerable* status on the basis of declining numbers.

The southern elephant seal formerly occurred at several sites in western Bass Strait, including King Island. Long-term planning for conservation in that area should not overlook the possibility that this species may recolonise some of its former breeding sites.

Critical habitat for the Australian sea-lion, accorded the status of *Lower Risk, near threatened*, is its breeding colonies, although most of them are in protected areas. Most are isolated, which makes monitoring of compliance with regulations difficult. Consequently, vigilant surveillance is required to limit the types of disturbance outlined at the beginning of this chapter. A major colony at Seal Bay on Kangaroo Island is the site of heavy tourist activity managed by the South Australian Department of Environment, Heritage and Aboriginal Affairs. The effect of these activities there are included in a study entitled "Sustainable Development Strategy for Kangaroo Island". Tourists also view sea-lions at other breeding colonies and at haul-out sites, and guidelines for viewing them need to be developed to encourage practices that do not interfere with the animals' behaviour.

Three species are accorded the status of *Lower Risk, conservation dependent*. They are the New Zealand fur-seal, Australian fur-seal and Antarctic fur-seal. Although their breeding colonies are secure as indicated above, this status is assigned because cessation of a "habitat specific conservation programme" (IUCN 1994, p. 14) could lead to undue disturbance by humans and to lower abundance. In that sense, their breeding colonies should be considered critical habitat.

The Australian fur-seal breeds at a small number of islands (currently ten); it formerly bred at several other islands in Bass Strait and in New South Wales. Long-term planning for conservation should not overlook the possibility that this species may recolonise some of its former breeding sites.

3.5 Conclusions

In summary, critical habitat for Australian seals comprises

- breeding colonies of the terrestrially breeding species, Australian sea-lion, New Zealand fur-seal and Australian fur-seal, on the Australian coast
- breeding colonies of the terrestrially breeding species, Antarctic fur-seal, Subantarctic fur-seal and southern elephant seal, on Subantarctic islands
- waters adjacent to breeding colonies on the Australian coast and waters adjacent to Subantarctic islands
- favoured feeding places of seals
- the vicinity of fishing vessels and fishing activities.

4 Threatening processes

This chapter addresses processes threatening Australian seals and suggests research and management actions to minimise the threats. It is relevant to all Australian seal species but note is made when a threat is particularly relevant to the *Endangered* Subantarctic fur-seal and the *Vulnerable* southern elephant seal.

Seals have been protected in Australian mainland waters from a variety of dates: since 1891 in Victoria, 1892 in Western Australia, 1919 in South Australia (Warneke 1982) and 1918 in New South Wales (L. Llewellyn, *in litt.*). In Tasmania, regulations on sealing were imposed in 1889, but sealing was permitted under limited control until the 1920s (Warneke and Shaughnessy 1985) and seals were not protected there until 1970 (Kirkwood *et al.* 1992). In Australian waters beyond the territorial seas (3 nautical miles), seals have been protected since 1975; and in waters south of 60°S, they have been protected since 1980 (Appendix III). Despite this legal protection, seals are subject to a variety of threatening processes, most of which are direct or indirect consequences of human actions. The threats are discussed here and they are also referred to in the species synopses and elaborated there as required.

Research and management recommendations are presented at the end of each section, and the most important ones are marked with an asterisk.

4.1 Direct killing

4.1.1 Otariids

Although killing is specifically prohibited by legislation, there are instances of seals being shot on the Australian coast. Seals have been killed in order to provide bait for lobster pots or for attracting sharks for tourist viewing, to remove "rogue" seals at fish farms and to remove seals taking fish from fishing gear or otherwise interfering with fishing operations. Warneke (1975) recorded that of 182 tagged juvenile Australian fur-seals recovered away from their natal colony (Seal Rocks in Victoria), 15 (8%) exhibited evidence of having been shot. In Victoria, Australian fur-seals causing persistent damage to fishing nets may be destroyed legally under an authority to control wildlife, but such authorities have rarely been issued for seals (M. Kitchell, *in litt.*). In Tasmania, it was legal to shoot seals that attacked fishing gear until 1975 (Kirkwood *et al.* 1992). These authors still consider shooting to be one of the major threats to seal populations in Tasmania.

As an alternative to shooting Australian fur-seals at fish farms in southern Tasmania, troublesome seals have been caught and relocated to the northern part of the state (Kirkwood *et al.* 1992). Five such marked seals released at Low Head on the north coast in 1990 and 1991 were re-sighted at Dover on the south coast, at least 480 km by sea, between 18 and 25 days later. The authors concluded that capture and relocation of troublesome seals assisted fish farmers because they can be re-trapped, the action engenders positive publicity and it provides an alternative to shooting. This does not seem to be an appropriate solution to the problem, however, because many of the relocated seals return, the seals are stressed and there is the potential of disease spread. The most appropriate method of keeping seals from fish farms is exclusion fences, coupled with education of fish farmers and preceded by placing fish farms in appropriate places (as discussed in section 4.2).

In southern Africa during the 1970s, the commercial purse seine fishery used weighted firecrackers to discourage fur-seals attending their vessels rather than shooting them. The "seal crackers" were considered reasonably successful and about 500,000 were purchased annually (Shaughnessy *et al.* 1981). They have been used more recently in Tasmania and South Australia, but with mixed results. The effects of "seal crackers" on seals are not well known and their use should not be encouraged.

4.1.2 Phocids

Phocid seals were taken in two harvests in pack ice in recent decades. The USSR harvested all five species near the Balleny Islands, Southern Ocean (1,000 km north-west of the Ross Sea and 3,000 km south-east of Tasmania) in the summer of 1986/87 (Dzhamanov 1990). Norwegian sealers harvested all species except Weddell seals in the south-west Atlantic Ocean in spring 1964 (Øritsland 1970).

Harvesting of phocids (and fur-seals) in the Southern Ocean is restricted by the Convention for the Conservation of Antarctic Seals (CCAS), which was promulgated under the Antarctic Treaty system in 1972. The protected species are: southern elephant seals, Ross seals and all species of southern fur-seals (genus *Arctocephalus*). Limits are set on the annual harvest of the other three species: crab-eater seal 175,000, leopard seal 12,000 and Weddell seal 5,000. These limits represent a small proportion of the estimated abundance of each species. The Convention applies south of 60°S and on the Kerguelen Plateau. The Australian legislation that endorses that Convention, *The Antarctic Treaty (Environment Protection) Act 1990*, prohibits Australian nationals from taking seals.

4.1.3 Seal harvesting

Calls for a cull of seals on the Australian coast are often made, usually by frustrated fishers or fishing bodies. They are occasionally put in the context of the Ecologically Sustainable Development paradigm. A cull would not be economically viable in the current absence of a market for seal products (other than bacula from adult male seals). A recent workshop on marine mammal and fisheries interactions held by the Scientific Advisory Committee of UNEP's Marine Mammal Action Plan agreed that "in the real world, the potential benefits of a marine mammal cull in fishery yield could be similar to or less than the normal fluctuations observed in fishery yield" (UNEP 1992, p.6). In Victoria during the 1940s, 1950s and 1960s, fishing industry spokesmen argued that the fur-seal population was rapidly increasing and responsible for the declines in the fish catches and hence the fluctuations in the availability of commercial fish. That argument had little credibility in Victoria because its seal population was stable or increasing very slowly. At Seal Rocks the population increased only slowly, at 2% per annum, between 1967 and 1991 (R. M. Warneke, in Shaughnessy *et al.* 1995b). Furthermore, a seal harvest was permitted in Victoria in 1948-49, but only 691 of the quota of 2,000 were killed (McNally and Lynch 1954).

It is not clear that reducing the abundance of a seal population would enable fish catches to increase. For example, important prey of the South African fur-seal are two species of hake. Since hake are cannibalistic, reducing the abundance of South African fur-seals will not necessarily increase the abundance of hake (Butterworth *et al.* 1988). Furthermore, the models indicate that the impact on the hake fishery of culling seals is minimal and could even be detrimental (Punt and Butterworth 1995). The Australian fur-seal is a subspecies of the South African fur-seal.

Before culling is entertained seriously, other methods of reducing interactions between seals and fishing activities should be investigated. These include encouraging fishers to avoid the seals, limiting the attractiveness of fishing vessels to seals, and altering fishing gear or fishing techniques (see section 4.2).

4.1.4 International trade

Although there is no known international trade in any of the Australian seal species, such trade is always a possibility, especially for bacula of adult males, which fetch high prices. A molecular genetic study of bacula purchased in Chinese medicine shops in Asia and North America suggested that one sample was from an Australian fur-seal. The possibility that it was from a South African fur-seal was not discounted (Malik *et al.* 1997). The latter taxon is more likely to be the source since these seals are harvested for commercial trade. The authors highlighted the possibility of the specimen being from an Australian fur-seal because there is a published sequence of its cytochrome *b* DNA, but not one for the South African fur-seal.

The Convention on International Trade in *Endangered* Species of Wild Fauna and Flora (CITES) aims to limit trade in endangered species between contracting parties. The Australian government is a signatory to CITES, by agreement with the States and Territories. The enabling legislation is the *Wildlife Protection (Regulation of Exports and Imports) Act 1982.* Several Australian seal species are listed on Appendix II of CITES: the southern elephant seal and species of the southern fur-seals of the genus *Arctocephalus.* Appendix II refers to "species which, although not necessarily threatened with extinction, may become so unless trade in specimens of such species is subjected to strict regulation...". Trade would be permitted in these species or in products from them under CITES, provided a management plan were in place. Since all these species are protected by Commonwealth and State legislation, their CITES listing is of no direct consequence to their management in Australia, but is included here for completeness.

Suggested research and management actions to minimise impact

- Discourage fishers and fish farmers from shooting seals.
- Question any calls for a seal cull to reduce interaction between seals and commercial fishers, particularly regarding the benefit and harm of that action.

4.2 Interaction with fisheries

Conflicts between seals and fisheries pose problems for both nature conservation agencies and fisheries agencies. Commercial and recreational fishers often regard seals as competitors and as pests, and some fishers carry firearms for dealing with problem seals (Robinson and Dennis 1988). On the other hand, removal of seals' prey by fishers could be limiting seal population levels.

Interaction between seals and fisheries takes two forms. They are overt or operational, when seals attend fishing boats and fishing gear, take fish that have been caught, take baits, disperse schools of fish targeted by fishers or drive them beyond the range of nets, and damage equipment. The other interactions are covert or ecological, in the form of competition for common prey species. The former interactions often have fatal consequences for seals as some are shot and others become entangled in fishing gear and in other man-made debris.

4.2.1 Operational interactions

On the Australian coast, the most obvious interactions with seals are those involving set nets (eg, to catch Australian salmon on the south coast of Western Australia and to catch sharks in South Australia), the drop-line fishery in Tasmania, the rock lobster fishery in southern Australia, and aquaculture for Atlantic salmon and rainbow trout in Tasmania, and for tuna in South Australia. These fisheries involve caught fish that are relatively accessible and, in some cases, static fishing gear that seals have ample time to find and explore. In the case of the drop-line fishery, the fishing gear is relatively slow moving and the caught fish are completely vulnerable to marauding seals. For Tasmanian waters, Kirkwood *et al.* (1992) summarised interactions between fur-seals and several fisheries (purse seine, rock lobster, gill net, drop line, trawl, troll and fish farm).

Australian sea-lions become entangled in nets set to catch shark commercially (Robinson and Dennis 1988). Anecdotal reports indicate that this could be a relatively important cause of mortality for sea-lions. AFMA's Southern Shark Management Advisory Committee (SharkMAC) has agreed to have shark fishers who work in Commonwealth waters record information in their logbooks on interactions between seals and shark nets.

Australian sea-lions and Australian fur-seals both interact with the rock lobster fishery. Small sea-lions get into rock lobster pots and take baits, which may lead to incidental by-catch, and also scavenge old baits that are discarded from rock lobster vessels. Warneke (1975) reported that 43 of 182 tag recoveries (24%) of juvenile Australian fur-seals were from animals that had drowned in rock lobster pots. Rock lobster fishers in South Australia are modifying pots with a vertical spike placed centrally, which deters small seals from entering (Anon. 1996). In Tasmania, some rock lobster fishers have developed methods of attaching 'seal proof' bait-holders to pots, and others have improved the design of bait holders to make it more difficult for seals to remove the bait (Kirkwood *et al.* 1992).

Although there have been few published reports of seals in Australian waters being caught incidentally to trawl fishing operations, there are many anecdotal reports. Australian fur-seals are caught in the south-east trawl fishery and place themselves at risk by swimming near active trawl nets (Shaughnessy and Davenport 1996). As the abundance of seals increases, it is likely that the by-catch will also increase.

It is likely that many of the sea-lions and fur-seals reported as entangled in netting had been caught in fishing nets. It has not been possible to determine if such netting had been discarded or was fishing actively. There have been cases where a section of net incorporating the seal has been cut out and returned to the sea. It is unknown how often events of this type occur but entangled seals are unlikely to survive. Consequently it would be more humane to kill seals entangled in netting quickly rather than to release them with netting attached. In the case of large trawlers, it might be feasible to catch and restrain a seal up to about 40 kg, and to remove the netting from it. But this would require training of fishing crews. This is being done in New Zealand (M. Cawthorn, pers. comm).

Quantitative research on interactions involving fishing gear and seals on the Australian coast and for the developing fisheries at Macquarie and Heard Islands is lacking. Information is required and the problems need to be defined carefully. Such information could be obtained with trained, independent scientific observers on fishing vessels. Information on the views and attitudes of fishers should also be gathered. From this and from consultations with the fishing industry, attempts should be made to develop fishing methods and to alter equipment to mitigate damage caused by seals, and the damage that fishers cause seals. The fisheries at Macquarie and Heard Islands are operating in areas where they could interact with the Subantarctic fur-seal (*Endangered*) and the southern elephant seal (*Vulnerable*). An observer program established for this fishery includes recording interactions with seals. Fisheries interacting with seals on the Australian coast are referred to above.

For seal problems at fish-holding pens (aquaculture), suggested gear modification involves keeping the seals away from fish with exclusion barriers, protection nets that are kept under tension with weights that surround the perimeter of the farm lease or surround individual holding pens while being set apart from them (Pemberton 1989). Acoustic deterrents have been used in Tasmania, but found to be ineffective (Pemberton 1989). The new high energy acoustic deterrents (eg, the Airmar dB Plus TM which transmits at 10 kHz with an average output of 194 dB re 1µPa at 1 m) should to be tested in carefully designed trials before the investment is made to use them. They are reported to have been effective at fish holding pens on the east coast of the US (Task Force 1996), although they have not been tested rigorously. The main predators there are harbour seals and the acoustic devices may not be as effective against fur-seals as they are against harbour seals.

Consideration should be given to the proposed location of new aquaculture ventures, as it has been demonstrated that the vulnerability of fish farms to attacks by seals was influenced by their proximity to seal haul-out sites (Pemberton and Shaughnessy 1993). Disregard for this principle was shown in 1997 in the planning for a fish farm off Snapper Point, in Backstairs Passage between Kangaroo Island and the mainland. The chosen site was 25 km from the largest colony of the Australian sea-lion at The Pages Islands. Education of fish farmers about the problems that seals cause at fish farms is also important.

Some information is available to advise people about seals and give guidelines for those, including fishers, who have contact with seals. Pamphlets have been produced by Tasmanian and Western Australian management agencies on seals, and Tasmania has also produced a pamphlet on seabirds (see Appendix X). Similar documents for other Australian states and for offshore waters, developed in consultation with the fishing industry, would be valuable in disseminating information and raising general awareness.

4.2.2 Ecological interactions

Quantitative information on the ecological competition between seals and fishers (both commercial and recreational) is required to determine the extent to which seals and humans are competing for the same prey. In New Zealand, for instance, there is little overlap between the prey of New Zealand fur-seals and fish species taken in commercial fisheries (Carey 1992). On the other hand, prey of South African fur-seals shows considerable overlap with the species taken commercially (David 1987). Studies of interactions between predators, prey and the fishery at Heard, McDonald and Macquarie Islands have been instigated, especially those involving southern elephant seals and Patagonian toothfish (Australian Antarctic Division 1997).

The prey of seals can be determined by several techniques, such as scat analysis, examination of vomitus, examination of stomach contents (collected by lavage or after killing the seal), and by direct observation. Gales and Pemberton (1994) have highlighted problems with studying the diet of Australian fur-seals. Because there are biases and shortfalls associated with each technique, it is preferable to use more than one of them in any study. For a study of prey analysis, it is essential to have available a collection of fish otoliths and squid beaks, and access to guides to these hard parts. An atlas of otoliths of fish in Tasmanian waters has been compiled by Gales and Pemberton (1994), and one of fish in Antarctic and Subantarctic waters by Williams and McEldowney (1990). Other useful approaches to studying the diet of seals are through comparison of their lipids with that of potential prey (eg, Iverson 1993), and through the use of a camera attached to a seal's dorsal surface that records an image when it feeds.

A study of feeding ecology also requires information on where seals feed at sea. Data required include the distance offshore; whether animals feed on the continental shelf, at the shelf break or beyond it; the water depth and the time of day. These topics can be investigated with the use of satellite-linked radio transmitters and time-depth recorders.

Because of the lack of information about interactions between seals and fisheries, in terms of competition for the same prey, a precautionary approach should be adopted to the setting of quotas for fish catches, particularly in areas where seals are known to feed. An independent assessment should be conducted of the potential environmental effects of new fisheries before they start (Croxall and Wace 1995).

In the context of the potential competition between fisheries and seals, the by-catch of fish by fishers should also be taken into account. It comprises primarily non-commercial fish species, but they may be important prey for seals. They may be unavailable to seals as a result of being caught and dumped or, on the other hand, they may provide enhanced feeding opportunities near fishing vessels (with concomitant dangers).

It should be noted that AFMA's objectives include management of fisheries in a manner consistent with the "principles of ecologically sustainable development and the exercise of the precautionary principle, in particular the need to have regard to the impact of fishing activities on non-target species …" *(Fisheries Management Act 1991)*.

When finfish aquaculture ventures are planned, the source and amount of food for the penned fish should be taken into account, because its removal is likely to compete with the food supply of marine predators, including seals.

Fishing could have a negative impact on vertebrate predators in the Southern Ocean. In particular, crab-eater and leopard seals could be affected by a krill fishery, as these seals feed directly on krill. Similarly, Subantarctic fur-seals (*Endangered*) and Antarctic fur-seals, which are both piscivorous, could be affected by the developing fin-fish fisheries near Heard and Macquarie Islands. Article 2 of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) refers to ecological relationships between species and aims to prevent damaging levels of fishing. Australia is a signatory to the Convention.

A framework for assessing fisheries in Australian waters with respect to ecologically sustainable development is being developed by Jean Chesson and Helena Clayton of the Bureau of Resource Sciences (H. Clayton, pers. comm.).

4.2.3 Marine protected areas

Adult female otariid seals on the Australian coast feed their pups for extended periods (about 10 months for fur-seals and 15 to 18 months for sea-lions) and traverse the waters close to their colonies at intervals of about a week or less. This makes them particularly susceptible to interactions with fishers and others that operate close to seal colonies. The establishment of marine protected areas adjacent to seal colonies could ameliorate some of the undesirable interactions between seals and fishers. More information is required on this topic so that advice can be given on the suitability, requirements and desirable size of marine protected areas.

Jurisdiction for marine protected areas needs to be considered carefully. Such reserves have an orientation toward nature conservation, being aimed at protecting seals and other wildlife from tourists, commuters and boaters, as well as from fishers. In that sense, it is better that they be managed by a nature conservation agency rather than by a fishery agency. But it is important that all stakeholders with an interest in the area have the opportunity to contribute to the development of a management plan. Furthermore, if marine protected areas were to extend a consistent distance from shore, confusion about their size would be avoided.

Suggested research and management actions to minimise impact

1 Operational interactions

- *Obtain quantitative information on interaction between seals and commercial fishers on the Australian coast and near Heard and Macquarie Islands. This should be obtained with trained, independent scientific observers on fishing vessels. It should include information on the views and attitudes of fishers. This includes the Subantarctic fur-seal (*Endangered*) and the southern elephant seal (*Vulnerable*), since they may interact with the developing fishery at Macquarie Island.
- *In consultation with the fishing industry, develop cooperative practices and gear modifications to minimise seals' interactions with fishing vessels and set gear, and educate fishers toward adopting such practices and modifications.
- *Produce a pamphlet for fishers (in consultation with them) outlining a code of best practice with suggested techniques to minimise catch losses, gear damage, by-catch and entanglement.
- Investigate the usefulness of various modifications to rock lobster pots currently being trialed by the industry to decrease the possibility of juvenile sea-lions and fur-seals entering, taking baits, robbing catch and being trapped and drowned. Promote the use of successful modifications.
- Determine who will be responsible for implementing any improved practices to minimise interaction between seals and fisheries. This will require discussions involving AFMA, Environment Australia and pertinent State fisheries and nature conservation agencies.
- Encourage the use of exclusion barriers at fish farms to limit damage caused by seals.
- Avoid establishing fish farms near seal colonies or haul-out sites.
- Test the effectiveness of the new high energy acoustic deterrents at fish holding pens in carefully designed trials.
- Instruct trawler crews in techniques to catch small seals on their vessels that are trapped in netting, and how to remove the seal from its entanglement before setting it free.

2 Ecological interactions

- *Obtain quantitative information on the ecological competition between seals and fishers (both commercial and recreational) in order to determine the extent to which seals and humans are competing for the same prey.
- *Determine where seals are feeding: distance offshore, the water depth and the time of day.

3 Marine protected areas

- Obtain quantitative information on interactions between seals and fishers close to seal breeding colonies so that advice can be given on the desirable size of marine protected areas.
- Establish marine protected areas to benefit seals, particularly (a) areas adjacent to breeding colonies that are traversed frequently by adult females to feed their dependent young and (b) the foraging range of adult females when they have dependent young.
- These recommendations are pertinent to Macquarie and Heard Islands, where the Subantarctic fur-seal (*Endangered*) and the southern elephant seal (*Vulnerable*) breed.

4.3 Entanglement

Entanglement of seals and other marine mammals in man-made debris cast overboard from vessels as well as in debris washed out to sea from land is a widespread problem. Material recorded entangling seals in Australian waters includes the following:

- trawl nets, polypropylene packaging straps (including bait-box bands), monofilament nets, nylon ropes (Pemberton *et al.* 1992, Prendergast and Johnson 1996)
- rubber band, possibly from the tube of a car tyre (Shaughnessy 1995)
- rubber rings used for connecting and sealing large diameter pipes (L. Llewellyn, *in litt.*)
- plastic bags, polyethylene cordage, six-pack yokes, loops of cotton cord, binder twine, and portions of garments (R. M. Warneke, *in litt.*).

Most of this material degrades slowly. It loops around a seal's neck, and occasionally catches on fore-flippers, mouth or teeth. Fishing hooks and squid jigs occasionally become caught in a seal's flesh. As the animals grow, the entangled material cuts into their flesh and the animals die a lingering death. An entangled seal caught in a large piece of net is likely to drown; alternatively it may tear itself free and swim off with a collar of netting around its neck.

Entanglement of seals has also been reported in nets of tuna farms at Port Lincoln, South Australia, involving Australian sea-lions and New Zealand fur-seals. Protection nets around individual pens that are kept taut and under tension with weights are recommended to keep seals away from fish in holding nets (Pemberton 1989, 1996b). Small mesh also decreases the likelihood of seals becoming entangled.

Marine debris has been the topic of international conferences, in 1984 (Shomura and Yoshida 1985), 1987 and 1994. The northern fur-seal population at the Pribilof Islands in Alaska has declined concurrently with the increase in the frequency of entangled seals and entanglement has been implicated as a cause of the population decrease (Fowler 1987). Closer to home, Jones (1994) noted that three broad areas require attention: a reduction of inputs of fishing debris into the ocean, collection of data on debris from domestic fisheries, and improved disposal facilities in some ports. Recommendations for action were included on each area.

Estimates are available for the proportion of entangled seals at some colonies in Australia. Some caution is required in interpreting these data as they refer solely to the animals ashore when the counts were made. Because not all seals are ashore together, the assumption is implicit that those ashore are representative of the whole population. Some entangled animals may die at sea and the effect of this would be to underestimate the proportion of entangled animals. The estimates of the incidence of entanglement do not take into account differences in the age-sex composition of the seals ashore or of the entangled seals.

On Tasmanian islands of Bass Strait and in southern Tasmania, the Australian fur-seal had the highest reported incidence of entanglement, at 1.9% of seals ashore. Within this figure there was a higher proportion of males than females (Pemberton *et al.* 1992). High levels of entanglement have also been recorded for this species at Seal Rocks, Victoria (Prendergast and Johnson 1996).

In a review of the problem in South Australia, Robinson and Dennis (1988, p. 103) referred particularly to sea-lions entangled in monofilament nets of 150 mm mesh. This is the type of netting used in the shark fishery. During the comprehensive survey of sea-lions in Western Australia and South Australia, Gales (1990) counted 5180 sea-lions and recorded 10 entangled animals. From this the incidence of entanglement can be calculated as 0.2%. It should be noted that this estimate is from an opportunistic, one-off survey. The entangling material was monofilament shark net (6 animals) and bait bands (2) in South Australia, and bait bands (2) in Western Australia.

Entanglement data on sea-lions are also available from colonies in the Kangaroo Island region, at Seal Bay and The Pages (records of South Australian National Parks and Wildlife). The combined incidence of entanglement at these locations since 1978 was 26 entanglements or 0.3%. The most common entanglement material was 150 mm monofilament netting. At The Pages, pups aged 4-20 months formed the group most affected (10 entanglements).

For New Zealand fur-seals at colonies on Kangaroo Island, the incidence of entanglement recorded on four occasions between August 1994 and June 1995 was 0.07%, from 14,650 fur-seals inspected in three colonies (Shaughnessy 1995). The incidence is also low for this species in Tasmania (D. Pemberton *in litt.* 31 October 1997).

These seemingly low rates of entanglement need to be put into perspective. First, they refer to animals seen ashore and exclude any that die at sea. The second point refers to the closely related Hooker's sea-lion of the Auckland Islands in the New Zealand subantarctic which is taken as a by-catch in a trawl fishery. It is also a rare animal and there is concern for its future. A population model for the Hooker's sea-lion indicates that an increase in the mortality rate of only 1% would cause the population to decrease (Woodley and Lavigne 1993). Numbers of the Australian sea-lion could be similarly affected by increased mortality.

Entanglements have been recorded for the Subantarctic and Antarctic fur-seals (Goldsworthy 1991), but quantitative data are not available. Overall, the number of entangled seals recorded of all species is likely to increase as seal populations increase and as interest in seals develops.

For southern phocids, entanglement in man-made marine debris is likely to be less of a threat than to seals of more temperate latitudes, because boat traffic is less frequent. Furthermore, nations that are signatory to the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) have agreed to prohibit driftnets in the Convention region (approximately south of 60°S and on the Kerguelen Plateau) and to discourage vessels from throwing fishing debris overboard. Nor should debris from driftnets be a problem in the Australian Fishing Zone, because their use is banned under the *Fisheries Management Act 1991.*

One cause of entanglement is the plastic bands that hold bait-boxes together. When discarded overboard, these bands float. A Tasmanian company has developed a bait box without a band and its widespread use would decrease the amount of entanglement. Bait-boxes with plastic packaging are banned under CCAMLR.

Suggested research and management actions to minimise impact

- *Encourage fishers and other mariners, through consultation, not to discard non-biodegradable material at sea.
- *Encourage fishers to use bait boxes that do not incorporate heat-sealed plastic bands. Approved bait boxes should be limited to those that are strapless or use clip-connected straps.
- *Conduct research into interactions between various fisheries (trawl, purse seine, beach seine and shark netting) and seals. Then consult with the industry in an effort to alter management practices to ameliorate actions that lead to entanglement.
- Instruct nature conservation agency staff in using a hoop net to catch entangled seals that are ashore and in methods of safe handling to remove the entanglement, following advice in the "Field Guide for Strandings" by Geraci and Lounsbury (1993). Attempts to rescue entangled seals at breeding sites during the breeding season would be fraught with great risk to seal pups and to staff, and are unlikely to succeed.
- Encourage tuna farmers at Port Lincoln to keep their nets taut to decrease the likelihood of seals becoming entangled.

4.4 Oil spills and chemical contaminants

4.4.1 Oil spills

One oil spill has been known to affect seal colonies in Australia. In February 1991, the bulk carrier 'Sanko Harvest' was wrecked and spilled 700 tonnes of heavy fuel oil into the sea along the south coast of Western Australia (Anon. 1991a). Two month old pups of the New Zealand fur-seal at two colonies in the Recherche Archipelago were contaminated with oil, but prompt action enabled them to be captured, restrained in holding pens and cleaned (Gales 1991). Oiled rocks in the colony were cleaned before pups were released. A second case occurred in Tasmania following the wreck of the 'Iron Baron' (D. Pemberton, *in litt.*, 31 Oct. 1997). Oil spilled from the wrecked ship 'Kirki' on the west coast of Western Australia was close to a breeding colony of sea-lions, but did not come ashore (N. Gales, *in litt.*, AMSA 1993, p. 108).

St Aubin (1990) reviewed worldwide information from encounters between oil and seals, covering 29 events over four decades. Although large-scale mortality of seals has not been recorded, he concluded that "pinnipeds are *vulnerable* to and may be harmed by oiling" (p. 103). Those forced to emerge through oil close to colonies exhibit severe effects.

Oil spills pose a threat to all seal populations, especially those at breeding colonies near major shipping lanes. fur-seals are likely to be more affected by oil spills than sea-lions or phocids, because they rely on clean fur for insulation, and it is likely to be fouled by oil.

Australia's National Plan to Combat Pollution of the Sea by Oil is managed by the Australian Maritime Safety Authority (Gray 1991, AMSA 1993). It coordinates actions of industry and the Commonwealth and State governments. In Commonwealth waters, prime responsibility rests with AMSA and in State waters it lies with the relevant State maritime authority. However, the National Plan does not yet include any detailed planning in relation to marine mammals, which is left entirely to the States. Some oil companies, such as Esso, do include wildlife rescue and rehabilitation in their planning for response to oil spills (R. M. Warneke, *in litt.*).

A recent development is the *National Oiled Wildlife Response Plan*, which was instigated following the oiling of wildlife that resulted from the 'Iron Baron' oil spill in 1995 off northern Tasmania (Gilbert 1996). Its first draft had been prepared by December 1997 (T. Gilbert, *in litt.*, December 1997). The Response Plan should note that zoos and aquaria can play a valuable role in training personnel in the management of animal care in these situations, and that they have appropriate quarantine facilities for the rehabilitation of oiled seals. On the other hand, their facilities are unlikely to be large enough to cope if large numbers of seals are affected, and they are unlikely to be near a spill site.

At Macquarie and Heard Islands, the potential threat of oil spills to seal populations is low, because of the small number of visits by ships. However, several ships visit Macquarie Island each summer to re-supply the Australian Antarctic Division base. The large quantities of fuel pumped ashore near colonies of the Subantarctic fur-seal (*Endangered*) on North Head Peninsula just north of the base present a possible hazard. The ships are also close to colonies of the southern elephant seal (*Vulnerable*). Tour ships that visit these islands are another potential source of oil spills. Visits to Heard Island are less frequent and, unlike Macquarie Island, fur-seal colonies are spread over much of the coastline. Emergency procedures for oil spills at Macquarie and Heard Islands should take seal populations into account.

The House of Representatives Standing Committee on Transport, Communications and Infrastructure (1992) inquired into ship safety. Their report entitled *Ships of shame*, recommended particularly an increase in the rate and effectiveness of Port State Control inspections in Australia to the level where it ceases to be viable for substandard shipping to call here (recommendation 4) and improvement in crew training and experience (recommendation 7). It also noted that the use of high tensile steel in lieu of mild steel in ship construction involves less steel (because it is stronger), and allows a larger payload and reduced construction costs, but leads to weaker ships because high tensile steel rusts at the same rate as mild steel. It has been blamed for structural failure in several ships, and might be expected to lead to a higher rate of oil spills in future.

Volkman *et al.* (1994) reviewed the literature on oil spills and marine mammals. They noted (p. 575) that "in the event of a major oil spill, protection of critical feeding and breeding sites, if known, must be attempted in order to reduce the risk of impact on the population".

4.4.2 Chemical contaminants

Agricultural and industrial contaminants in the sea have accumulated in marine predators and have been linked to increased vulnerability to disease. For instance, premature parturition in Californian sea-lions infected with San Miguel sea-lion virus (a calicivirus) were reported by Gilmartin *et al.* (1976). Levels of p,p'-DDE in blubber and liver of the parturient females were elevated several times in comparison with concentrations in corresponding tissues of full-term females. The authors suggested that the disease agent and environmental contaminants were inter-related in causing the premature parturition.

Chemical contaminants have also been associated with pathological changes in the uteri of ringed seal females in the Baltic Sea. These females had elevated levels of DDT and PCB when compared with levels in normal pregnant females (Helle *et al.* 1976). Similarly, Reijnders (1986) recorded reproductive failure in harbour seals feeding on fish from polluted coastal waters in The Netherlands.

Suggested research and management actions to minimise impact

- Encourage the improvement of the standard of shipping on the Australian coast, as recommended by the House of Representatives Standing Committee (1992).
- Establish contact between nature conservation agencies responsible for seal colonies and the AMSA group responsible for the National Plan to Combat Pollution of the Sea by Oil. Explain how seal colonies are at risk. Encourage the incorporation of appropriate measures for protecting seals into oil spill contingency plans.
- Ensure that the *National Oiled Wildlife Response Plan of Australia's National Plan to Combat Pollution* of *the Sea by Oil* is comprehensive and is implemented. It should include an integrated approach from relevant State and Commonwealth agencies and oil companies to develop coordinated contingency plans for dealing with oil spills in the marine environment, especially as spills would affect fur-seals and sea-lions at sea, and their colonies. This should include follow up monitoring of de-oiled seals, and inspection of seal colonies near a spill for several weeks after its occurrence in case a raft of oil arrives ashore unexpectedly.
- Emergency procedures for oil spills at Macquarie and Heard Islands should take into account breeding populations of the Subantarctic fur-seal (*Endangered*) and the southern elephant seal (*Vulnerable*).
- Monitor levels of chemical contaminants in seals on the Australian coast.

4.5 Disturbance by aircraft, vessels and humans

Most breeding sites and haul-out sites of seals on the Australian coast are on islands that have some protected status. Colonies of seals on the Subantarctic islands also have some protection under tenure. Nevertheless, disturbance by aircraft, vessels and humans is a threat at some colonies, particularly during the breeding season. Examples of such disturbance include inappropriately timed servicing of navigational aid equipment by the Australian Maritime Safety Authority (AMSA), over-flights by aircraft (which might be low-level flights by helicopters to view seals or to convey scientists to a colony), high-speed ferries in Bass Strait and in Backstairs Passage, and recreational visits to a sheltered beach on an island for a picnic by boaters.

A common result of disturbance at seal colonies is that animals flee to the sea. This is particularly disruptive during the breeding season when the mothers may be unable to relocate their pups, which rely on frequent feeds to survive and to gain weight. Pups and other small animals may get squashed when animals bolt, and pups that enter the sea may not be strong enough to return to the colony. Another result of disturbance is displacement of territorial bulls that may have to fight to regain their territory. This can also lead to mortality of pups. Even after the breeding season, when seals are ashore to moult and rest, disturbance interferes with their energetic balance and should be discouraged.

The effect of aircraft disturbance can be decreased by managers with responsibility for seal colonies taking appropriate action through the Fly Neighbourly Scheme of Airservices Australia. This involves the manager preparing a flying area policy for the airspace around seal colonies affected by aircraft and requesting Airservices Australia to include it in the En Route Supplement A (ERSA). That document includes operational information on all airports and navigational aids in Australia, and is issued to all pilots. A Fly Neighbourly Scheme has been developed for the seal colonies and other sensitive areas at the western end of Kangaroo Island by the local District Manager, South Australian National Parks and Wildlife (R. Ellis, pers. comm.).

Subantarctic fur-seals and southern phocids, including southern elephant seals, are susceptible to disturbance by aircraft, and visits by expeditioners and scientists. Advice on limiting disturbance is included in Antarctic Division Operations Manuals, and should be stressed to all visitors.

Suggested research and management actions to minimise impact

- Develop and distribute guidelines to AMSA personnel, scientists, high-speed ferries and boat clubs that frequent the coast about the importance of minimising disturbance to seals in breeding colonies, particularly during the breeding season.
- *Encourage preparation of flight policies for sensitive areas, for inclusion in the Fly Neighbourly Scheme of Airservices Australia for coastal Australia and in appropriate Antarctic operation manuals for Subantarctic and Antarctic areas. This is also pertinent to Macquarie and Heard Islands, where the Subantarctic fur-seal (*Endangered*) and the southern elephant seal (*Vulnerable*) breed.

4.6 Tourism and captive animals

4.6.1 Commercial seal watching

Seal watching is a commercial operation at several locations on the Australian coast. A major one is at Seal Bay on Kangaroo Island where Australian sea-lions are viewed by groups of tourists walking on the beach under the supervision of guides. This site is managed by South Australian National Parks and Wildlife. Care is taken not to interfere with the normal behaviour of the sea-lions by approaching them too closely, too frequently or in groups that are too large. The increase in visitor numbers in recent years (to 112,000 in 1996) concerns managers of the site. Pupping sites adjacent to Seal Bay are within designated Prohibited Areas and are not visited by tourists. Commercial tourism is also directed at Australian sea-lions at island colonies in Western Australia and elsewhere in South Australia. Management action is also required there, and should begin with development of management plans for the popular seal viewing areas.

The threatening process here is the desire of tourists for the "nature experience" of getting close to wild animals. This experience might be expected to be enhanced by close proximity, no limits on the length of stay, the presence of few other tourists and movement of the animals; however, this is not necessarily the case. The provision of suitable material and knowledgable guides to offer interpretation to tourists can give a greater degree of visitor satisfaction than unaccompanied visits. At the same time, guides can control activities such that the tourist experience is not spoiled for others, and the animals are not frightened away from their site ashore.

At Macquarie Island, southern elephant seals are viewed by tourists taken ashore at various places under the supervision of guides from the Tasmanian Parks and Wildlife Service.

Tourists view seals from vessels at many sites on the Australian coast, including:

- in New South Wales, at Montague Island (Australian and New Zealand fur-seals),
- in Victoria, at Seal Rocks, Western Port, at a channel beacon in Port Phillip Bay, at Lady Julia Percy Island, and at Cape Bridgewater (Australian fur-seals),
- in Tasmania, at Tenth Island, also known as Barrenjoey (Australian fur-seals),
- in South Australia, at Dangerous Reef and Hopkins Island (Australian sea-lions),
- in Western Australia, adjacent to islands in the Recherche Archipelago, from Albany and Augusta, and within Marmion Marine Park and Shoalwater Islands Marine Park (Australian sea-lions).

4.6.2 Non-commercial seal watching

Seals are also viewed by recreational divers at many sites on the Australian coast, for example, on the north coast of Kangaroo Island (New Zealand fur-seals and Australian sea-lions) and the Perth metropolitan area (Australian sea-lions). Diving with seals should be discouraged because of dangers to divers from seals and, particularly, from sharks.

There are many locations where seal viewing is a non-commercial activity. For example, Australian sea-lions are viewed at Point Labatt on Eyre Peninsula, South Australia, lookouts at roadside rest stops on the Nullarbor Plain in South Australia, and islands in the Jurien Bay region, in the Perth metropolitan area, and near Albany and Esperance in Western Australia; New Zealand fur-seals are viewed at Admirals Arch, Cape du Couedic, Kangaroo Island, South Australia; and Australian fur-seals are viewed at Cape Bridgewater, Victoria. These sites are managed by the South Australian National Parks and Wildlife, South Australian Highways Department, Western Australian Department of Conservation and Land Management, and the Victorian Department of Natural Resources and Environment. The last site is adjacent to the track of the Great South West Walk where a viewing platform was constructed above the seal colony in 1995. sea-lions are more likely to be at risk from such interactions with humans than are fur-seals, because the sea-lions habitat includes beaches protected from rough seas, and these are also preferred by humans.

Guidelines for viewing seals on islands from boats and by divers should be more widely established before bad habits develop. Since there are considerable differences between viewing situations, guidelines will need to be flexible. A set of guidelines for viewing seals on islands entitled *Sea-lions* has been developed by the Western Australia Department of Conservation and Land Management (no date) (see Appendix X). Guidelines for viewing fur-seals from boats at Tenth Island, Tasmania (Pemberton 1996a) and at Cape Bridgewater, Victoria (Stamation 1996) recognise the need to discourage boat operators from disturbing seals ashore and avoid making them move into the sea.

4.6.3 Shark viewing

Another form of commercial tourism that impinges on seals is the white shark viewing industry. Vessels with tourist passengers anchor at seal colonies for several days. This usually involves berleying with offal to increase the likelihood of attracting sharks, so that clients can then view sharks underwater from the safety of cages. Unless seals receive some protection around their colonies, the situation arises where they are protected ashore but an important predator is attracted to the inshore waters adjacent to colonies. Adult females nursing pups need to traverse these waters at about weekly intervals for about 8 to 12 months (or, for Australian sea-lions, twice weekly for 15 to 18 months) and are potentially vulnerable. Although there are no data on the effect of berleying on the predation rate of fur-seals or sea-lions, a precautionary attitude should be adopted and berleying should be prohibited at all seal colonies.

If berleying by the shark viewing industry is to be permitted at seal colonies as it is in South Australia, it should be restricted to some fur-seal colonies because they are more abundant than sea-lions and show signs of increasing. Berleying should be prohibited from seal colonies close to human habitation. The type of berley and handling procedures at other seal colonies should also be controlled. To limit such activities, the South Australian Government has declared a sanctuary zone of 2 km diameter around the sea-lion colony at Dangerous Reef. Similar sanctuaries should be considered around other sea-lion colonies where shark viewing is conducted.

4.6.4 Captive animals

Seals are displayed for viewing by tourists at several establishments in Australia. Their capture for this purpose requires a permit and few have been caught in the last decade, except those taken to zoos or aquaria for rehabilitation. Thus capture for display should not be considered as a threatening process. On the other hand, captive animals at such establishments can play a positive role in increasing public knowledge about the natural history and conservation of seals, including threats to their survival and the dangers of marine debris. They may also be suitable subjects for research projects (eg, Rogers *et al.* 1996) and greater contact between researchers and seal carers would enhance opportunities for cooperation.

Suggested research and management actions to minimise impact

- Educate tourism operators who frequent seal colonies of the importance of minimising disturbance, particularly during the breeding season. This applies to colonies on the Australian coast and is also pertinent to Macquarie and Heard Islands, where the Subantarctic fur-seal (*Endangered*) and the southern elephant seal (*Vulnerable*) breed.
- *Determine the optimal approach distance and maximum group-size for groups of tourists viewing Australian sea-lions, to limit adverse interactions, taking into account relevant factors such as age-sex category of the seals, and time since last breeding season.
- Develop management plans for the popular seal viewing areas.
- Develop guidelines for commercial operators and private individuals for viewing seals from boats, and encourage their distribution.
- Consider assigning Prohibited Area status to breeding sites of seals on the Australian coast (listed in Tables VII.1, VII.2 and VII.3). This might be temporary closure (eg during the pupping season) or might refer to part of an island rather than the whole island.
- Discourage diving with seals because of the dangers involved.
- Prohibit berleying at seal colonies as an attractant for white sharks. If it is to be condoned at seal colonies in Australian waters, it should at least be prohibited at Australian sea-lion colonies because of the conservation status of that species. Prohibit berleying at all seal colonies close to human habitation. The type of berley and handling procedures at any other seal colonies should also be controlled.

4.7 Disease

The tendency of some pinniped species to form aggregations on land and, in some cases, at sea near haul-out sites, provides good opportunities for transmission of infectious diseases. The deaths of about 18,000 harbour seals in England and other countries on the North Sea in 1988 (Kennedy 1990b) caused by phocine distemper virus indicated that disease can be an important cause of mortality in seal populations. This can increase the risks of extinction of local populations that are at low levels. On the other hand, the rapid recovery of harbour seals populations around the North Sea since 1988 (ICES 1994) suggests that the effects of disease in some populations may be temporary.

Some diseases that affect pinnipeds are reviewed here briefly and some that can be transmitted from pinnipeds to humans are discussed in Appendix V. The problem of releasing rehabilitated seals that have 'stranded' is also discussed from the view of the possibility of disease transmission.

4.7.1 Morbillivirus

Phocine distemper virus is a morbillivirus that has not been reported from seals in Australian waters. Antibodies to the closely related canine distemper virus have been reported in crab-eater seals and leopard seals from the Southern Ocean (Bengtson *et al.* 1991).

4.7.2 Tuberculosis

Tuberculosis (TB) caused by bacteria of the *Mycobacterium tuberculosis* complex has been reported from wild New Zealand fur-seals and Australian sea-lions found dead on the Western Australian coast (Cousins *et al.* 1993, Cousins 1996). The organism is known to be highly virulent in fur-seals, sea-lions, guinea pigs, rabbits and humans (Cousins 1996). Tuberculosis has been reported from these seals in captivity in Western Australia and from an animal trainer from the same aquarium (Forshaw and Phelps 1991). Transmission was most likely via aerosol from a barking or sneezing seal. A survey conducted in the late 1980s by Reddacliff and Lim (1990) indicated that TB did not occur then in captive pinnipeds in Australia. Nevertheless, the introduction of stranded seals to zoos and aquaria remains a risk (Cousins 1996).

Tuberculosis in wild seals exposes personnel who handle potentially infected seals or carcasses to a zoonotic risk, because the strain is pathogenic in man (Cousins *et al.* 1993, Thompson *et al.* 1993). A case of TB was diagnosed in a researcher working with Hooker's sea-lion at Snares Island in 1972 (Cawthorn 1994).

TB has also been diagnosed in an Australian fur-seal in Hobart (Woods *et al.* 1995) and in an adult male New Zealand fur-seal that died at Macquarie Island in 1966 (Cousins *et al.* 1993). The specific identity of the latter seal should be considered doubtful because little was known of Antarctic and Subantarctic fur-seals at Macquarie Island then.

The presence of this disease in wild populations of Australian seals deserves more attention, as does determination of its origins.

4.7.3 Calicivirus

One of the family of caliciviruses is the San Miguel sea-lion virus which was first reported in Californian sea-lions on San Miguel Island, California (Gilmartin *et al.* 1976). There, 20% of pups died following premature parturition. The virus is indistinguishable from vesicular exanthema of swine virus. The San Miguel sea-lion virus has also been reported from northern fur-seals, Steller sea-lions, northern elephant seals and walruses (reviewed by Smith and Boyt 1990).

4.7.4 Leptospirosis

An epizootic of the bacterial disease leptospirosis among Californian sea-lions on the coasts of California and Oregon was reported by Vedros *et al.* (1971). It was confined to subadult males and was thought to be associated with a high rate of abortions at one of the breeding colonies in 1970. Since then there has been recurrent, low-level mortality in these seals caused by leptospirosis (Harwood and Hall 1990).

4.7.5 Hookworm

Hookworm is a nematode that causes anaemia in seal pups. Hookworm disease, or uncinariasis, has been reported from several pinnipeds, especially northern fur-seals. For instance, in 1964 it was shown to be a primary cause of seal deaths at St Paul Island in the Pribilofs, Alaska (Keyes 1965). Infection of pups occurs via milk in the first few days of lactation (Olsen and Lyons 1965).

In Australia, hookworm has been reported from the Australian sea-lion (Beveridge 1980), the Australian and New Zealand fur-seals (Norman 1996), and the southern elephant seal (Harvey Johnston and Mawson 1945), but there was no indication of its pathogenicity. A useful checklist of parasites of Australian marine mammals has been published by Arundel (1978).

4.7.6 Release of rehabilitated, stranded seals

If a rehabilitated seal is to be reintroduced into the natural environment, the question arises as to where. Such releases may expose naive populations of conspecifics or other species to pathogens acquired by the rehabilitated animal in captivity (Haebler 1992, cited by Viggers *et al.* 1993). Should the population be put at risk for the sake of a single rehabilitated seal? The recent release of a rehabilitated southern elephant seal from Taronga Zoo with a fungal growth on its skin is an example of this problem (Woods *et al.* in prep.). If there is any doubt about the health of the rehabilitated seal, the health of the wild population should take precedence.

A workshop on rescue, rehabilitation and release of marine mammals held in the USA in December 1991 considered the problem of disease transfer by released animals. It recommended that a panel "review the known infectious agents of each marine mammal group, rank them according to their potential to transmit disease, and determine which pose an unacceptable risk if introduced to the marine environment" (St Aubin *et al.* 1996, p. 17).

The Scientific Committee on Antarctic Research (SCAR) also considered the matter of translocating rehabilitated seals at their meeting in July 1992. They adopted the following recommendation put to them by the SCAR Working Group on Biology:

> "Noting that well-meaning attempts that have been made to rehabilitate indigenous seals and seabirds, especially penguins, that have been held in captivity, to Subantarctic islands and to the Antarctic continent; Noting further that such re-introductions serve no conservation purpose and run the risk of introducing pathogens; SCAR, therefore, urges National Committees to discourage such practices" (SCAR 1993, p.9). The resolution was accepted by the Australian National Committee on Antarctic Research in 1995.

In accord with that resolution, and in order to decrease the likelihood of infection being transferred to breeding colonies, it is recommended that rehabilitated seals be released close to the site of capture. If that is impractical, consultation may be required between the holding facility and State nature conservation agency. They should not be released at a breeding colony.

Suggested research and management actions to minimise impact

- Determine the prevalence of disease in wild populations of Australian seals.
- Test seals taken into zoos and aquaria for diseases.
- Test seals captured at fish farms for diseases.
- Discourage translocation of rehabilitated seals to breeding colonies.
- Release rehabilitated seals near the site of capture.

4.8 Seismic survey activity

The search for oil below the seafloor relies on seismic survey techniques, including compressed air detonations. The effects of large blasts and the accompanying shock waves on seals are not well known. A recent review of knowledge in this field has been presented by McCauley (1994). Typical air guns produce peak sound emissions of low frequency in the range 6-100 Hz. Underwater audiograms for some otariid seals indicate that their greatest sensitivity lies in the range 2-32 kHz; for some phocid seals the range is 2-55 kHz. Thus it appears that the low frequency sounds of seismic air-gun arrays fall below the greatest hearing sensitivity of seals. As McCauley (1994) points out, this interpretation should be treated cautiously because audiograms differ between pinnipeds, and none exist for the Australian species. It is recognised that seismic activity will only be a threat to seals if it takes place close to them.

Suggested research and management actions to minimise impact

- Determine audiograms for pinniped species on the Australian coast, so that the effect of seismic survey techniques on them can be predicted.

4.9 Climate change

The small increases in ambient temperature predicted from climate change may increase the likelihood of epizootics in pinniped populations (Lavigne and Schmitz 1990). They demonstrated associations between mass mortalities of pinniped populations with increased density onshore and increased ambient temperatures. Five of their examples were from northern hemisphere seals and the sixth was from crab-eater seals in the Southern Ocean.

An increase in sea temperature from global warming could alter primary productivity of the oceans and hence the amount and composition of prey that seals feed upon. The likely direction and influence of such changes does not appear to have been investigated.

Global warming is a potential threat to ice-breeding (pagophilic) seals in that it may reduce the extent of sea ice, and so reduce the area available for breeding. Furthermore it may lead to a decrease in primary productivity of the Southern Ocean (Chittleborough 1991). The "ozone hole" evident in the stratosphere over Antarctica each summer extends to southern Australia and has the potential to depress photosynthesis (ie phytoplankton productivity) by increasing penetration of UV radiation. Another potential deleterious effect of increased UV is eye damage to pups of the crab-eater and Weddell seals, which are born in October when UV levels are near their peak.

An increase in sea level is predicted to follow an increase in ambient temperature. This would alter the configuration of the coastline, altering the accessibility and attractiveness to seals of many colonies and haul-out sites that are currently used.

5 Species synopses

Introduction

This chapter summarises information on all ten pinniped species considered to be part of the Australian fauna. The format of the species synopses is based on that in the *Action Plan for Australian Cetaceans* (Bannister *et al.* 1996). In preparing the species synopses, use was made of the status reports on eared seals and true seals prepared for the *Endangered* Species Program of the Australian National Parks and Wildlife Service in December 1991 (Goldsworthy 1991, Shaughnessy 1991). Use was also made of material from:

- species summaries in *Mammals in the Seas, Volume 2* (FAO 1979)
- chapters in *Handbook of Marine Mammals* (Ridgway and Harrison 1981a, 1981b)
- Laws (1984)
- chapters in proceedings of an international symposium and workshop on fur-seals held in April 1984 (Croxall and Gentry 1987)
- species accounts in *The mammals of Australia*, edited by Strahan (1995)
- published and unpublished reports of recent studies of seals on the Australian coast.

The species are considered in the following order.

- Otariids: Australian sea-lion, New Zealand fur-seal, Australian fur-seal, Antarctic fur-seal and Subantarctic fur-seal.
- Phocids: southern elephant seal, leopard seal, crab-eater seal, Weddell seal and Ross seal.

Species survival status

Information in the species synopses was utilised in determining the conservation status of each species. The results recorded in item 5.1 were obtained by applying the IUCN (1994) criteria and are summarised in Table 2.5.

IUCN categories included in item 5.2 refer to the 1994 IUCN *Red List of Threatened Animals* (IUCN 1993). Results of the survey by the Seal Specialist Group of the IUCN Species Survival Commission (Reijnders *et al.* 1993) are also provided and are referred to as SSG IUCN SSC.

The CITES status provided in item 5.3 refers to listings on the Appendices of the Convention on International Trade in *Endangered* Species of Wild Fauna and Flora (CITES). The convention is discussed briefly in Chapter 4.1.4.

Conservation objectives

The Australian Government's key goals for the Antarctic research program are referred to in the sub-sections concerned with conservation objectives for those species that breed in the Antarctic and on Subantarctic islands. The goals are:

- maintaining the Antarctic Treaty System and Australia's influence in the System
- understanding global climate change
- undertaking scientific work of practical importance
- protecting the Antarctic environment.

Australian Sea-Lion

1. Family	Otariidae
2. Scientific name	*Neophoca cinerea*
3. English name(s)	Australian sea-lion, hair seal

4. Taxonomic status (including species and subgroups)

Monospecific genus. Originally described from Kangaroo Island, South Australia by F. Péron in 1816 as *Otaria cinerea.*

5. Species survival status

5.1 Conservation status based on IUCN (1994)

Lower Risk, near threatened

5.2 IUCN status

IUCN (1993): Rare
SSG IUCN SSC: Rare

5.3 CITES status

Not listed

6. Distribution, including migration

The breeding range extends from Houtman Abrolhos, Western Australian, to The Pages (east of Kangaroo Island) in South Australia. Gales *et al.* (1994) reported 50 breeding sites, 27 in Western Australia and 23 in South Australia. Another ten breeding sites were recorded in the Great Australian Bight region in 1994 and 1995 (Dennis and Shaughnessy 1996), one in Western Australia and nine in South Australia. A further six small colonies on the west coast of South Australia were reported by Shaughnessy *et al.* (1997). Overall, 66 breeding colonies have been recorded to date, 28 in Western Australia and 38 in South Australia (Table VII.1 in Appendix VII).

About 30% of the population is in Western Australia and 70% in South Australia, with 42% of the total in the three largest colonies which are at the eastern end of the range, east of Port Lincoln (Gales *et al.* 1994).

Many colonies of Australian sea-lion are small and isolated, unlike most other otariids, and certainly different from the two fur-seal species on the south coast of Australia. This widespread distribution of small colonies probably offers the advantage of minimising competition for a limited trophic resource (see 7.1).

Migration of adult and subadult males has been recorded on the west coast of Western Australia between breeding colonies in the Jurien Bay area and non-breeding sites on islands near Perth (Gales *et al.* 1992b). Some adult females move pups away from the natal area to other haul-out areas to continue nursing; at Seal Bay, Kangaroo Island, this occurred at about 2-3 months of age (Higgins and Gass 1993).

Records of stragglers at Shark Bay, Western Australia, on the New South Wales coast and in southern Tasmania have been reviewed by Ling (1992), Llewellyn *et al.* (1994) and Kirkwood *et al.* (1992) respectively. A few records from western coastal Victoria have been noted by Warneke (1995b).

7. Habitat

7.1 General

Habitats used by Australian sea-lions were described by Gales *et al.* (1994). Their choice is wide, but they prefer the sheltered side of islands and avoid exposed rocky headlands that are preferred by *Arctocephalus forsteri.* Islands used on the south coast of Western Australia and South Australia are comprised either of igneous or metamorphic rock, or of igneous platforms below limestone caps. An important feature of colony sites is shallow, protected pools in which pups congregate. On the west coast of Western Australia they breed on low-lying limestone islands which are well protected by perimeter reefs.

Shelter, in the form of holes in rock or vegetation, is important for adult females to hide their pups. Bushes such as *Nitraria schoberi* are preferred where they are available. Nevertheless, little protection is available on the largest colonies (Dangerous Reef and The Pages), where most pups are born on open ground.

Although most colonies are on islands, there are several small ones on the mainland. Point Labatt, South Australia is a well known one (King and Marlow 1979). There is a small colony at the foot of the Baxter Cliffs, west of Twilight Cove, Western Australia, referred to as Thundulda by Warneke (1982). Another nine small breeding colonies were discovered at the base of the Bunda Cliffs between the Head of the Great Australian Bight and the South Australia - Western Australia border in August of 1994 and 1995 (Dennis and Shaughnessy 1996).

The marine environment over much of the sea-lion's range is characterised by shallow on-shelf waters (<200 m) of low productivity. It is primarily influenced by the Leeuwin Current which feeds warm, nutrient impoverished waters southwards along the west coast of Australia and then eastward along the south coast. This current acts as a barrier to the rich Subantarctic waters and the region has been described as being one of the most nutrient poor marine environments in the world (reviewed by Gales *et al.* 1994).

During winter the prevailing winds along southern Australia are westerly and, as the Leeuwin Current flows most strongly then, the current reaches its eastern extremity. During summer the high pressure weather systems that dominate the south coast of Australia cause consistent south-easterly winds that have the effect of blocking, and in some cases reversing, the flow of the eastward moving Leeuwin Current. This facilitates minor upwellings of relatively nutrient rich, cool water. All of these influences result in more productive waters in the eastern part of the sea-lion's range. The bias in population density of the sea-lion towards the east is also seen in the New Zealand fur-seal, which has a similar overall range in Australia (Shaughnessy *et al.* 1994).

7.2 Key localities

A survey of Australian sea-lions from 1987 to 1992 showed that three colonies in central South Australia at Dangerous Reef, Seal Bay on Kangaroo Island, and The Pages Islands accounted for 42% of the total population. The largest colonies in Western Australia were at Beagle and North Fisherman Islands, on the west coast, each with 3% of the total population (Gales *et al.* 1994).

Colonies along the cliffs of the Great Australian Bight account for about 7% of total estimated numbers, and may provide a genetic link between populations in Western Australia and South Australia (Dennis and Shaughnessy 1996).

All sites in South Australia are within Conservation Parks managed by the Department of Environment, Heritage and Aboriginal Affairs. All but one site in Western Australia (Hauloff Rock) are in Class A reserves managed by the Department of Conservation and Land Management.

8. Marine protected areas managed or relevant to the species

In South Australia, there are marine protected areas in waters associated with several sea-lion colonies. Waters within 2 km of Dangerous Reef in Spencer Gulf are gazetted under the South Australian *National Parks and Wildlife Act 1972* as part of the Sir Joseph Banks Group Conservation Park; one of the aims of the protected area is to prohibit berleying for white sharks near the sea-lion colony. Aquatic Reserves have been proclaimed under Fisheries legislation at Seal Bay on Kangaroo Island and at Point Labatt on Eyre Peninsula. The Great Australian Bight Marine Park (GABMP) in South Australian waters includes a sanctuary zone of width one nautical mile declared under the National Parks and Wildlife Act that includes nine sea-lion colonies.

In 1998 the Commonwealth proclaimed a Marine Park in the Bight consisting of two areas. One of these, the Marine Mammal Protected Area which extends to 31°47' S, is contiguous with that proclaimed by South Australia and is specifically designed to protect the Australian sea-lion and the southern right whale *Eubalena australis.* The area provides an additional buffer to the existing State sanctuaries and aims to allow for integrated management over the whole of the combined protected areas.

In Western Australia, Marmion Marine Park and Shoalwater Islands Marine Park surround islands that include haul-out sites of Australian sea-lions. Marine protected areas proposed by the Marine Parks and Reserves Selection Working Group (1994) include waters surrounding many sea-lion colonies and haul-out sites on both the south and west coasts of Western Australia.

These reserves protect waters frequently used by sea-lions and minimise interactions with fishing activities.

9. Biological overview

9.1 Growth and age

Birth weight/length		6.4 - 7.9 kg, 62 - 68 cm
Weaning age		15 - 18 months
Weight	*females*	61 - 104 kg (av. 77 kg)
	males	to 300 kg
Length	*females*	132 - 181 cm
	males	200 - 250 cm

Sources:
weight from Walker and Ling (1981);
length of adult males from King (1983).

9.2 Reproduction

Age at sexual maturity	
females	4 - 6 years
males	8 - 9 years

Pupping interval

Reported as 18 months by Ling and Walker (1978). This was refined to 17.6 months, with range 17.3 - 17.9 months for Seal Bay, Kangaroo Island by Higgins (1993). For breeding colonies on islands off the west coast of Western Australia, Gales *et al.* (1992b) estimated the pupping interval at 17.5 months. For another 11 colonies throughout the range, Gales *et al.* (1994) noted that the pupping interval was 17-18 months.

Gestation

Embryonic diapause is 4 to 5 months, and post-implantation period is prolonged at up to 14 months (Gales *et al.* 1997).

Pupping season

Extends for 5 months at Seal Bay and at islands on the west coast of Western Australia (Higgins 1990, Gales *et al.* 1992b), and up to 7 months at the largest colonies (The Pages and Dangerous Reef, T. E. Dennis, P. Seager, unpublished data). *N. cinerea* has a non-seasonal breeding cycle and its timing is asynchronous (Gales *et al.* 1994). Although it is synchronous for some adjacent colonies, there are pupping colonies in close proximity to each other for which it is asynchronous.

9.3 Diet

Australian sea-lions feed on a wide variety of prey, including cephalopods, fish, sharks, rock lobsters and sea birds (Gales and Cheal 1992, Ling 1992). There is little quantitative information on their diet because the usual technique for determining seal diet (examination of faeces) is unsuitable because few hard parts are found in this species (Gales and Cheal 1992). They also feed at fishing boats.

Between 1988 and 1990, several radio transmitters and time-depth recorders (TDRs) were deployed on Australian sea-lions at Seal Bay (Costa *et al.* 1990, 1991; Costa and Gales 1991). They found that nursing females were benthic feeders on the continental shelf in depths less than 150 m, 20 to 30 km offshore (Costa *et al.* 1988). One of the females carrying a radio was recorded by the RAAF 53 km offshore (T. E. Dennis, pers. comm.).

9.4 Behaviour

At Seal Bay, females hauled-out a day or two before giving birth and left about 10 days later to forage at sea. Foraging trips lasted approximately two days and increased in frequency gradually during lactation. Shore attendance bouts were about 1.5 days. This pattern continued until pups weaned. Females nursed their pups for 15-18 months until the next pup was born. Of females that did not pup consecutively each breeding season (29%), most (57%) continued to nurse their pups for up to 23 months and some continued for 40 months (Higgins and Gass 1993).

At Seal Bay, males were serially monogamous, ie they usually attended one female at a time. During the breeding season of five months, males did not maintain territories continuously, but spent up to four weeks ashore at a time, leaving their territories presumably to feed (Higgins 1990). Information on the reproductive behaviour of Australian sea-lions has been reviewed by Gales and Costa (1997).

9.5 Mortality and pathology

In the first six months, the mortality rate for pups was approximately 23% at Seal Bay (Higgins 1990). For pups on islands on the west coast of Western Australia, the mortality rate for the first five months varied from 7.1% to 24.3%, depending on whether pupping occurred in summer or winter, respectively. As the Leeuwin Current flows most strongly during winter it is possible that it was the primary factor associated with the higher mortality (Gales *et al.* 1992b). Even higher rates of pup mortality were reported in 1996 at The Pages Islands (56%) and Dangerous Reef (30%) by the time pupping was completed (T. E. Dennis, P. Seager, unpublished data); the cause of the elevated mortality has not been established.

At Seal Bay, attacks on pups by territorial bulls accounted for 19% of pup mortality during two breeding seasons (Higgins and Tedman 1990). In the initial two years of life mortality was estimated at between 40 and 50% (Higgins 1990).

Young sea-lions also drown in rock lobster pots (Gales *et al.* 1992b, Anon. 1996), but no estimate of the incidence of this mortality has been made.

9.6 Population abundance and rates of change

Based on a survey of most breeding sites of the Australian sea-lion between 1987 and 1992, Gales *et al.* (1994) estimated pup production at 2,430 (per breeding cycle) and the population size at about 10,000 animals (range 9,300 to 11,700).

That survey did not include any breeding sites along the Great Australian Bight. Surveys in 1994 and 1995 resulted in an estimate of 161 pups and a total population of 610 to 770 Australian sea-lions in colonies there. This region therefore accounts for about 7% of the known population size (Dennis and Shaughnessy 1996). Combining these two population estimates leads to an overall estimate of 9,900 to 12,500 animals with a mean of 11, 200. Of these, 2590 were pups.

Evidence of variability in pup production between seasons has been presented for islands on the west coast of Western Australia (Gales *et al.* 1992b), and for colonies on islands of the west coast of Eyre Peninsula (Shaughnessy *et al.* 1997).

King and Marlow (1979) suggested that populations of *N. cinerea* were decreasing, but there is little supporting evidence. Counts of pups on Kangaroo Island at Seal Bay (16 seasons) do not indicate any long-term trends (T. E. Dennis, pers. comm.), but those for The Pages (seven seasons) indicate that numbers declined between 1987 and 1997 (Dennis 1997). A survey of colonies on the west coast of South Australia conducted from 1995 to 1997 by Shaughnessy *et al.* (1997) demonstrated some marked decreases from estimates made in the late 1980s and early 1990s by Gales *et al.* (1994). For this comparison the term “pup” included both brown pups and moulted pups. In particular, pup numbers from ground counts on Purdie and Liguanea Islands in 1995 were much lower than those in 1990 (totalling 35 and 135, respectively). This suggests that pup production may be variable in some colonies of the Australian sea-lion between seasons.

Historical records indicate that its former range extended to Bass Strait, particularly Clarke Island and adjacent islands in the Furneaux Group (Warneke 1982). In Western Australia, the sea-lion’s current range corresponds with that occupied early in the nineteenth century (Abbott 1979). Its former range included islands near Albany and Perth where they are rarely seen now (reviewed in Gales *et al.* 1994). Furthermore, the small population on the Abrolhos Islands of the west coast of Western Australia is thought to have been more extensive before the arrival of Europeans. In South Australia, sea-lions occurred on the north and east coasts of Kangaroo Island early in the nineteenth century (Flinders 1814), where few are seen now. Hence, the overall population size is probably lower now than it was historically.

10. Threats

10.1 Harvesting

The species formerly occupied a more extensive range (section 9.6). From available records, it is apparent that sea-lion colonies, together with the more commercially valuable fur-seals, were reduced to very low numbers over much of southern Australia. It is unlikely that the colonies recently located in the Great Australian Bight, or those on some islands in the Recherche Archipelago, were harvested then because of their physical isolation and difficulty of access.

10.2 Current

Human disturbance

Displacement of sea-lions from established territories at critical times of the breeding season may lead to pup deaths. In an attempt to manage this problem in South Australia, the *National Parks and Wildlife Act 1972* has been used to give Prohibited Area status, and restrict access, to some breeding colonies.

The white shark viewing industry poses another threat to sea-lions by attracting sharks to their colonies with the potential to increase the mortality of sea-lions.

Fisheries

As there is little quantitative information available on the diet of Australian sea-lions, it is not currently possible to assess the level of ecological competition between Australian sea-lions and fishers. But, because of the broad diet of sea-lions, direct competition is probably limited. Several forms of competition with fishing activities are known. For instance, sea-lions rob lobster pots and nets set for schooling shark, and take Australian salmon and herring from nets set from shore on the south coast of Western Australia.
A result of interaction with fisheries is that sea-lions become entangled in fishing gear (and in other man-made debris) and some drown. In a review of the problem in South Australia, Robinson and Dennis (1988, p. 103) refer particularly to sea-lions becoming entangled in monofilament netting of 150 mm mesh, which is used in the shark fishery. As a result of this problem, some shark fishers in South Australia have chosen not to fish around the colony at The Pages in Backstairs Passage due to the number of sea-lions there and the number that are drowned in set gear. Bait bands have also been recorded on sea-lions in South Australia and in Western Australia. Data on entanglement are reviewed in Chapter 4.3.

Australian sea-lions (and New Zealand fur-seals) interact with nets at tuna farms near Port Lincoln, where they manage to take fish and some sea-lions become entangled in nets. Modifications to existing nets, including increasing tension on them, and adding bottom nets and top nets would greatly improve the situation (Pemberton 1996b).

10.3 Potential

Oil spills

Oil spills have not affected any Australian sea-lions colonies, but this could easily happen (see Chapter 4.4). For instance, the oil spill from the wrecked ship ‘Kirki’ was close to a breeding colony of sea-lions on the west coast of Western Australia but did not come ashore (N. Gales, *in litt.*). In general, sea-lions are less affected by oil spills than fur-seals because they do not rely on their pelage for insulation.

Potential reduction in food supply

Because little is known about the principal food resources used by the various age classes of the Australian sea-lion, it is difficult to predict the effect on sea-lions of a reduction in marine resources. The New Zealand fur-seal has been increasing in numbers and range in South Australia recently (Shaughnessy *et al.* 1995a). This increased population size could result in inter-species competition for prey resources if both species were feeding on the same prey and using similar foraging strategies.

Disease

The potential threat posed by disease is discussed in Chapter 4.7.

11. Conservation objectives

11.1 Research

- Follow trends in abundance.
- Investigate the genetic relatedness of the Australian sea-lion colonies across the species’ range.
- Investigate feeding ecology and foraging behaviour, and aim to measure the extent of overlap between sea-lions, fur-seals and other top predators such as little penguins.
- Investigate the levels of interaction and by-catch of Australian sea-lions in fishing operations.
- Investigate interactions between people and sea-lions at several sites, including the tourist beach at Seal Bay, Kangaroo Island.

11.2 Management

- Seals should be recognised as an integral and vulnerable component of marine ecosystems.
- Determine whether the aims of management should be for the population to increase (in size and/or distribution), remain steady or to decrease.
- Minimise interactions between fishers and sea-lions (see Chapter 4.2).
- Manage the sea-lion colonies that are visited by tourists for the long-term benefit of the tourism industry and the sea-lions.
- Consider establishing or redefining marine reserves around all sea-lion colonies with a standard width, and investigate the appropriate width.
- Evaluate innovative modifications to lobster pots aimed at excluding sea-lions (and fur-seals), and promote their use.
- Develop a best practice strategy for lobster fishers that advises on a protocol for the dumping of old baits, unwanted catch and undersize lobsters. This is aimed at minimising seals’ association of fishing vessels and set gear with foraging opportunities.

12. Conservation actions already initiated

12.1 Research

- Location of most breeding colonies and main haul-out sites has been determined.
- Abundance estimates and breeding seasons have been determined for many breeding colonies (but monitoring should continue to determine trends).
- Many aspects of the seals’ breeding biology have been determined.
- Planning has been initiated for a study of interactions between sea-lions and tourists at Seal Bay, Kangaroo Island.

- Tagging studies using transponder chips embedded under the skin have been initiated at Seal Bay.
- Movement patterns on the west coast of Western Australia have been studied.

12.2 Management

- The species is protected under Federal, State and Territory laws.
- Most breeding colonies are protected (Table VII.1) and most haul-out sites on islands are also protected.
- Marine protected areas have been declared at several sea-lion colonies in South Australia and there are two marine parks in Western Australia within the range of seals, with more reserves recommended (see section 8 above).
- Plans have been developed for modifying rock lobster pots to discourage sea-lions from entering and removing baits.

13. Conservation actions required

13.1 Research

- *Investigate the genetic relatedness of populations of the Australian sea-lion to determine stock identity and whether management plans for the species need to be colony specific, regionally based, or can be uniform across its range.
- Conduct a comprehensive survey of the sea-lion population across its range in a single breeding season to determine its population size. Because colonies of this species do not breed at the same time, this project would have to be conducted over two years. This would improve the population estimates of Gales *et al.* (1994) and provide comparisons with them.
- *Monitor trends in abundance of selected sea-lion colonies across the species' range each breeding season (or at least every second season) because there is evidence of variable pup production between seasons, and because it is important to determine if the population is increasing, decreasing or static. Colonies should be chosen so that they are accessible by boat, cover the geographic range, cover the population size range, and should breed at different times of the year; some should be close to commercial fisheries; and each should be of reasonable size (at least 40 pups). For Western Australia, suitable colonies are Six Mile, Salisbury, Kimberley, Rocky, Red Islet (off Fitzgerald River mouth) and Hauloff (on the south coast) and Buller, North Fisherman and Beagle (on the west coast). Islands on the west coast deserve special attention because their populations are more vulnerable, being small and more frequently visited. For South Australia, suitable colonies are The Pages, Seal Bay, Dangerous Reef, Liguanea Island, Olive Island and Purdie Island.
- *Examine pup counts critically for trends; those for the colonies at Seal Bay (data for 16 pupping seasons) and the nearby Pages Islands (seven seasons) are suitable because they are the longest for the species.
- Document early harvest data, and use them to model the population and to estimate abundance before European sealing began.
- Investigate the role of disease and toxicity in the ecology of the species.
- *Investigate the high incidence of pup mortality at The Pages Islands and Dangerous Reef (or other colonies) when next it occurs.
- *Investigate feeding ecology and foraging behaviour of Australian sea-lions, including the use of inshore benthic and pelagic resources near colonies by weaning and recently weaned pups. It should also aim to measure the extent of dietary overlap between sea-lions, fur-seals and other top predators such as little penguins.
- *Estimate the by-catch of sea-lions in fisheries, especially in the set-net or gill-net fisheries for sharks and Australian salmon.
- *Quantify the interactions between sea-lions and fisheries, and advise how detrimental aspects of the interactions can be ameliorated.

13.2 Management

- *Access to breeding colonies should be strictly limited during the pupping season in order to minimise disturbance to the seals and to protect people from the seals. This poses an extra problem for Australian sea-lions because the pupping season of different colonies are not synchronous and they do not occur at the same time each year.
- For handling 'stranded' animals, see comments in Appendix IV.
- *Encourage fishers and other mariners not to discard net fragments and other non-biodegradable material at sea, and not to shoot seals (which is illegal).
- *Promote an education program within the fishing industry to encourage self-regulation of activities that lead to the problems of entanglement and by-catch of Australian sea-lions.
- Encourage tuna farmers at Port Lincoln to improve their exclusion nets in order to increase protection to their fish from marine predators and to reduce entanglement of marine mammals (as recommended by Pemberton 1996b).
- Prepare contingency plans for dealing with an oil spill near a sea-lion colony (see Chapter 4.4).
- Ensure research projects on Australian sea-lions planned for Seal Bay involve minimal impact on the animals and the site. Seal Bay has been a popular site for research because of its accessibility. The South Australian National Parks and Wildlife should also encourage research at other sites in the State, because sea-lion behaviour may vary across the species range.
- Prohibit berleying at Australian sea-lion colonies. Because sea-lions are not abundant, are endemic to Australia and are the subject of a widespread tourism industry, increasing the potential predation on them is inadvisable.
- Include Hauloff Rock, Western Australia into the reserve system of the Department of Conservation and Land Management. This site supports breeding colonies of both Australian sea-lions and New Zealand fur-seals and is vacant crown land.

14. Organisation(s) responsible for conservation of species

14.1 International

Not applicable.

14.2 National

Environment Australia in Australian territorial waters (3 to ca. 200 nautical miles).

14.3 State

Government nature conservation and fisheries agencies, on land and in State and Territory waters (out to 3 nautical miles).

15. Other organisations and individuals involved

K. Twyford, A. Warner, R. Allen and P. Seager, South Australian National Parks and Wildlife; C. Kemper, South Australian Museum; T. Dennis, Kingscote; D. Coughran and P. Mawson, Western Australia Department of Conservation and Land Management; N. Gales, Western Australia Department of Conservation and Land Management (formerly with Department of Conservation, Wellington, New Zealand); L. Higgins and D. Costa, University of California, Santa Cruz, USA; P. Shaughnessy, CSIRO Wildlife and Ecology.

New Zealand Fur-Seal

1. Family	Otariidae
2. Scientific name	Arctocephalus forsteri
3. English name(s)	New Zealand fur-seal, South Australian fur-seal, long-nosed fur-seal

4. Taxonomic status (including species and subgroups)

Described by R.-P. Lesson in 1828 as *Otaria forsteri*. No subspecies are recognised, despite its fragmented distribution. It is one of eight species in the genus *Arctocephalus* (Repenning *et al.* 1971). Recent research (skull morphometrics and DNA) indicates that the taxonomic classification of *Arctocephalus* may require revision (Brunner 1998, Lento *et al.* 1994, 1997, S. Goldsworthy in prep.).

5. Species survival status

5.1 Conservation status based on IUCN (1994)

Lower Risk, conservation dependent

5.2 IUCN status

IUCN (1993): Not listed
SSG IUCN SSC: Not listed

5.3 CITES status

Appendix II

6. Distribution, including migration

The New Zealand fur-seal breeds in New Zealand, primarily in the South Island, Stewart Island and its Subantarctic islands, and in southern Australia on the south coasts of Western Australia and South Australia, and at Maatsuyker Island, Tasmania (Crawley 1990, Shaughnessy *et al.* 1994, Brothers and Pemberton 1990). The number of breeding locations in Australian waters was put at 30 by Shaughnessy *et al.* (1994): 16 in Western Australia, 13 in South Australia and one in Tasmania. Since then, pups have also been reported at Flinders Island, Western Australia (P. Lambert, pers. comm.) and at Macquarie Island (Goldsworthy *et al.* 1998). Colonies are listed in Table VII.2 (Appendix VII).

There are occasional reports of non-breeding animals from the west coast of Western Australia (including the Perth metropolitan area), Victoria, Bass Strait islands, New South Wales (particularly Montague Island), Queensland (south of Fraser Island) and New Caledonia (N. J. Gales, pers. comm., Mawson and Coughran in prep., Warneke 1995b, Llewellyn *et al.* 1994, Irvine *et al.* 1997, Haynes-Lovell 1994, King 1976). Animals on the east coast of Australia may have moved there from New Zealand or from South Australia. The only evidence of trans-Tasman movement is a seal that had been tagged as a pup in a New Zealand colony that drowned in a net at Lakes Entrance, Victoria in October 1994 (H. Best, pers. comm.). At Montague Island, New Zealand fur-seals with orange coloured flipper tags have been sighted (Irvine *et al.* 1997). Such tags have been used at Kangaroo Island, South Australia. Animals with tags applied at colonies on Kangaroo Island have also been reported from Tathra, Jervis Bay and Sydney.

Historical information presented by Warneke (1982) indicates that the range of *A. forsteri* used to extend to the Furneaux Group in eastern Bass Strait where it was quite abundant. Abbott (1979) concluded that the overall range in Western Australia has not changed since the arrival of Europeans.

7. Habitat

7.1 General

It prefers rocky parts of islands with jumbled terrain and boulders. In Australia, they prefer smoother igneous rock to rough limestone. There are several breeding sites on the "mainland" of Kangaroo Island.

7.2 Key localities

Most (77%) of the Australian population is in central South Australian waters (from Kangaroo Island to southern Eyre Peninsula). More specifically, 49% are on the South Neptune and North Neptune Islands. In Western Australia, the largest colony is at Salisbury Island, with 6% of the Australian population (Shaughnessy *et al.* 1994).

8. Marine protected areas managed or relevant to the species

In South Australia, a marine protected area has been proposed for waters surrounding the major fur-seal colonies on the South and North Neptune Islands. In Western Australia, marine protected areas proposed by the Marine Parks and Reserves Selection Working Group (1994) include waters surrounding many fur-seal colonies and haul-out sites on the south coast.

9. Biological overview

9.1 Growth and age

Birth weight/length		4 - 6 kg, 60 - 70 cm
Weaning age		8 - 12 months*
Weight	*females*	35 - 50 kg
	males	120 - 180 kg
Length	*females*	100 - 150 cm
	males	150 - 250 cm

Sources:
* (Goldsworthy 1991)
Goldsworthy and Crawley (1995).

9.2 Reproduction

Age at sexual maturity	
females	first pup at 6 years
males	hold territory at about 9 years

Source: Goldsworthy (1991)

Pupping interval	1 year
Gestation	8 - 9 months

Fecundity

0.67 at Cape Gantheaume (Goldsworthy and Shaughnessy 1994).

Pupping season

November-January; 90% of pups were born from 3 December to 6 January in 1988-89 at Cape Gantheaume, Kangaroo Island, with median date 21 December (Goldsworthy and Shaughnessy 1994).

9.3 Diet

On Kangaroo Island they feed principally on fish and cephalopods, also seabirds, including little penguins. Cephalopods are more important in summer and fish are more important in winter (Goldsworthy and Crawley 1995). They also feed at fishing boats.

9.4 Behaviour

Colonies are occupied year-round, but activity is greatest during summer (breeding season). Adult males begin defending territories vigorously in late November and their numbers ashore peak in early January (Goldsworthy and Shaughnessy 1994). Adult females begin to haul-out in early December and their numbers ashore peak late in the month. They give birth soon after coming ashore, mate eight days after giving birth and leave the colony to feed about two days later. They feed their pups over several months, alternating periods at sea feeding with shore attendance bouts suckling their pups.

9.5 Mortality and pathology

Mortality rate of pups is low: to 6 weeks of age, it is up to 1.0%; and from 6 weeks to 16 weeks it is up to 9% (Shaughnessy *et al.* 1995a).

9.6 Population abundance and rates of change

New Zealand fur-seals in Australian waters suffered a severe decline in numbers due to indiscriminate commercial sealing in the late 18th and early 19th centuries (Warneke 1982, Ling 1987).

Recent population estimates are based on a survey of pups, mostly in the 1989-90 summer, and converted to estimates of abundance for the whole population by multiplying by 4.9 (Shaughnessy *et al.* 1994) This gave estimates of 27,600 seals for South Australia and 7,000 seals for Western Australia. In Tasmania there were another 100 seals at Maatsuyker Island (Brothers and Pemberton 1990). Overall, this lead to an estimate of 34,700 New Zealand fur-seals in Australian mainland waters in the early 1990s.

Trends in population size have been determined at several colonies on Kangaroo Island (Shaughnessy *et al.* 1995a). The exponential rate of increase, r, of pup numbers based on estimates in n years has been:

Cape Gantheaume	r = 0.16 (n=5)
Cape du Couedic, Nautilus North	r = 0.19 (n=4)
Cape du Couedic, Nautilus Rock	r = 0 (n=4)
North Casuarina	r = 0.04 (n=2).

The abundance of pups has been estimated at all colonies on Kangaroo Island on three occasions between 1988-89 and 1995-96. The rate of increase is r = 0.103 (Shaughnessy 1997).

At the Nautilus Rock colony, space does not appear to be available for expansion. The colony at North Casuarina Islet is likely to have been established longer than the other colonies on Kangaroo Island since it was the only one referred to by Wood Jones (1925b). It is likely to reach its carrying capacity before other colonies.

On South Neptune Islands, several breeding colonies have established since 1970 and the population size has been increasing (Shaughnessy *et al.* 1996). In 1990, several breeding colonies were discovered in South Australia and Western Australia, but whether this was due to population increase or to an increase in knowledge is not known. On the south coast of Western Australia, there is a general impression that fur-seals are more common there now than previously.

At Maatsuyker Island, Tasmania, pup abundance was determined in March of 1990, 1991 and 1992; the population was well established with 50 to 80 pups being born annually (Kirkwood *et al.* 1992). Despite the recent increases, the overall population level in Australia is probably lower now than it was historically.

10. Threats

10.1 Harvesting

Seals were harvested along the entire southern coast of Australia during the early 1800s. There is little precise information on the numbers of *A. forsteri* taken or on the location of breeding colonies prior to exploitation. Ling (1987) estimated that at least 70,400 fur-seal skins were taken from Kangaroo Island, and possibly other islands west of Bass Strait.

10.2 Current

Some seals that interfere with fishing gear are shot by commercial and recreational fishers, but there is no quantitative information regarding the illegal culling. On the south coast of Western Australia, fur-seals take Australian salmon and herring from nets set from shore.

fur-seals interact with nets at tuna farms near Port Lincoln, where they manage to take fish and some animals become entangled. Modifications to existing nets, including increasing tension on them, and adding bottom nets and top nets would greatly improve the situation (Pemberton 1996b).

Substantial numbers of New Zealand fur-seals (eg 800 in 1989) have been caught in the deep water trawl fishery for hoki *Macruronus novaezeelandiae* off the west coast of the South Island of New Zealand (Mattlin *et al.* 1998). Small numbers of New Zealand fur-seals are thought to be included with Australian fur-seals in by-catch in the Australian southeast trawl fishery.

A commercial trawl fishery began in 1994 in the vicinity of Macquarie Island for Patagonian toothfish *Dissostichus eleginoides.* No fur-seals are reported to have been taken in that fishery.

10.3 Potential

Fisheries

Commercial and recreational fishermen regard seals as competitors and as pests (see Chapter 4.2).

Entanglement

The incidence of entanglement of New Zealand fur-seals is lower than that of other seals on the Australian coast. Nevertheless, it is an insidious problem (see Chapter 4.3).

Oil spills

The one major oil spill that affected seal colonies in Australia involved this species at islands in the Recherche Archipelago (see Chapter 4.4). Young pups that were affected were not old enough to swim away from the colony and were caught and treated successfully (Gales 1991). If older age-classes had been affected, the seals would have been impossible to recover and treat.

Disease

The potential threat posed by disease is discussed in Chapter 4.7.

11. Conservation objectives

11.1 Research

- Investigate the genetic relatedness of New Zealand fur-seal colonies.
- Improve estimates of abundance at colonies in Western Australia using a mark-recapture technique on pups or by marking exhaustively.
- Continue monitoring trends in abundance at colonies on Kangaroo Island, South Australia, and at Maatsuyker, Tasmania and select colonies in Western Australia for monitoring.
- Obtain information on diet to assess possible interaction with the fishing industry.
- Investigate feeding ecology and foraging behaviour and aim to measure the extent of overlap between sea-lions, fur-seals and other top predators such as little penguins.
- Obtain information on interactions at fishing vessels. Monitor interactions between fur-seals and the trawl fishery at Macquarie Island.
- Obtain information on movements and feeding areas using satellite-linked radio transmitters and time-temperature-depth recorders.

11.2 Management

- Seals should be recognised as an integral and vulnerable component of marine ecosystems.
- Determine whether the aims of management should be for the population to increase (in size and/or distribution), remain steady or to decrease.
- Minimise possible detrimental effects from interaction with fisheries (see Chapter 4.2).
- Evaluate innovative modifications to lobster pots aimed at excluding fur-seals (and sea-lions), and promote their use.
- Develop a best practice strategy for lobster fishers that advises on a protocol for the dumping of old baits, unwanted catch and undersize lobsters. This is aimed at minimising seals' association of fishing vessels and set gear with foraging opportunities.
- Consider establishing or redefining marine reserves around significant fur-seal colonies (producing at least 20 pups each season) with a standard width, and investigate the appropriate width.

12. Conservation actions already initiated

12.1 Research

- Investigations of the genetic relatedness of New Zealand fur-seal colonies, and between New Zealand and Australian fur-seals are underway using mitochondrial DNA (Lento *et al.* 1994, 1997) and electrophoresis, using material from Western Australia, South Australia, Tasmania and New Zealand.
- Distribution and abundance were determined in most colonies in Western Australia and South Australia in the 1989-90 breeding season.
- Trends in population size are being determined for colonies on Maatsuyker Island, Tasmania and on Kangaroo Island, South Australia.
- Duration of the pupping season has been determined at colonies on Kangaroo Island and South Neptune Island.
- Material has been collected at Cape Gantheaume for a study of food (S. Goldsworthy).
- Attendance patterns in the colony of adult females and adult males have been determined.
- Differences in external appearance between Australian and New Zealand fur-seals have been described (Goldsworthy *et al.* 1997).
- Differences in skull measurements between *A. forsteri* and *A. pusillus doriferus* have been described (Brunner 1998).
- Breeding biology has been determined at South Neptune Islands and Cape Gantheaume colonies.
- Entanglement data have been collected at two colonies on Kangaroo Island and at Maatsuyker Island, but need to be published.

12.2 Management

- The species is protected under Federal, State and Territory laws.
- Most breeding colonies are protected (Table VII.2) and most haul-out sites on islands are also protected. In addition, prohibited areas have been declared at some colonies on Kangaroo Island.
- In Western Australia, a plan for a representative system of marine reserves has been prepared (Marine Parks and Reserves Selection Working Group 1994).

13. Conservation actions required

13.1 Research

- Determine the duration of the pupping season at Maatsuyker Island and at two sites in Western Australia (eg, at Hood Island and Doubtful Island) to ensure that estimates of abundance of pups are conducted at appropriate times.
- *Replicate the overall survey conducted in the 1989-90 breeding season in Western Australia and South Australia to determine trends. Although that survey was not done in the most appropriate manner, replication should be conducted on the same dates and by the same methods for each colony.
- *Monitor pup abundance in several colonies in Western Australia and South Australia by a mark-recapture technique every two to three years. Colonies to be monitored should be chosen so that they are accessible by boat and cover the species' geographic range and some colonies should be close to commercial fisheries. For Western Australia, suitable colonies are Daw, New Year, Salisbury, Hood, Seal Rock, Rocky, Doubtful and Flinders Islands. For South Australia, suitable colonies are at Cape Gantheaume, North Casuarina Islet, Cape du Couedic and Neptune Islands. Mark-recapture is the preferred technique for this monitoring, because it provides an

unbiased estimate of abundance, and it is of high precision (low variability). Monitoring abundance at selected colonies every two to three years is preferred to overall surveys every five to ten years (see below) because the former is cheaper, and it still gives a good indication of the status of the population.

- Determine pup abundance in all breeding colonies in Western Australia, South Australia and Tasmania in a single summer by the most efficacious means. This should be done once every five to ten years, and would be an extension of the monitoring conducted at selected colonies.
- *At Maatsuyker Island continue monitoring pup abundance annually.
- Document early harvest data, and use them to model the population and estimate abundance before European sealing began.
- At Macquarie Island, continue monitoring the number of animals ashore during the moulting period (late March).
- Investigate the role of disease and toxicity in the ecology of the species.
- *Investigate feeding ecology and foraging behaviour at more than one breeding colony. This should include a description of how they relate to commercial fisheries, and determination of feeding localities of adults. It should also aim to measure the extent of dietary overlap between sea-lions, fur-seals and other top predators such as little penguins.
- *Quantify the interactions between fur-seals and fishing equipment, and advise how detrimental aspects of the interactions can be ameliorated.
- *Estimate the by-catch of fur-seals in fisheries, including the number of animals taken in gill-net, trawl, drop-line and long-line fisheries.
- *At Macquarie Island, study interactions between fur-seals and the trawl fishery, including diet and foraging locations.

13.2 Management

- *Access to breeding colonies should be strictly limited during the pupping season in order to minimise disturbance to the seals and to protect people from the seals.
- For handling ‘stranded’ animals, see comments in Appendix II.
- *Encourage fishers (and other mariners) not to discard net fragments and other non-biodegradable material at sea, and not to shoot seals (which is illegal).
- Encourage tuna farmers at Port Lincoln to improve their exclusion nets in order to increase protection to their fish from marine predators and to reduce entanglement of marine mammals (as recommended by Pemberton 1996b).
- Prepare contingency plans for dealing with an oil spill near a fur-seal colony (see Chapter 4.4).
- Include Hauloff Rock, Western Australia into the reserve system of the Department of Conservation and Land Management. This site supports breeding colonies of both Australian sea-lions and New Zealand fur-seals and is vacant crown land.

14. Organisation(s) responsible for conservation of species

14.1 International

CITES

14.2 National

Environment Australia in Australian territorial waters (3 to ca. 200 nautical miles)

14.3 State

Government nature conservation and fisheries agencies, on land and in State and Territory waters (out to 3 nautical miles).

15. Other organisations and individuals involved

N. Brothers, and I. Skira, Tasmanian Parks and Wildlife Service; D. Pemberton, Tasmanian Museum and Art Gallery (formerly with Tasmanian Parks and Wildlife Service); M. Hindell, S. Goldsworthy and students at University of Tasmania studying fur-seals at Maatsuyker Island; K. Twyford, R. Ellis and R. Allen, South Australian National Parks and Wildlife; C. Kemper, South Australian Museum; T. Dennis, Kingscote; D. Coughran and P. Mawson, Western Australia Department of Conservation and Land Management; P. Shaughnessy, CSIRO Wildlife and Ecology; H. Best, Department of Conservation, Wellington, New Zealand; N. Gales, Western Australia Department of Conservation and Land Management (formerly with Department of Conservation, Wellington, New Zealand); G. Lento, Victoria University, Wellington, New Zealand; S. Troy, Cooperative Research Centre for Ecologically Sustainable Development of the Great Barrier Reef (formerly with University of Melbourne).

Australian Fur-Seal

1. Family	Otariidae
2. Scientific name	*Arctocephalus pusillus*
3. English name(s)	Australian fur-seal, Tasmanian fur-seal, giant fur-seal

4. Taxonomic status (including species and subgroups)

Described by Wood Jones (1925a) as *A. doriferus* from a specimen collected in South Australia. Its taxonomy was clarified by King (1969) on the basis of skull characters and body size, when she demonstrated that there were two species of fur-seal on the Australian coast. It was recognised as *A. p. doriferus*, a subspecies of the South African (Cape) fur-seal, by Repenning *et al.* (1971). Recent research (skull morphometrics and DNA) indicates that the taxonomic classification of *Arctocephalus* may require revision (Brunner 1998, Lento *et al.* 1994, 1997, S. Goldsworthy in prep.).

5. Species survival status

5.1 Conservation status based on IUCN (1994)

Lower Risk, conservation dependent

5.2 IUCN status

IUCN (1993): Not listed
SSG IUCN SSC: Not listed

5.3 CITES status

Appendix II

6. Distribution, including migration

Breeding colonies are restricted to islands in Bass Strait with four in Victoria and five in Tasmania (Warneke 1988, 1995b, Pemberton and Kirkwood 1994), and a small breeding colony is becoming established at Wright Rock (Pemberton 1996a). Several islands have not been re-occupied since their populations were removed by early commercial sealing (Warneke and Shaughnessy 1985). They are reported to have bred at Seal Rocks, near Port Stephens, and Montague Island in New South Wales (Warneke 1982). The Australian fur-seal’s range includes South Australia, southern Tasmania, New South Wales and Jervis Bay Territory with several haul-out sites known in each State (Shaughnessy 1995, Brothers and Pemberton 1990, Llewellyn *et al.* 1994, M. Fortescue, pers. comm.).

7. Habitat

7.1 General

They prefer rocky parts of islands with flat, open terrain. They occupy flatter areas than do New Zealand fur-seals at sites where they both occur.

7.2 Key localities

The largest breeding colonies are at Lady Julia Percy Island and Seal Rocks in Victoria, and at Judgement Rocks and Reid Rocks in Tasmania (Warneke 1988, Pemberton and Kirkwood 1994).

8. Marine protected areas managed or relevant to the species

In Victoria, the contiguous Wilson Promontory Marine Park and Wilson Promontory Marine Reserve are relevant to Australian fur-seals. They extend from Shallow Inlet in the west to Entrance Point in the east (at the entrance to Corner Inlet). Within the Marine Reserve, fur-seals occur on Kanowna Island and adjacent Anderson Islets in the Anser Group. The reserve boundaries are set at 300 m from the islands (Department of Conservation, Forests and Lands 1989).

In Port Phillip Bay, transient Australian fur-seals visit the Annulus (Pope’s Eye) Marine Reserve. The reserve boundary is at a radius of 100 m from the centre of the Annulus. In Western Port, a marine reserve is under consideration for Seal Rocks. Other marine protected areas are proposed for the waters around The Skerries and Lady Julia Percy Island (M. Kitchell, *in litt.* 8 June 1995).

In Tasmania, a marine protected area has been proposed around Deal Island in Bass Strait that would include the colony of Australian fur-seals at Judgement Rock (D. Pemberton *in litt.* 31 October 1997).

9. Biological overview

9.1 Growth and age

Birth weight/length		5 - 12 kg, 60 - 80 cm
Weaning age		10 - 12 months
Weight	*females*	41 - 113 kg (av. 78 kg)
	males	218 - 360 kg (av. 279 kg)
Length	*females*	136 - 171 cm (av. 157 cm)
	males	201 - 227 cm (av. 216 cm)
Age, max.	*females*	>21 years
	males	>19 years

Source: Warneke (1995a).

9.2 Reproduction

Age at sexual maturity	
females	3 to 6 years
males	ca. 5 years, hold territories at 8 to 13 years
Gestation	8 - 9 months
Pupping interval	1 year

Source: Warneke (1995a)

Pupping season

Late October to late December at Seal Rocks, Victoria; 90% of pups were born in a 26-day period with a median date of 1 December (Warneke and Shaughnessy 1985). At Tenth Island, Tasmania, in 1990, the median date of birth was 26 November, with 90% of pups born over a 48-day period (Pemberton and Kirkwood 1994).

9.3 Diet

Principally fish and cephalopods, also seabirds (Warneke and Shaughnessy 1985). The primary squid taken in Tasmanian waters was Gould's squid (Gales *et al.* 1993). Of 25 species of fish that were identified, only a few were important at a particular location and in a particular season (Gales and Pemberton 1994). The most important prey were redbait, leatherjackets and jack mackerel. Fish predominated in winter and cephalopods in summer. Sizes of prey indicated that mostly adult fish and squid were eaten. The jack mackerel taken by Australian fur-seals correspond in size with those taken in the commercial fishery. These seals also feed at fishing boats.

9.4 Behaviour

Colonies are occupied year-round, but activity is greatest during the summer breeding season. Adult females give birth soon after coming ashore, mate about six days after giving birth, and then leave the colony to feed. They alternate periods at sea feeding with shore attendance bouts suckling their pups for several months. There is considerable variation in the time of weaning. Pups begin to forage effectively in June or July, supplementing their milk diet. Most are weaned by September or October, but a small proportion continue to suckle into their second year.

9.5 Mortality and pathology

At Seal Rocks, Victoria, the mortality rate of pups in the first two months is at least 15% (Warneke 1982). For Tasmanian colonies, Pemberton and Kirkwood (1994) estimated pup mortality at 15% by about six weeks of age (early January).

9.6 Population abundance and rates of change

An aerial survey of breeding and non-breeding sites in December 1986 (Warneke 1988) resulted in an estimate of 8,000 pups. In 1991, pup production was estimated at 5,130 for Tasmanian colonies and the total population size for Australian waters was estimated at between 47,000 and 60,000, with pup production estimated at 13,335 (Pemberton and Kirkwood 1994).

At Seal Rocks, pup numbers in late December 1991 were estimated at 2,800 using mark-recapture, which exceeded the count of 2,000 pups (Shaughnessy *et al.* 1995b). Trends at Seal Rocks based on pup counts by R. M. Warneke each season from 1967 to 1991 show considerable fluctuations but indicate a slow increase at an exponential rate of $r = 0.02$.

For Tasmanian colonies, Pemberton and Kirkwood (1994) demonstrated increases in pup numbers over the three year duration of their study at four of five colonies. As they indicated this needs to be treated with caution because of the short length of the study, because pup numbers were estimated by several techniques, and because of annual variation in pup numbers at small islands caused by storms.

Despite the recent increases, the overall population level in Australia is likely to be lower now than it was historically, and may only be half of its original size (Kirkwood *et al.* 1992).

10. Threats

10.1 Harvesting

The sealing era in Australia lasted from 1798 to about 1825. Warneke and Shaughnessy (1985) estimated that the number of *A. p. doriferus* skins taken was in the order of 200,000, which would have meant that the original population would have been two to five times the current population size, with an annual pup production between 20,000 and 50,000 pups. Sealing at a few remnant colonies in eastern Bass Strait, Tasmania, continued on a regulated seasonal basis after protection in 1889 until about 1923 (Warneke and Shaughnessy 1985). In Victoria, a harvest was conducted in 1948-49. Although a limit was set at 2,000 animals, only 691 were killed (McNally and Lynch 1954).

10.2 Current

Fisheries

Fishermen in Victoria maintained that seals drastically reduced stocks of commercially viable fish, a claim that was not substantiated by evidence from fishery statistics or by dietary studies (Warneke 1982). Seals interfered with sedentary mesh-net fisheries by damaging nets, mauling fish and allowing them to escape (Warneke 1982). Seals that interfere with fishing gear are often shot by commercial and recreational fishermen, but there is no information regarding the extent of illegal culling. Recoveries of tagged juvenile *A. p. doriferus* ($n = 88$) indicated that 66% of deaths resulted from drowning in nets and traps or from gunshot wounds, although the full extent of this mortality in the overall population is unknown (Warneke 1975).

Seal attacks pose an economic threat to fish farms in southern Tasmania (Pemberton and Shaughnessy 1993). Seals are often accidentally drowned in nets and traps, and many are shot when interfering with fisheries operations. Protection nets (also referred to as predator proof fences) have been installed on many fish farms to reduce the problem. These are nets of braided polypropylene twine hung at least 1.5 m from the outside of individual pens and heavily weighted to keep them apart from the pen. Alternatives are steel mesh exclusion nets around and under pens, and nylon and/or polypropylene nets around the perimeter of the lease enclosing all the pens (Pemberton and Shaughnessy 1993).

Entanglement

There is a high incidence of entanglement in Tasmanian waters (1.9%) which is a potential threat to seal populations (Pemberton *et al.* 1992). At Seal Rocks, Victoria, a high incidence of entanglement (up to 1.2%) was also observed (Prendergast and Johnson 1995). See also Chapter 4.3.

10.3 Potential

Oil spills

Oil spills pose a threat to all seal populations, especially those near major shipping lanes. See Chapter 4.4.

Disease

The potential threat posed by disease is discussed in Chapter 4.7.

11. Conservation objectives

11.1 Research

- Provide estimates of abundance using a mark-recapture technique on pups.
- Monitor trends in abundance at selected colonies.
- Investigate feeding ecology and foraging behaviour, and aim to measure the extent of overlap between sea-lions, fur-seals and other top predators such as little penguins.
- Obtain information on diet to assess possible interaction with the fishing industry.
- Obtain information on interactions at fishing vessels.
- Obtain information on movements and feeding areas using satellite-linked radio transmitters and time-temperature-depth recorders.

11.2 Management

- Seals should be recognised as an integral and vulnerable component of marine ecosystems.
- Determine whether the aim of management should be for the population to increase (in size and/or distribution), remain steady or to decrease.
- Minimise possible detrimental effects from interaction with fisheries (see Chapter 4.2).

- Evaluate innovative modifications to lobster pots aimed at excluding fur-seals (and sea-lions), and promote their use.
- Develop a best practice strategy for lobster fishers that advises on a protocol for the dumping of old baits, unwanted catch and undersize lobsters. This is aimed at minimising seals' association of fishing vessels and set gear with foraging opportunities.
- Consider establishing or redefining marine reserves around significant fur-seal colonies (producing at least 20 pups each season) with a standard width, and investigate the appropriate width.
- The Australian fur-seal breeds at a small number of islands (currently ten), whereas it formerly bred at several other islands in Bass Strait and in New South Wales. Long-term planning for conservation should not overlook the possibility that this species may recolonise some of its former breeding sites.

12. Conservation actions already initiated

12.1 Research

- An investigation of the genetic relatedness of Australian fur-seal colonies is underway using mitochondrial DNA (Chambers *et al.* 1995) with material from Tasmania.
- Differences in external appearance between Australian and New Zealand fur-seals have been described (Goldsworthy *et al.* 1997).
- Differences in of skull measurements between *A. forsteri* and *A. pusillus doriferus* have been described (Brunner 1998).
- Distribution of breeding colonies and main haul-out sites has been determined.
- Abundance estimates have been determined for many breeding colonies and this effort should be maintained.
- Breeding biology has been determined.
- Early harvest data have been collated.
- Aspects of foraging ecology are being studied.
- Most of these actions are underway in Tasmania by TASPAWS biologists (eg, Hindell and Pemberton 1997).

12.2 Management

- The species is protected under Federal, State and Territory laws.
- Most breeding colonies are protected (Table VII.3) and most haul-out sites on islands are also protected.

13. Conservation actions required

13.1 Research

- *Monitor pup abundance in breeding colonies in Tasmania and Victoria using a mark-recapture technique at least every two to three years. Furthermore, aim to determine the pup abundance in all colonies in a single summer.
- Model the population using harvest data, and estimate abundance before European harvesting.
- Analyse the extensive array of pup counts, and tagging and resighting data accumulated over many years at Seal Rocks, Victoria by R. M. Warneke to estimate trends in abundance, mortality rates, pregnancy rates, and age at first reproduction.
- Investigate the role of disease and toxicity in the ecology of the species.
- *Investigate feeding ecology and foraging behaviour. This should include a description of how they relate to commercial fisheries, and determination of feeding localities of adults. It should also aim to measure the extent of dietary overlap between sea-lions, fur-seals and other top predators such as little penguins.
- *Quantify the interactions between fur-seals and fisheries, and advise how detrimental aspects of the interactions can be ameliorated.
- *Estimate the by-catch of fur-seals in fisheries, including the number of animals taken in gill-net, trawl, drop-line and long-line fisheries.

13.2 Management

- *Access to breeding colonies should be strictly limited during the pupping season in order to minimise disturbance to the seals and to protect people from the seals.
- For handling 'stranded' animals, see comments in Appendix IV.
- *Encourage fishers and other mariners not to discard net fragments and other non-biodegradable material at sea and not to shoot seals (which is illegal).
- Prepare contingency plans for dealing with an oil spill near a fur-seal colony (see Chapter 4.4).
- Long-term planning for conservation should not overlook the possibility that this species may recolonise some of its former breeding sites in Bass Strait and New South Wales.

14. Organisation(s) responsible for conservation of species

14.1 International

CITES

14.2 National

Environment Australia in Australian territorial waters (3 to ca. 200 nautical miles).

14.3 State

Government nature conservation and fisheries agencies, on land and in State territorial waters (out to 3 nautical miles).

15. Other organisations and individuals involved

N. Brothers and I. Skira, Tasmanian Parks and Wildlife Service; D. Pemberton, Tasmanian Museum and Art Gallery (formerly with Tasmanian Parks and Wildlife Service); Marine Mammal Department, Royal Melbourne Zoological Gardens (captive, stranded and rehabilitated animals); Museum of Victoria; R. Warneke, Warneke Marine Mammal Services; A. Irvine, University of Sydney; R. Harcourt and J. Arnould, Macquarie University; R. Kirkwood, Phillip Island Nature Park; P. Shaughnessy, CSIRO Wildlife and Ecology.

Antarctic Fur-Seal

1. Family	Otariidae
2. Scientific name	*Arctocephalus gazella*
3. English name(s)	Antarctic fur-seal, Kerguelen fur-seal

4. Taxonomic status (including species and subgroups)

Described by W. Peters in 1875 as *Arctophoca gazella* from Kerguelen. It is one of eight species of *Arctocephalus* (Repenning *et al.* 1971). It was considered to be conspecific with the Subantarctic fur-seal for many years (King 1959). Recent research (skull morphometrics and DNA) indicates that the taxonomic classification of *Arctocephalus* may require revision (Brunner 1998, Lento *et al.* 1994, 1997, S. D. Goldsworthy in prep.).

5. Species survival status

5.1 Conservation status based on IUCN (1994)

Lower Risk, conservation dependent

5.2 IUCN status

IUCN (1993): Not listed
SSG IUCN SSC: Not listed

5.3 CITES status

Appendix II

6. Distribution, including migration

In the Australian Subantarctic region there are two breeding colonies at Macquarie Island, several at Heard Island (Shaughnessy and Goldsworthy 1993), and at least one site on the McDonald Islands (Johnstone 1982). On the basis of these records, Shaughnessy (1992) recommended that this species be considered part of the Australian fauna. The species interbreeds with *A. tropicalis* at Macquarie Island (Shaughnessy *et al.* 1988a). The major concentration of *A. gazella* is in the Scotia Arc region of Antarctica, including South Georgia where it is estimated that 95% of this species breeds (Boyd 1993).

As few females haul-out on islands over winter, it is assumed that they migrate, but the locations are unknown. Males appear to remain in the vicinity of breeding colonies throughout this time. At Heard Island large numbers of non-breeding male fur-seals (up to 15,000) have been reported hauling out to moult after the summer breeding season (Shaughnessy and Goldsworthy 1990). As this number is much greater than that expected from the size of the breeding population (about 1,100 animals), these immigrants may have travelled from the large concentration of *A. gazella* at South Georgia (approximately 6,600 km from Heard Island), or possibly from a large, undiscovered population on the west coast of Kerguelen (Shaughnessy and Goldsworthy 1990).

Antarctic fur-seals have been reported from Mawson and Davis on the coast of the Australian Antarctic Territory, and at sea in the Southern Ocean (Shaughnessy and Burton 1986, Tynan 1996).

7. Habitat

7.1 General

On Heard Island, *A. gazella* utilise flat grassy meadows, usually within 60 m of the beach (Shaughnessy and Goldsworthy 1990). On the McDonald Islands, they use beaches that are backed by cliffs (Johnstone 1982). At Macquarie Island, breeding *A. gazella* utilise open cobble-stone beaches, and non-breeding seals also utilise tussock slopes above the colonies.

7.2 Key localities

There are three breeding populations in the Australian Subantarctic region: Heard Island, McDonald Islands and Macquarie Island.

8. Marine protected areas managed or relevant to the species

None. A marine reserve has been proposed as part of a marine conservation strategy for Macquarie Island (Scott 1994). A proposal for a marine reserve around Macquarie Island has been initiated by the Tasmanian government (D. Rounsevell *in litt.*).

9. Biological overview

9.1 Growth and age

Birth weight/length		4 - 6 kg, 60 - 70 cm
Weaning age (Doidge and Croxall 1989)		4 months
Weight	*females*	25 - 40 kg
	males	125 - 200 kg
Length	*females*	105 - 135 cm
	males	170 - 200 cm

Source: Goldsworthy and Shaughnessy (1995b).

9.2 Reproduction

Age at sexual maturity	
female	3 - 4 years
male	4 - 6 years, hold territories at 9 years
Pupping interval	1 year

Gestation

3 - 4 months delayed implantation of blastocyst, active gestation for 8 - 9 months.

Pupping season

November-December; at Heard Island 90% of pups were born over a 26 day period with 11 December as the median date of birth (Shaughnessy and Goldsworthy 1990). At Macquarie Island, the median date of birth of a mixed colony of *A. gazella* and *A. tropicalis* was 10 December (Shaughnessy *et al.* 1988a).

9.3 Diet

At both Heard and Macquarie Islands, they feed mostly on pelagic myctophid fish (*Electrona* spp. and *Gymnoscopelus* spp.). At Heard Island they also feed on squid (Green *et al.* 1989, Green *et al.* 1990) and the proportion of squid in the diet increased during late autumn and early winter (Green *et al.* 1991). At South Georgia they feed almost exclusively on krill *Euphausia superba* (Doidge and Croxall 1985).

9.4 Behaviour

Adult males begin hauling-out and contesting for territories in late October and early November. Females haul-out about a day prior to parturition and come into oestrus and are mated 7 days post-partum. Females then nurse their pups on shore, between foraging trips to sea, until they wean in April. Males defend territories which contain on average 5 females each on Heard Island (Shaughnessy and Goldsworthy 1990) where the female density in breeding colonies is low, and 10 each at South Georgia, where female density is high (McCann and Doidge 1987). Males fast during the breeding season until all females have been mated. After the weaning period, females and pups abandon colonies and females don't haul-out again until the next breeding season. From April to November fur-seal colonies are almost deserted except for occasional males.

9.5 Mortality and pathology

At Heard Island, some pups die as a result of vigorous storms and others are taken by leopard seals (Shaughnessy and Goldsworthy 1990).

9.6 Population abundance and rates of change

At Heard Island, breeding fur-seals were first recorded in 1962-63 (Budd and Downes 1969). Counts were made at irregular intervals until 1987-88, when 248 pups were recorded. In that 25 year period, pup production increased at an exponential rate of r = 0.207 based on pup counts in seven summers (Shaughnessy and Goldsworthy 1990). This rate may be inflated due to incomplete earlier counts and by immigration of breeding animals.

At Heard Island in the 1987-88 summer, the population size was estimated at between 870 and 1,120 (Shaughnessy and Goldsworthy 1990), by applying multipliers of 3.5 and 4.5 to the number of pups (Harwood and Prime 1978). In late February 1988, an estimated 15,000 fur-seals were ashore.

On the McDonald Islands the status of *A. gazella* is largely unknown. Johnstone (1982) counted "up to 100" pups in March 1980. He implied that these were on eastern beaches, without specifying the location(s). In January 1971, Budd (1972) reported 46 pups on the northern beach of the east coast. Adult male fur-seals were also seen on the southern beach of the east coast, but not pups. It was suspected that breeding fur-seals may have been using caves on that beach.

On Macquarie Island in the 1995-96 season, 89 *A. gazella* pups were born, constituting 72% of the total pup production; in addition there were 9 pups with mixed phenotypes (Goldsworthy 1996). Based on this, the number of Antarctic fur-seals at Macquarie Island can be estimated at between 310 and 400, by applying multipliers of 3.5 and 4.5 (Harwood and Prime 1978) to the number of *A. gazella* pups. The exponential rate of increase of the breeding population on Macquarie Island for the five years to 1996-97 was r = 0.13 (Goldsworthy *et al.* 1998).

10. Threats

10.1 Harvesting

fur-seals at Macquarie Island were exterminated by 19th century sealers. The island and its fur-seals were discovered in 1810 and nearly all the fur-seals were eliminated within 10 years. The number harvested is estimated to have been at least 193,000 (Shaughnessy and Fletcher 1987), but the identity of the original species is unknown.

For Heard Island, the only reported cargo of fur-seal skins was in 1856, after which sealers turned their attention to elephant seals. Shaughnessy *et al.* (1988b) argued that there had been more fur-sealing on the island before then and deduced that fur-seals were almost exterminated there by the 1870s.

Macquarie Island is managed as a nature reserve by the Tasmanian Parks and Wildlife Service, and Heard Island is managed as a wilderness reserve by the Australian Antarctic Division. fur-seals are protected at both locations and they are also protected on the Australian coast. Southern fur-seals are protected from harvesting by the Convention for the Conservation of Antarctic Seals (Chapter 4.1.2).

10.2 Current

Ashore

There is suitable breeding habitat on Macquarie Island and Heard Island for populations to continue increasing.

Fisheries

Exploratory fishing was conducted near Heard Island in the winter of 1987 (Williams and Ensor 1988). A commercial trawl fishery began in 1994 in the vicinity of Macquarie Island for Patagonian toothfish. Furthermore, the fishery for myctophids in the Convention for the Conservation of Marine Living Resources (CCAMLR) region has increased in recent years. Because these fish are important for the Heard and Macquarie populations of fur-seals, the fishery and its effects should be monitored. This advice has been passed from the SCAR Group of Specialists on Seals to CCAMLR (Anon. 1995).

The fishery at Heard, McDonald and Macquarie Islands, and its likely effects on high level predators was the topic of a workshop held at the Australian Antarctic Division in late April and early May, 1997. A conclusion was that "existing information is not sufficient to identify whether fishing is likely to have any substantial impacts on seals and penguins" (Australian Antarctic Division 1997, p. 7). Nevertheless, the workshop recommended that "conservation objectives for high level predators should be included among the objectives of the long-term management plans for these fisheries" (*ibid*, p.8).

Entanglement

The lack of commercial fisheries around Australian populations until recently has ensured that the threat from entanglement in marine debris has been low, but it is likely to increase with the recent advent of fisheries in the area. fur-seals entangled in fishing gear have been recorded at both Heard and Macquarie Islands.

Introgression

Hybridisation between Antarctic, Subantarctic and New Zealand fur-seals at Macquarie Island could threaten the integrity of each species there.

10.3 Potential

Oil spills

Due to the small number of visits by ships to Macquarie, Heard and the McDonald Islands, the potential threat of oil spills to seal populations is low. However, several ships visit Macquarie Island each summer to re-supply the Australian Antarctic Division base, and large quantities of fuel pumped ashore near the main fur-seal colony (at Secluded Beach) just north of the base present a possible hazard. Tour ships also visit these islands and are another potential source of oil spills. Visits to Heard Island are less frequent and, unlike Macquarie Island, fur-seal colonies are spread over much of the coastline.

Rehabilitated seals

If animals of this species were to haul-out on mainland Australia, they should not be sent to breeding stations on Subantarctic islands for fear of inadvertently introducing disease from other captive animals (see Chapter 4.7 and Appendix IV).

Disease

The potential threat posed by disease is discussed in Chapter 4.7.

11. Conservation objectives

11.1 Research

- Improve knowledge of the biology of fur-seal populations at Macquarie and Heard Islands, especially as this relates to the Australian Government goals for research in Antarctica.
- Monitor interactions between fur-seals and the trawl fishery at Macquarie Island.

11.2 Management

- Seals should be recognised as an integral and vulnerable component of marine ecosystems.
- Determine whether the aims of management should be for the population to increase (in size and/or distribution), remain steady or to decrease.
- Ensure a viable population of Antarctic fur-seals is maintained at Heard and Macquarie Islands.
- Ensure that Antarctic fur-seals that haul-out on the coast of the Australian Antarctic Territory are not harassed.
- Meet obligations to the Convention for the Conservation of Antarctic Seals (CCAS) for reporting statistical information on all seals killed in or captured and released from the Convention area (south of 60°S). This is required by 30 June each year under CCAS.

12. Conservation actions already initiated

12.1 Research

- Most of the fur-seal population at Macquarie Island is marked and many animals were marked as pups and hence are of known-age. The number of pups born each year has been determined for most years since 1954 (Shaughnessy and Goldsworthy 1993).
- A study of the hybridisation of the three species of fur-seal at Macquarie Island (Antarctic, Subantarctic and New Zealand fur-seals) using DNA paternity analyses and behavioural observations to determine the role of female mate-choice, population density and breeding substrate has been conducted (S. Goldsworthy).
- A study of foraging ecology and energetics of the two major species breeding at Macquarie Island (Antarctic and Subantarctic fur-seals) is underway, including the location of foraging areas (S. Goldsworthy and S. Robinson).

12.2 Management

- The species is protected under Federal, State and Territory laws. Breeding colonies and haul-out sites at Macquarie, Heard and McDonald Islands are protected.
- Seals of the genus *Arctocephalus* are protected in waters south of 60°S under the CCAS. The Australian legislation that endorses CCAS is *The Antarctic Treaty (Environment Protection) Act 1990* which prohibits Australian nationals from taking any seals south of 60°S.
- A management plan for the Heard Island Wilderness Reserve has been prepared (Australian Antarctic Division 1995). It does not refer specifically to the fur-seal population.
- A management plan for the Macquarie Island Nature Reserve has been prepared (Department of Parks, Wildlife and Heritage 1991). It does not refer specifically to the fur-seal population, but refers to wildlife management in general terms (section 3.10.1).
- A marine protected area around Macquarie Island has been proposed (Scott 1994, Copson *et al.* 1994) and a proposal has been initiated by the Tasmanian Government (D. Rounsevell, in litt.).

13. Conservation actions required

13.1 Research

- *Determine the genetic source of the populations at Heard and Macquarie Islands.
- *Follow trends in abundance at Heard and Macquarie Islands by determining the number of pups born annually, or as often as practicable.
- Determine mortality and fecundity rates using animals tagged since 1986 at Macquarie Island.
- Determine the components of mass transfer from mothers to pups during gestation and lactation.
- Determine pup growth rates, and compare with similar data collected at South Georgia.
- Investigate the role of disease and toxicity in the ecology of the species.
- *Study interactions between fur-seals and the trawl fishery at Heard and Macquarie Islands, including diet and foraging locations.

13.2 Management

- *Access to breeding colonies should be strictly limited during the pupping season in order to minimise disturbance to the seals and to protect people from the seals.
- For handling 'stranded' animals, see comments in Appendix IV.
- *Declare a marine reserve around Macquarie Island to include the territorial sea to 12 nautical miles as a protected area with minimal human interference (see recommendations by Scott 1994). Declare a similar marine reserve around Heard Island. Such reserves would provide safe access to the fur-seals' terrestrial breeding sites and protect a portion of their feeding grounds.
- *Encourage fishers and other mariners not to discard net fragments and other non-biodegradable material at sea, and not to shoot seals (which is illegal).
- Prepare contingency plans for dealing with an oil spill near a fur-seal colony (see Chapter 4.4).
- Investigate interaction between fur-seals and the vegetation at colonies and haul-out sites on Heard and Macquarie Islands. At Signy Island the increasing fur-seal population has destroyed large areas of vegetation (Smith 1988).

14. Organisation(s) responsible for conservation of species

14.1 International

CITES; Antarctic Treaty System through the Convention for the Conservation of Antarctic Seals.

14.2 National

Environment Australia in Australian territorial waters (3 to ca. 200 nautical miles).

14.3 State

Government nature conservation and fisheries agencies, on land and in State and Territory waters (out to 3 nautical miles).

15. Other organisations and individuals involved

N. Brothers, G. Copson and I. Skira, Tasmanian Parks and Wildlife Service; S. Goldsworthy, M. Hindell, S. Robinson, and L. Wynen, University of Tasmania; H. Burton, Australian Antarctic Division; K. Green, NSW National Parks and Wildlife Service, Cooma; M. Downes, Melbourne (history of sealing); P. Shaughnessy, CSIRO Wildlife and Ecology.

Subantarctic Fur-Seal

1. Family	Otariidae
2. Scientific name	*Arctocephalus tropicalis*
3. English name(s)	Subantarctic fur-seal, Amsterdam fur-seal

4. Taxonomic status (including species and subgroups)

Described by J. E. Gray in 1872 as *Gypsophoca tropicalis.* It is one of eight species of *Arctocephalus* (Repenning *et al.* 1971) and was considered to be conspecific with the Antarctic fur-seal for many years (King 1959). Recent research (skull morphometrics and DNA) indicates that the taxonomic classification of *Arctocephalus* may require revision (Brunner 1998, Lento *et al.* 1994, 1997, S. Goldsworthy in prep.).

5. Species survival status

5.1 Conservation status based on IUCN (1994)

Endangered (refers to the Australian population)

5.2 IUCN status

IUCN (1993): Not listed
SSG IUCN SSC: Not listed

5.3 CITES status

Appendix II

6. Distribution, including migration

The only breeding colonies of *A. tropicalis* in Australian territory are at Macquarie Island where they breed with *A. gazella* (Shaughnessy *et al.* 1988a). *A. tropicalis* haul-out at Heard Island, and one pup was born there during the 1987-88 summer (Goldsworthy and Shaughnessy 1989). On the basis of these records, Shaughnessy (1992) recommended that the species be considered part of the Australian fauna.

The largest colonies are at Gough Island, South Atlantic Ocean and at Amsterdam Island, South Indian Ocean. Other colonies are at the Prince Edward Islands and Iles Crozet, South Indian Ocean (Bonner 1981). *A. tropicalis* is not reported to be migratory, although individuals have been reported to make long movements and more than 50 have been reported on the coastline of southern Australian from Western Australia to New South Wales (Gales *et al.* 1992a, Warneke 1995b, Llewellyn *et al.* 1994, Mawson and Coughran in prep., Kirkwood *et al.* 1992, G. J. B. Ross, pers. comm.). A few have been reported at sea in the south Indian Ocean (Tynan 1996).

7. Habitat

7.1 General

A. tropicalis prefer a rocky coastal habitat. At Gough Island colonies are on rocky shores, including rock platforms and exposed boulder beaches (Bester 1982). At Macquarie Island, breeding *A. tropicalis* utilise open cobble-stone beaches, and non-breeding seals also utilise tussock slopes above the colonies.

7.2 Key localities

Macquarie Island, particularly Secluded Beach and Goat Bay on North Head Peninsula.

8. Marine protected areas managed or relevant to the species

None. A marine reserve has been proposed as part of a marine conservation strategy for Macquarie Island (Scott 1994). A proposal for a marine reserve around Macquarie Island has been initiated by the Tasmanian government (D. Rounsevell *in litt.*).

9. Biological overview

9.1 Growth and age

Birth weight/length		4 - 6 kg, 60 - 70 cm
Weaning age (Kerley 1985)		about 300 days
Weight	*females*	30 - 50 kg
	males	97 - 158 kg
Length	*females*	100 - 140 cm
	males	150 - 200 cm

Source: Goldsworthy and Shaughnessy (1995a).

9.2 Reproduction

Age at sexual maturity

females (Bester 1995)	4 - 6 years
males (Bester 1987, 1990)	3 - 4 years; hold territories at 7 years
Pupping interval	1 year

Gestation

4 months delayed implantation of blastocyst, then active gestation for 8 months (Bester 1995)

Pupping season

November-January

9.3 Diet

On Macquarie Island, *A. tropicalis* feed almost entirely on pelagic myctophid fish *Electrona* spp. and *Gymnoscopelus* spp. (Green *et al.* 1990). Recent studies of foraging behaviour at Macquarie Island using time-depth-temperature recorders indicate that these seals forage at night and usually at shallow depths (Goldsworthy 1991).

9.4 Behaviour

Adult males establish territories in late October before commencement of the breeding season. They fast during the breeding season. Females haul-out about a day prior to parturition and come into oestrus and are mated 6 - 7 days post-partum. Females then nurse their pups on shore, between foraging trips to sea, until the pups wean in about September.

9.5 Mortality and pathology

There have not been any reports on the mortality or pathology of the small population of Subantarctic fur-seals at Macquarie Island.

9.6 Population abundance and rates of change

On Macquarie Island in the 1995-96 breeding season, 25 *A. tropicalis* pups were born, constituting 20% of the total pup production; in addition there were 9 pups with mixed phenotypes (Goldsworthy 1996). Based on this, the number of Subantarctic fur-seals at Macquarie Island can be estimated at between 90 and 110, by applying multipliers of 3.5 and 4.5 to the number of pups (Harwood and Prime 1978). The exponential rate of increase of the breeding population of *A. tropicalis* for the five years to 1996-97 was low at r = 0.019 (Goldsworthy *et al.* 1998).

10. Threats

10.1 Harvesting

At Macquarie Island, fur-seals were eliminated within approximately 10 years of their discovery in 1810. It is estimated that as many as 193,000 were harvested (Shaughnessy and Fletcher 1987). The species of fur-seal on the island prior to sealing is unknown. Shaughnessy *et al.* (1988a) suggested that the Subantarctic fur-seal was a strong possibility and Taylor (1992) argued that it was the juvenile age-class of the New Zealand fur-seal.

Macquarie Island is managed as a nature reserve by the Tasmanian Parks and Wildlife Service; and Heard Island is managed as a wilderness reserve by the Australian Antarctic Division. fur-seals are protected at both locations and they are protected on the Australian coast. Southern fur-seals are also protected from harvesting by the Convention for the Conservation of Antarctic Seals (Chapter 4.1.2).

10.2 Current

Ashore

There is suitable breeding habitat on Macquarie Island and Heard Island for populations to continue increasing.

Fisheries

Exploratory fishing was conducted near Heard Island in the winter of 1987 (Williams and Ensor 1988). A commercial trawl fishery began in 1994 in the vicinity of Macquarie Island for Patagonian toothfish. Furthermore, the fishery for myctophids in the Convention for the Conservation of Marine Living Resources (CCAMLR) region has increased in recent years. Because these fish are important for the Heard and Macquarie populations of fur-seals, the fishery and its effects should be monitored. This advice has been passed from the SCAR Group of Specialists on Seals to CCAMLR (Anon. 1995).

The fishery at Heard, McDonald and Macquarie Islands, and its likely effects on high level predators was the topic of a workshop held at the Australian Antarctic Division in late April and early May, 1997. A conclusion was that “existing information is not sufficient to identify whether fishing is likely to have any substantial impacts on seals and penguins” (Australian Antarctic Division 1997, p. 7). Nevertheless, the workshop recommended that “conservation objectives for high level predators should be included among the objectives of the long-term management plans for these fisheries” (*ibid*, p.8).

Entanglement

The lack of commercial fisheries around Australian populations until recently has ensured that the threat from entanglement in marine debris has been low, but it is likely to increase with the recent advent of fisheries in the area. fur-seals entangled in fishing gear have been recorded at both Heard and Macquarie Island.

Introgression

Hybridisation between Antarctic, Subantarctic and New Zealand fur-seals at Macquarie Island could threaten the integrity of each species there.

10.3 Potential

Oil spills

Due to the small number of visits by ships to Macquarie and Heard Islands, the potential threat of oil spills to seal populations is low. However, several ships visit Macquarie Island each summer to re-supply the Australian Antarctic Division base, and the large quantities of fuel pumped ashore near the main fur-seal colony (at Secluded Beach) just north of the base present a possible hazard. Tour ships also visit these islands and are another potential source of oil spills.

Rehabilitated seals

If animals of this species were to haul-out on mainland Australia, they should not be sent to breeding stations on Subantarctic islands for fear of inadvertently introducing disease from other captive animals (see Chapter 4.7 and Appendix IV).

Disease

The potential threat posed by disease is discussed in Chapter 4.7.

11. Conservation objectives

11.1 Research

- Improve knowledge of the biology of fur-seal populations at Macquarie and Heard Islands, especially as this relates to the Australian Government goals for research in Antarctica.
- Monitor interactions between fur-seals and the trawl fishery at Macquarie Island.

11.2 Management

- Seals should be recognised as an integral and vulnerable component of marine ecosystems.
- Determine whether the aims of management should be for the population to increase (in size and/or distribution), remain steady or to decrease.
- Ensure a viable population of Subantarctic fur-seals is maintained at Macquarie Islands and that Subantarctic fur-seals that haul-out on the coast of Australia are not harassed.
- Meet obligations to the Convention for the Conservation of Antarctic Seals (CCAS) for reporting statistical information on all seals killed in or captured and released from the Convention area (south of 60°S). This is required by 30 June each year under CCAS.

12. Conservation actions already initiated

12.1 Research

- Most of the fur-seal population at Macquarie Island is marked and many animals were marked as pups and hence are of known-age. The number of pups born each year has been determined for most years since 1954 (Shaughnessy and Goldsworthy 1993).
- A study of the hybridisation of the three species of fur-seal at Macquarie Island (Antarctic, Subantarctic and New Zealand fur-seals) using DNA paternity analyses and behavioural observations to determine the role of female mate-choice, population density and breeding substrate has been conducted (S. Goldsworthy).
- A study of foraging ecology and energetics of the two major species breeding at Macquarie Island (Antarctic and Subantarctic fur-seals) is underway, including the location of foraging areas (S. Goldsworthy and S. Robinson).

12.2 Management

- The species is protected under Federal, State and Territory laws. Breeding colonies and haul-out sites at Macquarie Island and Heard Island are protected.
- Seals of the genus *Arctocephalus* are protected in waters south of 60°S under the CCAS. The Australian legislation that endorses CCAS is The Antarctic Treaty (Environment Protection) Act 1990 which prohibits Australian nationals from taking all seals south of 60°S.
- A management plan for the Macquarie Island Nature Reserve has been prepared (Department of Parks, Wildlife and Heritage 1991). It does not refer specifically to the fur-seal population, but refers to wildlife management in general terms (section 3.10.1).
- A marine protected area around Macquarie Island has been proposed (Scott 1994, Copson *et al.* 1994) and a proposal has been initiated by the Tasmanian Government (D. Rounsevell, in litt.).

13. Conservation actions required

13.1 Research

- *Determine the genetic source of the population at Macquarie Island.
- *Follow trends in abundance at Macquarie Island by determining the number of pups born annually, or as often as practicable.
- Determine mortality and fecundity rates using animals tagged since 1986 at Macquarie Island.
- Determine the components of mass transfer from mothers to pups during gestation and lactation.
- Determine pup growth rates, and compare with similar data to be collected at Marion, Crozet and Amsterdam Islands.
- Investigate the role of disease and toxicity in the ecology of the species.
- *Study interactions between fur-seals and the trawl fishery at Heard and Macquarie Islands, including diet and foraging locations.

13.2 Management

- *Access to breeding colonies should be strictly limited during the pupping season in order to minimise disturbance to the seals and to protect people from the seals.
- For handling 'stranded' animals, see comments in Appendix IV.
- *Declare a marine reserve around Macquarie Island to include the territorial sea to 12 nautical miles as a protected area with minimal human interference (see recommendations by Scott 1994). Declare a similar marine reserve around Heard Island. Such reserves would provide safe access to the fur-seals' terrestrial breeding sites and protect a portion of their feeding grounds. This is particularly pertinent because the Subantarctic fur-seal is classified as *Endangered* against IUCN (1994) criteria.
- *Encourage fishers and other mariners not to discard net fragments and other non-biodegradable material at sea, and not to shoot seals (which is illegal).
- Prepare contingency plans for dealing with an oil spill near a fur-seal colony (see Chapter 4.4).
- Investigate interaction between fur-seals and the vegetation at colonies and haul-out sites on Heard and Macquarie Islands. At Signy Island the increasing fur-seal population has destroyed large areas of vegetation (Smith 1988).

14. Organisation(s) responsible for conservation of species

14.1 International

CITES; Antarctic Treaty System through the Convention for the Conservation of Antarctic Seals.

14.2 National

Environment Australia in Australian territorial waters (3 to ca. 200 nautical miles).

14.3 State

Government nature conservation and fisheries agencies, on land and in State and Territory waters (out to 3 nautical miles).

15. Other organisations and individuals involved

N. Brothers, G. Copson andI. Skara, Tasmanian Parks and Wildlife Service; S. Goldsworthy, M. Hindell, S. Robinson and L. Wynen, University of Tasmania; P. D. Shaughnessy, CSIRO Wildlife and Ecology.

Southern Elephant Seal

1. Family	Phocidae
2. Scientific name	*Mirounga leonina*
3. English name(s)	Southern elephant seal, sea elephant

4. Taxonomic status (including species and subgroups)

Described by C. Linneaus in 1759 as *Phoca leonina* from Isla Más a Tierra, Islas Juan Fernández, Chile. The three major populations are at Macquarie Island, at Heard Island and Kerguelen, and at South Georgia. Animals from these populations are not generally recognised as separate taxa.

5. Species survival status

5.1 Conservation status based on IUCN (1994)

Vulnerable (refers to the Australian population)

5.2 IUCN status

IUCN (1993): Not listed
SSG IUCN SSC: Not listed

5.3 CITES status

Appendix II

6. Distribution, including migration

Breeds on subantarctic islands, including Macquarie and Heard Islands. Limited genetic differences have been demonstrated between these populations (Gales *et al.* 1989).

Recent studies with instrumented animals (Hindell *et al.* 1991) indicate that some animals from Macquarie Island move south, close to the Antarctic coast. One has been recorded close to Campbell Island (Slip *et al.* 1994a). There is considerable interchange of marked animals between Heard Island and Kerguelen in the north, and the Vestfold Hills region, Antarctica, in the south (Burton 1985).

Elephant seals are visitors to Australia, in particular to Tasmania where several births have been recorded (Pemberton and Skira 1989, Kirkwood *et al.* 1992). Records from Victoria and South Australia also include births (Warneke 1995c, Robinson and Dennis 1988). There are three records of animals ashore in New South Wales, including two near Sydney (Llewellyn *et al.* 1994), and several in Western Australia (Mawson and Coughran in prep.). Elephant seals formerly occurred on islands in western Bass Strait where they lived "in large rookeries on the Hunter Islands, King Island, and the New Year Islands" according to the French naturalist Francois Péron (Micco 1971, p. 23). These rookeries were eliminated by early European sealers.

7. Habitat

7.1 General

Elephant seals favour beaches, tussock grass and wallows on subantarctic islands. During the annual moult, animals use mud wallows inshore from beaches. There are some haul-out sites on the Antarctic coastline.

7.2 Key localities

Macquarie and Heard Islands are major breeding populations in the Australian sector of the subantarctic. In the Australian Antarctic Territory, small numbers of pups have been reported from Browning Peninsula and Peterson Island, near Casey station (Murray 1981), and there is a well-frequented haul-out area at Vestfold Hills (Burton 1985).

On the coast of mainland Australia, Maatsuyker Island is a key locality where several pups have been born and many animals recorded.

8. Marine protected areas managed or relevant to the species

None. A marine reserve has been proposed as part of a marine conservation strategy for Macquarie Island (Scott 1994). A proposal for a marine reserve around Macquarie Island has been initiated by the Tasmanian government (D. Rounsevell *in litt.*).

9. Biological overview

9.1 Growth and age

Birth weight/length		45 kg, 1.3 m
Weaning age		3 weeks
Weight	*females*	250 - 350 kg
	males	2000 - 3800 kg
Length	*females*	200 - 260 cm
	males	350 - 420 cm

Source: Bryden (1995).

9.2 Reproduction

Age at sexual maturity

females	4-6 years
males	10 years.

Animals at South Georgia mature earlier

Pupping interval 1 year

Gestation

50 weeks, including 12 weeks delayed implantation

Pupping season

September-October.

Sources: Laws (1979a), Carrick *et al.* (1962).

9.3 Diet

Southern elephant seals feed mainly on cephalopods and fish (Green and Burton 1993, Slip 1995). Their major foraging areas are located in cold Antarctic waters, along the Antarctic Polar Front and in warmer Subantarctic waters north to 50°S (Slip *et al.* 1994a).

They are an important part of the Southern Ocean marine ecosystem, with most adults foraging on or near the continental shelf of Antarctica (Hindell *et al.* 1991, Slip *et al.* 1994a). With such a large biomass, they must remove large amounts of prey annually from these regions.

A comparison of stomach contents of animals at Macquarie and Heard Islands showed that cephalopod beaks and fish eye lenses were the major items (Green and Burton 1993), with more fish remains in the stomachs of seals from Heard Island, and more benthic fish at Heard Island than at Macquarie Island. A study of stomach contents of elephant seals at Heard Island in 1992-93 indicated that 86% of stomachs contained squid and 66% contained fish (Slip 1995). The stomach contents of adults differed from those of juveniles; the latter contained smaller squid. Cephalopods eaten by elephant seals were similar to those of other Southern Ocean predators, particularly beaked whales.

9.4 Behaviour

Adult females are ashore for 30 days in the breeding season during September and October, 7-8 days pre-partum and 23 days for lactation. Pupping is highly synchronised over 4-6 weeks, with 80% of pups born in 3 weeks. Weaned pups remain ashore for 4-6 weeks after females desert them. Males are polygynous. Adults return to shore to moult in summer and most are ashore between January and March. They fast during the 30-40 day moult, during which hair and epidermis are shed. Few animals are ashore during winter.

Elephant seals spend a large proportion of each year at sea. After the breeding season, adult females are at sea for about 10 weeks before the moult in January-February, and adult males are at sea for about 14 weeks before their moult in March. They moult onshore for about four weeks before returning to sea until the next breeding season (summarised from Slip *et al.* 1994).

Diving studies of southern elephant seals using time-depth recorders applied at Macquarie Island after the moult indicated that 90% of their time at sea was spent diving. Animals dive continuously and to great depths; mean dive duration for individual animals ranged from 16 to 37 minutes, and mean dive depths for individual animals ranged from 269 to 589 m (Slip *et al.* 1994a).

9.5 Mortality and pathology

Causes of mortality in elephant seals at Macquarie Island were described by Carrick and Ingham (1962). For pups, starvation after separation from the adult female was the most frequent cause, followed by trampling and crushing by adult males, and inundation of colonies after heavy storms. The killer whale was considered an important predator. During the breeding season, most adult males that die are bachelors, in good condition and without any visible external injury.

Tierney (1977) described disease and injury in elephant seals from the Vestfold Hills area, Antarctica. Trauma resulting in deep lacerations was most commonly recorded and this was attributed to other (un-named) species.

9.6 Population abundance and rates of change

Population size has been decreasing in recent decades in the Australian sector. At Macquarie it has decreased by 44.6% from 156,000 in 1959 to 86,500 in 1985 (Hindell and Burton 1987), at an average rate of 2.3% per annum over 26 years. There has been a similar decrease at Heard Island where pup production decreased by 60% from 31,827 in 1949 to 13,111 in 1985 (Burton 1986), at an average rate of 2.5% per annum over 36 years. The reason for these decreases is not apparent. The population at Macquarie Island has stabilised in recent years (Hindell and Slip 1997).

Numbers of animals have also declined at other locations, particularly populations of the Kerguelen stock, including those at Marion Island, Kerguelen and Iles Crozet. On the other hand, the South Georgia stock has remained stable (summarised by Hindell *et al.* 1994). At Macquarie Island the decline in population size has been accompanied by a marked decline in the survival rate of juveniles over the same time period. These population declines have taken place in the absence of observable declines in other major vertebrates in the Southern Ocean. At the same time, population levels of fur-seals and some baleen whales have increased.

Hindell (1991) proposed that the population size at Macquarie Island in the 1950s might have been unusually high, as the population recovered from a century of sealing that ended in 1919. In other words, the population may have overshot its original size during the 1950s. The decline since then may have been towards equilibrium level, although it may take years for the equilibrium to be reached. Another suggestion is that changes in the environment of the Southern Ocean may have adversely affected the abundance or availability of prey of southern elephant seals (Burton 1986). Predation by killer whales has also been suggested as cause for the declines, especially at Marion Island (Condy *et al.* 1978). No evidence for increased predation at Macquarie Island has been suggested.

10. Threats

10.1 Harvesting

Past exploitation

Elephant seals were heavily harvested during the 19th century, primarily for oil. This included populations at Macquarie and Heard Islands, and at King Island in Bass Strait where the species was eliminated by about 1805. Harvesting continued until the mid-1960s at South Georgia and Kerguelen. Small numbers were taken by the Norwegian and USSR harvests in spring 1964 and summer 1986-87 (Chapter 4.1.2).

Current exploitation

Southern elephant seals are now protected by the Convention for the Conservation of Antarctic Seals south of 60°S (Chapter 4.1.2) and are protected under Australian legislation.

10.2 Current

Population decline

Decreases in elephant seal populations since the 1950s at several subantarctic islands including Macquarie and Heard may be a cause for concern. The declines are thought to be related to the survival of juveniles (Hindell 1991), but the factors influencing juvenile survival are unknown.

It is important that population levels of southern elephant seals be monitored, and that further information on their ecology be gathered, particularly of the marine phase.

Entanglement

Entanglement in man-made marine debris is likely to be uncommon (see Chapter 4.3).

Oil spills

Due to the small number of visits by ships to Macquarie and Heard Islands, the potential threat of oil spills to seal populations is low. However, several ships visit Macquarie Island each summer to re-supply the Australian Antarctic Division base, and the large quantities of fuel pumped ashore present a possible hazard. Tour ships also visit these islands and are another potential source of oil spills. Visits to Heard Island are less frequent.

Fisheries

Commercial fishing for Patagonian toothfish and icefish within the AFZ in Subantarctic waters is developing. Because these fish are considered important for the Heard and Macquarie populations of elephant seals, the fishery and its effects should be monitored carefully.

The fishery at Heard, McDonald and Macquarie Islands, and its likely effects on high level predators was the topic of a workshop held at the Australian Antarctic Division in late April and early May, 1997. A conclusion was that "existing information is not sufficient to identify whether fishing is likely to have any substantial impacts on seals and penguins" (Australian Antarctic

Division 1997, p. 7). Nevertheless, the workshop recommended that "conservation objectives for high level predators should be included among the objectives of the long-term management plans for these fisheries" (*ibid*, p.8).

10.3 Potential

Fisheries

Fishing in the Southern Ocean could have a negative impact on vertebrate predators such as the southern elephant seal (see Chapter 4.2).

Disease

The potential threat posed by disease is discussed in Chapter 4.7.

Climate Change

See comments under Chapter 4.9.

11. Conservation objectives

11.1 Research

- Determine reasons for the decline in abundance of elephant seals at Macquarie and Heard Islands.
- Determine the role of southern elephant seals and their prey in the Antarctic marine ecosystem.
- Improve knowledge of the biology of southern elephant seal populations, especially as this relates to the Australian Government goals for research in Antarctica.

11.2 Management

- Seals should be recognised as an integral and vulnerable component of marine ecosystems.
- Meet obligations for reporting statistical information to SCAR on all seals killed in or captured and released from the Convention area (south of 60°S). This is required by 30 June each year under the Convention for the Conservation of Antarctic Seals.
- The southern elephant seal formerly bred at several sites in western Bass Strait, including King Island. Long-term planning for conservation in that area should not overlook the possibility that this species may recolonise some of its former breeding sites.

12. Conservation actions already initiated

12.1 Research

The SCAR Group of Specialists on Seals has made recommendations for research on southern elephant seals (Anon. 1991b). They can be summarised as:

- stock discreteness
- stock assessment
- age-specific annual survival rates
- composition of the diet
- relative *per capita* food intake
- location of feeding areas
- causes of morbidity
- reporting system for the recovery of tags.

Several research projects on southern elephant seals are underway at Macquarie Island:

- a demographic study based on branding several cohorts of weaned pups to provide time series data
- a study of food consumption and energy expenditure of free ranging animals to investigate, for instance, how foraging by mothers and the amount of their fat reserves influences the amount of energy transferred to pups during lactation
- a study of dispersal and survival of newly weaned pups, which will test the hypothesis that young animals and adults exploit different foraging grounds which leads to a reduced survivorship rate of juveniles.

12.2 Management

- Reporting to SCAR of seals killed or captured by Australians has been completed for most years by the Australian Antarctic Division.
- A marine protected area around Macquarie Island has been proposed (Scott 1994, Copson *et al.* 1994) and a proposal has been initiated by the Tasmanian Government (D. Rounsevell, *in litt.*).

13. Conservation actions required

13.1 Research

- *Follow trends in abundance of elephant seals at Macquarie and Heard Islands.
- *Continue the long-term demographic study at Macquarie Island (based on mark-recapture) aimed at estimating the following population parameters: mortality rate, dispersal, age structure, fecundity and age at first breeding. The study should include appropriate resighting effort.
- Conduct a demographic study based on cross-sectional age structure, using estimates of age from teeth removed from live animals under anaesthetic.
- Investigate the role of disease and toxicity in the ecology of the species.
- *Study the elephant seals' foraging ecology, especially animals in their first year. This should include locating foraging areas of various age-classes using satellite telemetry and time-depth recorders.
- Measure the energy flow from mothers to pups. As an index, monitor the growth of pups from birth to weaning each breeding season.
- Determine the field metabolic rate of elephant seals from Macquarie Island while they are at sea.

13.2 Management

- *Access to breeding colonies should be strictly limited during the pupping season in order to limit disturbance to the seals and to protect people from the seals.
- *Declare a marine reserve around Macquarie Island to include the territorial sea to 12 nautical miles as a protected area with minimal human interference (see recommendations by Scott 1994). Declare a similar marine reserve around Heard Island. Such reserves would provide safe access to the seals' terrestrial breeding sites.
- Long-term planning for conservation on King Island and nearby islands, Tasmania, should not overlook the possibility that the southern elephant seal may recolonise some of its former breeding sites.
- For handling animals 'stranded' on the Australian coast, see comments in Appendix IV.
- Prepare contingency plans for dealing with an oil spill near an elephant seal colony (see Chapter 4.4).
- *Encourage fishers and other mariners not to discard net fragments and other non-biodegradable material at sea, and not to shoot seals (which is illegal).

14. Organisation(s) responsible for conservation of species

14.1 International

Antarctic Treaty System through the Convention for the Conservation of Antarctic Seals.

14.2 National

Australian Antarctic Division at Heard Island and the Australian Antarctic Territory; Environment Australia in Australian territorial waters (3 to ca. 200 nautical miles).

14.3 State

Government nature conservation and fisheries agencies, on land and in State and Territory waters (out to 3 nautical miles); Tasmanian Parks and Wildlife Service at Macquarie Island.

15. Other organisations and individuals involved

N. Brothers, I. Skira and G. Copson, Tasmanian Parks and Wildlife Service; D. Pemberton, Tasmanian Museum and Art Gallery (formerly with Tasmanian Parks and Wildlife Service); H. R. Burton, C. McMahon and D. J. Slip, Australian Antarctic Division; M. Hindell, University of Tasmania; R. Woods, Western Plains Zoo; M. Downes, Melbourne (history of sealing).

Leopard Seal

1. Family	Phocidae
2. Scientific name	*Hydrurga leptonyx*
3. English name(s)	Leopard seal

4. Taxonomic status (including species and subgroups)

Described by H.-M. D. de Blainville in 1820 as *Phoca leptonyx* from a specimen taken near the Falkland Islands. *Hydrurga* is a monospecific genus. The four Antarctic phocids, crab-eater, leopard, Ross and Weddell seals, are grouped in the subfamily Lobodontinae. No subspecies of the leopard seal are recognised.

5. Species survival status

5.1 Conservation status based on IUCN (1994)

Lower Risk, least concern

5.2 IUCN status

IUCN (1993): Not listed
SSG IUCN SSC: Not listed

5.3 CITES status

Not listed

6. Distribution, including migration

Leopard seals breed on pack ice of the Southern Ocean; their range is circumpolar. There are seasonal, north-south movements associated with the expansion and contraction of the pack ice.

Leopard seals are frequent visitors to Macquarie Island and south-eastern Australia (Rounsevell 1988). The majority of reports are of juvenile seals and are from the period July to November, which coincides with the increase and then maximum extent of the Southern Ocean pack-ice zone. Numbers of leopard seals ashore appear to peak on a 4-5 year cycle (Rounsevell and Eberhard 1980, Rounsevell 1988, Testa *et al.* 1991).

The largest concentration of leopard seals has been reported from Heard Island where they haul-out in all months of the year (Gwynn 1953). Genetic differences have been demonstrated between animals from Heard and Macquarie Islands (Slip *et al.* 1994b), but no subspecies are recognised.

Records of leopard seals are so regular and frequent in south-eastern Australia (particularly Tasmania), mainly during the winter, that Rounsevell and Pemberton (1994) proposed that this species be regarded as part of the mammalian fauna for the region. They have also been recorded ashore in Queensland, New South Wales (including Lord Howe Island), Victoria, South Australia and Western Australia (Haynes-Lovell 1994, King 1983, Llewellyn *et al.* 1994, Hamilton 1939, Warneke 1995c, Wood Jones 1925b, Mawson and Coughran in prep.).

7. Habitat

7.1 General

Their main habitat is the pack ice of the Southern Ocean. They are pelagic.

7.2 Key localities

Heard Island and Macquarie Island are important haul-out sites for leopard seals. On the coast of mainland Australia, Tasmania is a key locality.

8. Marine protected areas managed or relevant to the species

None. A marine reserve around Macquarie Island is proposed as part of Ocean Rescue 2000 (Scott 1994). A proposal for a marine reserve around Macquarie Island has been initiated by the Tasmanian government (D. Rounsevell *in litt.*).

9. Biological overview

9.1 Growth and age

Birth weight/length		35 kg, 1.5-1.6 m
Weaning age (Siniff and Stone 1985)		Up to 4 weeks
Weight	*females*	225 - 591 kg (av. 367 kg)
	males	200 - 455 kg (av. 324 kg)
Length.	*females*	241 - 338 cm (av. 291 cm)
	males	250 - 320 cm (av. 279 cm)

Source: Hofman (1979).

9.2 Reproduction

Age at sexual maturity	
females	4 years
males	4.5 years
Pupping interval	1 year
Gestation	9 months

Pupping season

Late October to mid-November.
Sources: Laws (1984), Siniff and Stone (1985).

9.3 Diet

Laws (1984) concluded the following representation of food items on the basis of several studies of stomach samples: 50% krill, 20% penguins, 14% seal, 9% fish and 6% cephalopods. Young animals are thought to take more krill than older animals, which in turn take more seals and penguins. Leopard seals prey on newly weaned crab-eater seals from November to February (Siniff and Stone 1985).

9.4 Behaviour

Leopard seals are primarily solitary animals. Adult females advertise sexual receptivity vocally over long distances (Rogers *et al.* 1996). They breed, moult and rest on pack ice, and their movements are associated with the seasonal expansion and contraction of pack ice. They also haul-out on subantarctic islands and southern continents.

Pups are born from October to mid-November, and mating occurs during December and early January (Siniff and Stone 1985). Lactation lasts for up to four weeks. The female is not accompanied by a male then, as is the case with, for example, crab-eater seals. Adult male leopard seals are thought to be slightly polygynous (Le Boeuf 1991).

9.5 Mortality and pathology

Little is known. Animals that move north to Australian mainland waters and come ashore injured often have wounds to the head, particularly near the mouth, caused by stingray spines embedded in the flesh. Two leopard seals have been recorded in Victoria with highly toxic puffer fish (Toxodontidae) in their stomachs (R. M. Warneke, *in litt.*).

9.6 Population abundance and rates of change

Population abundance is difficult to determine because of the great areas involved and the logistics of working in pack ice. Abundance has been estimated from aerial and shipboard censuses of pack-ice seals, which were primarily directed at crab-eater seals. Estimated numbers for leopard seals were 222,000 to 440,000 by Gilbert and Erickson (1977) and 300,000 by Erickson and Hanson (1990). The latter noted that these estimates should be considered minimal, because they exclude an unknown fraction of animals not on the pack-ice surface during surveys, although observations were made at peak haul-out time.

No information is available on trends in abundance for leopard seals because not enough animals were seen in the pack ice surveys for meaningful comparisons to be made (Erickson and Hanson 1990).

The SCAR Group of Specialists on Seals is encouraging widespread, near-synoptic surveys to determine abundance of pack ice seals (including leopard seals), primarily in the 1998-99 summer.

10. Threats

10.1 Harvesting

Leopard seals were included in the Norwegian harvest in spring 1964 and the USSR harvest in the summer of 1986-87(see Chapter 4.1.2).

Harvesting of leopard seals is permitted under the Convention for the Conservation of Antarctic Seals (Chapter 4.1.2), but it is not permitted under Australian legislation.

10.2 Current

Entanglement in man-made marine debris is likely to be uncommon (see Chapter 4.3).

10.3 Potential

Fisheries

Fishing in the Southern Ocean could have a negative impact on vertebrate predators (see Chapter 4.2). In particular, leopard (and crab-eater) seals could be affected by a krill fishery, as they feed directly on krill. During winter, leopard seals are thought to compete with krill feeding specialists, including crab-eater seals and Adelie penguins. They are considered to be less efficient in this sense, and so would be the first seal species to be affected by a krill harvest (Siniff and Stone 1985).

Disease

The potential threat posed by disease is discussed in Chapter 4.7.

Climate Change

See comments under Chapter 4.9.

11. Conservation objectives

11.1 Research

Improve knowledge of the biology of leopard seal populations, especially as this relates to the Australian Government goals for research in Antarctica.

11.2 Management

Leopard seals should be recognised as an integral and vulnerable component of marine ecosystems. Meet obligations for reporting statistical information on all seals killed in or captured and released from the Convention area (south of 60°S). This is required by 30 June each year under the Convention for the Conservation of Antarctic Seals.

12. Conservation actions already initiated

12.1 Research

A research program involving countries active in Antarctica has been developed by the SCAR Group of Specialists on Seals (Anon. 1994). It is entitled Antarctic Pack Ice Seals (APIS) and was accepted at the SCAR meeting in August 1994. It refers to leopard, crab-eater, Weddell and Ross seals which utilise the Southern Ocean pack ice. The proposed topics are listed in section 13.1.

12.2 Management

Reporting to SCAR of seals killed or captured by Australians has been completed for most years by the Australian Antarctic Division.

13. Conservation actions required

13.1 Research

*Research topics proposed by the SCAR Group of Specialists on Seals for the APIS program refer to all species of pack ice seals. They are:

- distribution, abundance and species composition
- genetic identity of populations
- habitat use and seasonal movements
- seals as platforms for oceanographic research
- population dynamics
- diving, feeding behaviour and activity patterns
- diet
- energetics and physiology
- toxicology and disease.

Aspects of this research are being conducted by T. Rogers, Australian Marine Mammal Research Centre. These seals haul-out on subantarctic islands during winter, where some aspects of their biology can be studied.

13.2 Management

- Contribute (with other nations) to redefining the "sealing zones" that are described in Annex 4 of the Convention for the Conservation of Antarctic Seals.
- For handling animals 'stranded' on the Australian coast, see comments in Appendix IV.

14. Organisation(s) responsible for conservation of species

14.1 International

Antarctic Treaty System through the Convention for the Conservation of Antarctic Seals.

14.2 National

Australian Antarctic Division at Heard Island and in the Australian Antarctic Territory; Environment Australia in Australian territorial waters (3 to ca. 200 nautical miles).

14.3 State

Government nature conservation and fisheries agencies, on land and in State and Territory waters (out to 3 nautical miles); Tasmanian Parks and Wildlife Service at Macquarie Island.

15. Other organisations and individuals involved

W. de la Mare, H. R. Burton and C. Southwell, Australian Antarctic Division; N. Brothers, I. Skira and G. Copson, Tasmanian Parks and Wildlife Service; D. Pemberton, Tasmanian Museum and Art Gallery (formerly with Tasmanian Parks and Wildlife Service); T. Rogers, Australian Marine Mammal Research Centre, Taronga Zoo; M. M. Bryden, University of Sydney; D. Cato, Defence Science and Technology Organisation.

Crab-eater Seal

1. Family	Phocidae
2. Scientific name	*Lobodon carcinophagus*
3. English name(s)	Crab-eater seal, white seal

4. Taxonomic status (including species and subgroups)

Described by J.-B. Hombron and H. Jacquinot in 1842 from a specimen taken at about 60°S, 35°W in the Southern Ocean. *Lobodon* is a monospecific genus. The four Antarctic phocids, crab-eater, leopard, Ross and Weddell seals, are grouped in the subfamily Lobodontinae. No subspecies of the crab-eater seal are recognised.

5. Species survival status

5.1 Conservation status based on IUCN (1994)

Lower Risk, least concern

5.2 IUCN status

IUCN (1993): Not listed
SSG IUCN SSC: Not listed

5.3 CITES status

Not listed

6. Distribution, including migration

Crab-eater seals breed on the pack ice of the Southern Ocean; their range is circumpolar. Their movements are associated with the seasonal expansion and contraction of pack ice. Migration has been recorded southward during spring and northward during autumn (reviewed by Laws 1984). Radio tracking of animals in pack ice close to the Antarctic Peninsula indicated they are associated with the continental shelf (Bengtson and Stewart 1992). A similar association was found for animals south-west of Australia (Kerry *et al.* 1987).

There are at least 20 records of the species on the Australian mainland: two in New South Wales (Llewellyn *et al.* 1994, King 1983), 13 in Victoria (Warneke 1995c), one each in Tasmania and South Australia (King 1983, Ling and Walker 1979), and three in Western Australia (Mawson and Coughran in prep.). In addition, there are several records from Heard and Macquarie Islands (Ingham 1960, Fletcher and Shaughnessy 1984).

An impression can be gained from the literature that there are six discrete populations of crab-eater seals, associated with the six pack ice areas that remain over summer. But there is no genetic evidence for or against this notion (Erickson *et al.* 1971) and no subspecies are recognised.

7. Habitat

7.1 General

Their main habitat is the pack ice of the Southern Ocean. They are pelagic.

7.2 Key localities

During the breeding season in late spring crab-eater seals occupy the pack ice over the edge of the continental shelf. Early studies interpreted the zone they occupied to be at the edge of the pack ice, where these two zones overlap near the Antarctic Peninsula during the breeding season .

During summer they occupy the outer edge of the pack ice and are most abundant in cake and brash ice of 7-8 oktas (eighths) cover (Gilbert and Erickson 1977).

8. Marine protected areas managed or relevant to the species

None.

9. Biological overview

9.1 Growth and age

Birth weight/length		20 to 30 kg, 1.2 m
Weaning age		2-3 weeks
Weight	*females*	227 kg
	males	224 kg
Length.	*females*	262 cm
	males	257 cm

Sources: Laws (1979b), Shaughnessy and Kerry (1989), Green *et al.* (1993).

9.2 Reproduction

Age at sexual maturity

Declined from 4 years in 1950 to 2.5 years by 1968 at Antarctic Peninsula (Laws and Baird, in Laws 1984).

Pupping interval	1 year
Gestation	8.5 months

Pupping season

October and early November, soon after ice extent is at its maximum.

Sources: Laws (1979b), Bengtson and Siniff (1981).

9.3 Diet

They feed primarily on krill, and small amounts of fish and squid (Øritsland 1977). Fish and mysids were also reported as part of the diet by Green and Williams (1986).

9.4 Behaviour

Crab-eater seals breed, moult and rest on pack ice, and their movements are associated with its seasonal expansion and contraction. During the breeding season, family groups comprising a mother, her pup and an adult male are dispersed over the pack ice. Males are thought to be serially monogamous. Mating has not been observed, but is thought to occur on the ice surface.

9.5 Mortality and pathology

Crab-eater seals are preyed on by leopard seals and killer whales. Conspicuous scars apparent on most individuals result from leopard seals. Most of the wounding and scarring of crab-eater seals is thought to take place between weaning and the onset of maturity (Siniff and Bengtson 1977).

A die-off of more than 300 crab-eater seals was recorded near the Antarctic Peninsula in 1955. It is thought to have been caused by a contagious virus specific to crab-eater seals that was not displayed by Weddell seals in the same area (Laws and Taylor 1957). Tests on recently collected blood samples of crab-eater seal (Bengtson *et al.* 1991) demonstrated the presence of a morbillivirus more closely related antigenically to canine distemper virus than the phocine distemper virus implicated in the 1988 epizootic in the North sea, which killed 18,000 harbour seals *Phoca vitulina* (Heide-Jorgensen *et al.* 1992).

9.6 Population abundance and rates of change

Population abundance is difficult to determine because of the great areas involved and the logistics of working in pack ice. For the late 1960s and early 1970s, crab-eater seal numbers were estimated at 15 million, from aerial and shipboard surveys in late summer when the area of pack ice is minimal (Gilbert and Erickson 1977). Repeat surveys in two parts of the range, Amundsen Sea and Bellingshausen Sea, in 1983 revealed considerably lower densities (Erickson and Hanson 1990). For the pelagic pack ice zone of the Southern Ocean, the latter produced a minimal estimate of 7 million crab-eater seals, and proposed a population size of 11 to 12 million animals.

These estimates should be treated with caution, as it is not clear how they were affected by behaviour patterns. For instance, estimates of abundance assume that all animals haul-out in the middle of the day. Studies of haul-out pattern throughout the day using satellite-linked dive recorders indicate that some seals may still be in the water in the middle of the day (Bengtson and Stewart 1992, Nordoy *et al.* 1995). In fact, Erickson and Hanson (1990) noted that their estimate should be considered minimal, because (i) it excludes an unknown fraction of animals not on the pack-ice surface during surveys, even though they were conducted at or near peak haul-out time, and (ii) it refers only to the zone of unconsolidated pack ice, and excludes animals in ice-free areas of the Southern Ocean.

The SCAR Group of Specialists on Seals is encouraging widespread, near-synoptic surveys to determine abundance of pack ice seals, primarily in the 1998-99 summer.

The age structure of crab-eater seal populations shows strong cohorts separated by intervals of 4 to 5 years (Testa *et al.* 1991).

10. Threats

10.1 Harvesting

Past exploitation

Crab-eater seals were taken in the Norwegian harvest in spring 1964 and in the USSR harvest done in the summer of 1986-87 (see Chapter 4.1.2). Small numbers were taken near Antarctic stations to feed sledge dogs, but those harvests were primarily directed at Weddell seals.

Current exploitation

Harvesting of crab-eater seals is permitted under the Convention for the Conservation of Antarctic Seals (see Chapter 4.1.2), but it is not permitted under Australian legislation.

10.2 Current

Entanglement in man-made marine debris is likely to be uncommon compared with the problem for seals in more temperate latitudes (see Chapter 4.3).

10.3 Potential

Fisheries

Fishing in the Southern Ocean could have a negative impact on vertebrate predators (see Chapter 4.2). In particular, crab-eater (and leopard) seals could be affected by a krill fishery, as they feed directly on krill.

Disease

The potential threat posed by disease is discussed in Chapter 4.7.

Climate Change

See comments in Chapter 4.9.

11. Conservation objectives

11.1 Research

Improve knowledge of the biology of crab-eater seal populations, especially as this relates to the Australian Government goals for research in Antarctica.

11.2 Management

- Crab-eater seals should be recognised as an integral and vulnerable component of marine ecosystems.
- Meet obligations for reporting statistical information on all seals killed in or captured and released from the Convention area (south of 60°S). This is required by 30 June each year under the Convention for the Conservation of Antarctic Seals.

12. Conservation actions already initiated

12.1 Research

A research program involving countries active in Antarctica has been developed by the SCAR Group of Specialists on Seals (Anon. 1994). It is entitled Antarctic Pack Ice Seals (APIS) and was accepted at the SCAR meeting in August 1994. It refers to leopard, crab-eater, Weddell and Ross seals which utilise the Southern Ocean pack ice. The proposed topics are listed in section 13.1.

12.2 Management

Reporting to SCAR of seals killed or captured by Australians has been completed for most years by the Australian Antarctic Division.

13. Conservation actions required

13.1 Research

*Research topics proposed by the SCAR Group of Specialists on Seals for the APIS program refer to all species of pack ice seals. They are:

- distribution, abundance and species composition
- genetic identity of populations
- habitat use and seasonal movements
- seals as platforms for oceanographic research
- population dynamics
- diving, feeding behaviour and activity patterns
- diet
- energetics and physiology
- toxicology and disease.

Aspects of this research protocol have been initiated by researchers at the Australian Antarctic Division (C. Southwell, W. de la Mare and H. R. Burton).

13.2 Management

- Contribute (with other nations) to redefining the "sealing zones" that are described in Annex 4 of the Convention for the Conservation of Antarctic Seals.
- For handling animals 'stranded' on the Australian coast, see comments in Appendix IV.

14. Organisation(s) responsible for conservation of species

14.1 International

Antarctic Treaty System through the Convention for the Conservation of Antarctic Seals.

14.2 National

Australian Antarctic Division at Heard Island and in the Australian Antarctic Territory; Environment Australia in Australian territorial waters (3 to ca. 200 nautical miles).

14.3 State

Government nature conservation and fisheries agencies, on land and in State and Territory waters (out to 3 nautical miles); Tasmanian Parks and Wildlife Service at Macquarie Island.

15. Other organisations and individuals involved

C. Southwell, W. de la Mare and H. R. Burton, Australian Antarctic Division; T. Rogers, Australian Marine Mammal Research Centre, Taronga Zoo; P. Shaughnessy, CSIRO Wildlife and Ecology.

Weddell Seal

1. Family	Phocidae
2. Scientific name	*Leptonychotes weddellii*
3. English name(s)	Weddell seal

4. Taxonomic status (including species and subgroups)

Described by R.-P. Lesson in 1826 from a specimen taken at the South Orkney Islands. *Leptonychotes* is a monospecific genus. The four Antarctic phocids, crab-eater, leopard, Ross and Weddell seals, are grouped in the subfamily Lobodontinae. No subspecies of the Weddell seal are recognised.

5. Species survival status

5.1 Conservation status based on IUCN (1994)

Lower Risk, least concern

5.2 IUCN status

IUCN (1993): Not listed
SSG IUCN SSC: Not listed

5.3 CITES status

Not listed

6. Distribution, including migration

Local populations of Weddell seals are found in areas of suitable fast ice close to the Antarctic continent and at peri-antarctic islands. Their range is circumpolar. After the amount of shore fast ice diminishes in late summer, part of the population moves away from the coast and into the pack ice.

Evidence for fidelity to the colony of birth comes from tagging programs conducted at McMurdo Sound, Signy Island and Vestfold Hills (summarised by Laws 1984). This is supported by evidence for genetic differences between populations based on electrophoretic analysis of blood proteins (Shaughnessy 1969, Seal *et al.* 1971), however, no subspecies are recognised.

There is one record of this seal in South Australia (Wood Jones 1925b), and several for Heard and Macquarie Islands (Ingham 1960, King 1983).

7. Habitat

7.1 General

Their main habitat is fast ice adjacent to the Antarctic mainland and nearby islands. Pupping colonies occur along coastlines or ice shelves, where tide cracks or other openings make egress from the water predictable.

7.2 Key localities

Areas of suitable fast ice around the Antarctic continent.

8. Marine protected areas managed or relevant to the species

None.

9. Biological overview

9.1 Growth and age (females and males)

Birth weight/length	22 - 25 kg, 1.2 m
Weaning age	7 weeks
Weight	318 - 550 kg
Length	210 - 329 cm

Source: DeMaster (1979).

9.2 Reproduction

Age at sexual maturity

females (Testa *et al.* 1990)	6-8 years
males (Testa and Siniff 1987)	as for females

Pupping interval	1 year
Gestation	11 months

Pupping season

September to early November, with later dates at more southerly locations.

Pregnancy rate

Fluctuates with a 4 - 6 year cycle at McMurdo Sound, Signy Island and Vestfold Hills (Testa *et al.* 1990).

Source: DeMaster (1979)

9.3 Diet

Feeds primarily on fish. A sample of 48 stomachs from the Antarctic Peninsula area and from McMurdo Sound showed the following contents: 53% fish, 11% cephalopods, 1% krill, 35% other invertebrates (Øritsland 1977). In a study of food from stomachs, vomitus and faeces near Davis and Mawson in the Australian Antarctic Territory, fish remains predominated. At Davis, a crustacean species was next in importance, while at Mawson cephalopods were second in importance. Seasonal changes in relative abundance of food items were detected at Davis (Green and Burton 1987).

9.4 Behaviour

Weddell seals mate under water. Adult males hold territories under tide cracks around which females and their pups are dispersed on the surface of the pack ice. Weddell seals are readily approached and tractable, and have been the subject of much physiological study (Kooyman 1981).

9.5 Mortality and pathology

The upper incisor and canine teeth of Weddell seals project almost horizontally, and are used to abrade ice to maintain breathing holes. In adults the teeth become worn and infections and abscesses affect the longevity of some animals. Worn teeth also limit their movements between ice surface and water (Stirling 1969). Some pups are crushed by ice.

9.6 Population abundance and rates of change

Population abundance is difficult to determine because of the great areas involved and the logistics of working in pack ice. Abundance has been estimated from aerial and shipboard censuses at 800,000 (Gilbert and Erickson 1977, Erickson and Hanson 1990). The latter noted that these estimates should be considered minimal, because they exclude an unknown fraction of animals not on the pack-ice surface during surveys, although they were conducted at peak haul-out time.

No trends in abundance have been estimated for Weddell seals because not enough animals were seen in the pack ice surveys for meaningful comparisons to be made (Erickson and Hanson 1990). Stable pup numbers were recorded for a local population in the Vestfold Hills, near Davis station, for the period 1977 - 1990 (Green *et al.* 1995).

The SCAR Group of Specialists on Seals is encouraging widespread, near-synoptic surveys to determine abundance of pack ice seals, primarily in the 1998-99 summer.

The population at McMurdo Sound has recovered from heavy harvesting for food for sled dogs, particularly in the 1950s (Testa and Siniff 1987).

10. Threats

10.1 Harvesting

Past exploitation

There was locally heavy harvesting to feed sled dogs at Antarctic bases particularly at McMurdo Sound (Stirling 1971) but also at Australian bases. This was phased out several years ago and should not be repeated following the recent removal of dogs from Antarctica. Small numbers of animals were taken in the USSR harvest in the summer of 1986/87 (see Chapter 4.1.2).

Current exploitation

Restricted harvesting of Weddell seals is permitted south of 60°S under the Convention for the Conservation of Antarctic Seals. It is not permissible to kill pups and it is prohibited to kill or capture Weddell seals one year old or older between 1 September and 31 January, in order to preserve the breeding stock. Harvesting is not permitted under Australian legislation.

10.2 Current

Entanglement in man-made marine debris is likely to be uncommon (see Chapter 4.3).

10.3 Potential

Fisheries

Fishing in the Southern Ocean could have a negative impact on vertebrate predators such as the Weddell seal (see Chapter 4.2).

Disease

The potential threat posed by disease is discussed in Chapter 4.7.

Climate Change

See comments in Chapter 4.9.

11. Conservation objectives

11.1 Research

Improve knowledge of the biology of Weddell seal populations, especially as this relates to the Australian Government goals for research in Antarctica.

11.2 Management

- Weddell seals should be recognised as an integral and vulnerable component of marine ecosystems.
- Meet obligations for reporting statistical information on all seals killed in or captured and released from the Convention area (south of 60°S). This is required by 30 June each year under the Convention for the Conservation of Antarctic Seals.

12. Conservation actions already initiated

12.1 Research

A research program involving countries active in Antarctica has been developed by the SCAR Group of Specialists on Seals (Anon. 1994). It is entitled Antarctic Pack Ice Seals (APIS) and was accepted at the SCAR meeting in August 1994. It refers to leopard, crab-eater, Weddell and Ross seals which utilise the Southern Ocean pack ice. The proposed topics are listed in section 13.1.

12.2 Management

Reporting to SCAR of seals killed or captured by Australians has been completed for most years by the Australian Antarctic Division.

13. Conservation actions required

13.1 Research

Research topics proposed by the SCAR Group of Specialists on Seals for the APIS program refer to all species of pack ice seals. They are:

- distribution, abundance and species composition
- genetic identity of populations
- habitat use and seasonal movements
- seals as platforms for oceanographic research
- population dynamics
- diving, feeding behaviour and activity patterns
- diet
- energetics and physiology
- toxicology and disease.

Aspects of this research protocol have been initiated by H. R. Burton of the Australian Antarctic Division. Plans for research on Weddell seals should take particular note of the valuable age-marked population near Davis and the logistic support available there.

*Determine the distribution and size of breeding sites in the fast ice zone of the Australian Antarctic Territory. This is required for a full assessment of the status of this species under IUCN's 1994 guidelines (see Table 2.3).

13.2 Management

- Contribute (with other nations) to redefining the "sealing zones" that are described in Annex 4 of the Convention for the Conservation of Antarctic Seals.
- For handling animals 'stranded' on the Australian coast, see comments in Appendix IV.

14. Organisation(s) responsible for conservation of species

14.1 International

Antarctic Treaty System through the Convention for the Conservation of Antarctic Seals.

14.2 National

Australian Antarctic Division at Heard Island and in the Australian Antarctic Territory; Environment Australia in Australian territorial waters (3 to ca. 200 nautical miles).

14.3 State

Government nature conservation and fisheries agencies, on land and in State and Territory waters (out to 3 nautical miles); Tasmanian Parks and Wildlife Service at Macquarie Island.

15. Other organisations and individuals involved

H. R. Burton, Australian Antarctic Division; K. Green, NSW National Parks and Wildlife Service, Cooma.

Ross Seal

1. Family	Phocidae
2. Scientific name	*Ommatophoca rossii*
3. English name(s)	Ross seal, big-eyed seal, singing seal

4. Taxonomic status (including species and subgroups)

Described by J. E. Gray in 1844 from a specimen obtained from the Ross Sea. *Ommatophoca* is a monospecific genus. The four Antarctic phocids, crab-eater, leopard, Ross and Weddell seals, are grouped in the subfamily Lobodontinae. No subspecies of the Ross seal are recognised.

5. Species survival status

5.1 Conservation status based on IUCN (1994)

Lower risk, least concern

5.2 IUCN status

IUCN (1993): Not listed
SSG IUCN SSC: Not listed

5.3 CITES status

Not listed

6. Distribution, including migration

Ross seals breed on pack ice of the Southern Ocean. Their range is circumpolar, with the densest concentrations on pack ice of the south-eastern Atlantic Ocean (Erickson and Hanson 1990). Migration is presumably affected by seasonal expansion and contraction of pack ice. This seal is virtually unknown beyond the Antarctic pack ice. There is one record for Heard Island (Ingham 1960) and one for South Australia (Ling and Walker 1979).

7 Habitat

7.1 General

Their main habitat is the Southern Ocean pack ice, where they prefer heavy pack ice. They are pelagic.

7.2 Key localities

Heavy pack ice of the Southern Ocean.

8. Marine protected areas managed or relevant to the species

None.

9. Biological overview

9.1 Growth and age

Birth weight/length		27 kg, 105-120 cm
Weaning age		Not known
Weight	*females*	159 - 204 kg (av. 186 kg)
	males	129 - 216 kg (av. 173 kg)
Length	*females*	196 - 326 cm (av. 213 cm)
	males	168 - 208 cm (av. 199 cm)

Source: Laws and Hofman (1979).

9.2 Reproduction

Age at sexual maturity

females	approx. 3-4 years
males	approx. 2-7 years

(Øritsland 1970)

Pupping interval

No data, but presumably 1 year

Gestation

1 year (Skinner and Westlin-van Aarde 1989)

Pupping season

November, based on few observations, mostly in the South Pacific Ocean (Tikhomirov 1975).

9.3 Diet

On the basis of stomach contents from animals collected near the Antarctic Peninsula, Øritsland (1977) reported that the diet comprised 64% cephalopods, 14% other invertebrates, and 22% fish. Skinner and Klages (1994) proposed that fish may be at least as important as squid in their diet.

9.4 *Behaviour*

Ross seals breed, moult and rest on pack ice, and their movements are associated with the seasonal expansion and contraction of pack ice. They are primarily solitary animals. When disturbed, an individual holds up its head and inflates its throat. They produce a wide range of bird-like vocalizations.

9.5 *Mortality and pathology*

No data.

9.6 *Population abundance and rates of change*

Population abundance is difficult to determine because of the great areas involved and the logistics of working in pack ice. On the basis of shipboard and aerial surveys of pagophilic seals in the Southern Ocean, Gilbert and Erickson (1977) estimated Ross seal numbers at 220,000, and Erickson and Hanson (1990) estimated them at 131,000. The latter noted that this estimate should be considered minimal, because it excludes an unknown fraction of animals not on the pack-ice surface during surveys, although they were conducted at peak haul-out time.

No information is available on trends in abundance for Ross seals because not enough animals were seen in the pack ice surveys for meaningful comparisons to be made (Erickson and Hanson 1990).

The SCAR Group of Specialists on Seals is encouraging widespread, near-synoptic surveys to determine abundance of pack ice seals, primarily in the 1998-99 summer.

10. Threats

10.1 *Harvesting*

A few animals were taken in the Norwegian harvest in spring 1964 and the USSR harvest in the summer of 1986/87 (see Chapter 4.1.2). Ross seals are protected by the Convention for the Conservation of Antarctic Seals south of 60°S (see Chapter 4.1.2), and under Australian legislation.

10.2 *Current*

Entanglement in man-made marine debris is unlikely to be common (see Chapter 4.3).

10.3 *Potential*

Fisheries

Fishing in the Southern Ocean could have a negative impact on vertebrate predators such as the Ross seal (see Chapter 4.2).

Disease

The potential threat posed by disease is discussed in Chapter 4.7.

Climate Change

See comments in Chapter 4.9.

11. Conservation objectives

11.1 *Research*

Improve knowledge of the biology of Ross seal populations, especially as this relates to the Australian Government goals for research in Antarctica.

11.2 *Management*

- Ross seals should be recognised as a an integral and vulnerable component of marine ecosystems.
- Meet obligations for reporting statistical information on all seals killed in or captured and released from the Convention area (south of 60°S). This is required by 30 June each year under the Convention for the Conservation of Antarctic Seals.

12. Conservation actions already initiated

12.1 *Research*

A research program involving countries active in Antarctica has been developed by the SCAR Group of Specialists on Seals (Anon. 1994). It is entitled Antarctic Pack Ice Seals (APIS) and was accepted at the SCAR meeting in August 1994. It refers to leopard, crab-eater, Weddell and Ross seals which utilise the Southern Ocean pack ice. The proposed topics are listed in section 13.1.

12.2 *Management*

Reporting to SCAR of seals killed or captured by Australians has been completed for most years by the Australian Antarctic Division.

13. Conservation actions required

13.1 *Research*

Research topics proposed by the SCAR Group of Specialists on Seals for the APIS program refer to all species of pack ice seals. They are:

- distribution, abundance and species composition
- genetic identity of populations
- habitat use and seasonal movements
- seals as platforms for oceanographic research
- population dynamics
- diving, feeding behaviour and activity patterns
- diet
- energetics and physiology
- toxicology and disease.

13.2 *Management*

- For handling animals ‘stranded’ on the Australian coast, see comments in Appendix IV.
- Contribute (with other nations) to redefining the “sealing zones” that are described in Annex 4 of the Convention for the Conservation of Antarctic Seals.

14. Organisation(s) responsible for conservation of species

14.1 *International*

Antarctic Treaty System through the Convention for the Conservation of Antarctic Seals.

14.2 *National*

Australian Antarctic Division at Heard Island and in the Australian Antarctic Territory; Environment Australia in Australian territorial waters (3 to ca. 200 nautical miles).

14.3 *State*

Government nature conservation and fisheries agencies, on land and in State and Territory waters (out to 3 nautical miles); Tasmanian Parks and Wildlife Service at Macquarie Island.

15. Other organisations and individuals involved

C. Southwell, W. de la Mare and H. R. Burton, Australian Antarctic Division.

Flagship Taxa

This chapter identifies three flagship taxa for public education programs.

The **Australian sea-lion** is the only endemic seal species in Australia. It is found on the west and south coasts of Western Australia, and on the coast of South Australia. It has 66 breeding colonies on islands from Houtman Abrolhos, near Shark Bay in Western Australia, to The Pages, near Kangaroo Island in South Australia. Its population size is about 11,000 animals, of which about 40% is in three colonies in central South Australia at Dangerous Reef near Port Lincoln, Seal Bay on Kangaroo Island, and The Pages Islands.

The Australian sea-lion is a picturesque animal. Adult females and juveniles are grey above and pale below, adult males are chocolate brown with a pale mane. It is relatively well known by the public, being the basis of tourism at several sites in South Australia and Western Australia. sea-lions have become habituated to people at Seal Bay, which had 100,000 visitors in 1996. sea-lions also utilise non-breeding sites near Perth and occasionally haul-out in the Perth metropolitan area.

sea-lions rob baits from rock lobster pots and small animals occasionally become trapped and drown. They also become entangled in fishing gear and in other man-made debris.

Australian sea-lions have several unusual biological characteristics. They breed on an 18-month cycle and have an extended pupping season of five months, whereas other seal species breed annually with a breeding season of about one month. Mothers suckle their pups for 18 months, or even longer if the next pup dies, while other seal species nurse for much shorter times. The timing of breeding at individual colonies of the sea-lion is not in synchrony, whereas colonies of other seal species breed at similar times in either spring or summer. The conservation status of the Australian sea-lion has been assessed as *Lower Risk, near threatened* against IUCN (1994) criteria.

Southern elephant seals breed on Subantarctic islands, including Macquarie Island and Heard Island, in the Australian region. In the 1980s, population numbers were 86,500 at Macquarie Island and 13,000 at Heard Island. There are also populations of these seals at other Subantarctic islands, including a large population at South Georgia.

Tagging studies have shown considerable interchange of marked animals between Heard Island and Kerguelen in the north, and the well-frequented haul-out area at the Vestfold Hills region near Davis Station in Antarctica to the south. Studies with instrumented elephant seals show that some of them move south, close to the Antarctic coast. They dive to great depths, with mean dive depths for individual animals ranging from 269 to 589 m. They also dive continuously, with 90% of their time at sea spent diving and a mean dive duration for individual animals ranging from 16 to 37 minutes.

Elephant seals visit the Australian coast, particularly Tasmania, where they are frequently recorded and several pups have been born. There are also records of elephant seals ashore in New South Wales (including two near Sydney), and several in Victoria, South Australia and Western Australia. Elephant seals formerly bred on islands in western Bass Strait, but these populations were eliminated by early European sealers.

Southern elephant seals are large, robust animals, with large dark eyes. The adult and subadult males have a distinctive appearance with their enlarged proboscis. They are the object of public attention whenever they visit the Australian coast.

These seals were harvested at Macquarie and Heard Islands soon after they were discovered in the 19th century. At Macquarie Island, harvesting continued until 1919. Populations recovered at both islands, but have declined again since the 1950s for reasons that are not apparent. One suggestion is that the populations overshot equilibrium levels. Other suggestions are that changes in the environment of the Southern Ocean may have adversely affected the abundance or availability of the elephant seal's prey, or that predation by killer whale has caused the decline. The population at Macquarie Island is reported to have stabilised recently.

The conservation status of the southern elephant seal has been assessed as *Vulnerable* against IUCN (1994) criteria on the basis of the sharp decrease in its numbers. For this reason, its conservation status deserves attention.

Leopard seals are solitary animals of the pack ice zone of the Southern Ocean. Their abundance has been estimated at between 222,000 and 440,000 from aerial and shipboard censuses in the pack ice. They breed, moult and rest on pack ice, and their movements are associated with the seasonal expansion and contraction of pack ice. They are vocal underwater over long distances, especially during the breeding season.

Leopard seals are frequent visitors to Macquarie Island and the Australian coast, particularly Tasmania. Records of visitation appear to peak on a 4-5 year cycle. They are relatively abundant at Heard Island, where they occur year round.

The leopard seal has a distinctive appearance. It has a slender, reptilian figure with a head that seems disproportionately large and a large mouth with many teeth. Although it has a reputation as a fearsome predator of warm blooded animals, such as penguins and other seals, its main prey is plankton. It is the object of public attention whenever it visits the Australian coast. The conservation status of the leopard seal has been assessed as *Lower Risk, least concern* against IUCN (1994) criteria.

References

Abbott, I. (1979). The past and present distribution and status of sea-lions and fur-seals in Western Australia. *Records of the Western Australian Museum* 7: 375-90.

Anon. (1991a). Oil spill threat to New Zealand fur-seals. *Marine Pollution Bulletin* 11: 166.

Anon. (1991b). *Report of the workshop on southern elephant seals.* SCAR Group of Specialists on Seals, Monterey Bay Aquarium, Monterey, California, 22-23 May 1991, 29 pp.

Anon. (1994). *Antarctic pack ice seals: indicators of environmental change and contributors to carbon flux.* SCAR Group of Specialists on Seals, 12 pp.

Anon. (1995). *Summary report.* Meeting of the SCAR Group of Specialists on Seals, Universita degli Studi di Padova, Padova, Italy, 25-28 May 1994, 11 pp.

Anon. (1996). "Seal friendly" lobster potting. *Southern Fisheries* 4(3): 2.

Arundel, J. H. (1978). Parasites and parasitic diseases of Australian marine mammals. In *Proceedings No. 36 Fauna, Part B of course for veterinarians.* University of Sydney Post-Graduate Committee in Veterinary Science, Sydney, pp. 323-33.

Australian Antarctic Division (1995). *Heard Island Wilderness Reserve management plan.* Australian Antarctic Division, Kingston, Tasmania, 72 pp.

Australian Antarctic Division (1997). *Report of the workshop on predator-prey-fisheries interactions at Heard Island and McDonald Islands and at Macquarie Island.* Australian Antarctic Division, Kingston, Tasmania, 37 pp.

Australian Maritime Safety Authority (1993). *Review of the National Plan to Combat Pollution of the Sea by Oil; report of the High Level Working Party.* AGPS, Canberra, 241 pp.

Bannister, J. L., Kemper, C. M. and Warneke, R. M. (1996). *The Action Plan for Australian Cetaceans.* Australian Nature Conservation Agency, Canberra, 242 pp.

Bengtson, J. L. and Siniff, D. B. (1981). Reproductive aspects of female crab-eater seals (Lobodon carcinophagus) along the Antarctic Peninsula. *Canadian Journal of Zoology* 59: 92-102.

Bengtson, J. L. and Stewart, B. S. (1992). Diving and haulout behavior of crab-eater seals in the Weddell Sea, Antarctica, during March 1986. *Polar Biology* 12: 635-44.

Bengtson, J. L., Boveng, P., Franzén, U., Have, P., Heide-Jorgensen, M. P. and Härkönen, T. J. (1991). Antibodies to canine distemper virus in antarctic seals. *Marine Mammal Science* 7: 85-7.

Bester, M. N. (1982). Distribution, habitat selection and colony types of the Amsterdam Island fur-seal *Arctocephalus tropicalis* at Gough Island. *Journal of Zoology*, London 196: 217-31.

Bester, M. N. (1987). Subantarctic fur-seal, *Arctocephalus tropicalis*, at Gough Island (Tristan Da Cunha group). *NOAA Technical Report NMFS* 51: 57-60.

Bester, M. N. (1990). Reproduction in the male sub-Antarctic fur-seal *Arctocephalus tropicalis. Journal of Zoology*, London 222: 177-85.

Bester, M. N. (1995). Reproduction in the female Subantarctic fur-seal, *Arctocephalus tropicalis. Marine Mammal Science* 11: 362-75.

Beveridge, I. (1980). *Uncinaria hydromyidis* sp. n. (Nematoda: Ancylostomatidae) from the Australian water rat, *Hydromys chrysogaster. Journal of Parasitology* 66: 1027-31.

Bonner, W. N. (1981). Southern fur-seals *Arctocephalus* (Geoffroy Saint-Hilaire and Cuvier, 1826). *In Handbook of marine mammals; the walrus, sea-lions, fur-seals and sea otter.* Ridgway, S. H. and Harrison, R. J. (eds). Academic Press, London, vol. 1, pp. 161-208.

Boyd, I. L. (1993). Pup production and distribution of breeding Antarctic fur-seals (*Arctocephalus gazella*) at South Georgia. *Antarctic Science* 5:17-24.

Brothers, N. and Pemberton, D. (1990). Status of Australian and New Zealand fur-seals at Maatsuyker Island, southwestern Tasmania. *Australian Wildlife Research* 17: 563-9.

Brunner, S. (1998). Cranial morphometrics of the southern fur-seals *Arctocephalus forsteri* and *A. pusillus* (Carnivora: Otariidae). *Australian Journal of Zoology* 46: 67-108.

Bryden, M. M. (1995). Southern elephant seal *Mirounga leonina* Gray, 1827. In *The mammals of Australia.* Strahan, R. (ed.). Reed Books, Chatswood, pp. 686-7.

Budd, G. M. (1972). Breeding of the fur-seal at McDonald Islands, and further population growth at Heard Island. *Mammalia* 36: 423-7.

Budd, G. M. and Downes, M. C. (1969). Population increase and breeding in the Kerguelen fur-seal, *Arctocephalus tropicalis gazella*, at Heard Island. Mammalia 33: 58-67.

Burton, H. R. (1985). Tagging studies of male southern elephant seals (*Mirounga leonina* L.) in the Vestfold Hills area, Antarctica, and some aspects of their behaviour. In *Studies of sea mammals in south latitudes.* Ling, J. K. and Bryden M. M. (eds). South Australian Museum, Adelaide, pp. 19-30.

Burton, H. (1986). A substantial decline in numbers of the southern elephant seal at Heard Island. *Tasmanian Naturalist* 86: 4-8.

Butterworth, D. S., Duffy, D. C., Best, P. B. and Bergh, M. O. (1988). On the scientific basis for reducing the South African seal population. *South African Journal of Science* 84: 179-88.

Carey, P. W. (1992). Fish prey species of the New Zealand fur-seal (*Arctocephalus forsteri*, Lesson). *New Zealand Journal of Ecology* 16: 41-6.

Carrick, R. and Ingham, S. E. (1962). Studies on the southern elephant seal, *Mirounga leonina* (L.) V. Population dynamics and utilization. *CSIRO Wildlife Research* 7: 198-206.

Carrick, R., Csordas, S. E. and Ingham, S. E. (1962). Studies on the southern elephant seal, *Mirounga leonina* (L.) IV. Breeding and development. *CSIRO Wildlife Research* 7: 161-97.

Cawthorn, M. W. (1994). Seal finger and mycobacterial infections of man from marine mammals: occurrence, infection and treatment. *Conservation Advisory Science Notes* No. 102, Department of Conservation, Wellington, New Zealand, 15 pp.

Chambers, G. K., Moon, C. D. and Lento, G. M. (1995). *Genetic variation in Tasmanian populations of the Australian fur-seal* (Arctocephalus pusillus doriferus). Unpublished report to the Tasmanian Department of Parks, Wildlife and Heritage, Hobart.

Chittleborough, R. G. (1991). Potential impacts of climatic change on the Southern Ocean ecosystem. *Memoirs of the Queensland Museum* 30: 243-7.

Commonwealth of Australia (1997). *Australia's ocean policy: oceans planning and management.* Background paper 1. Environment Australia, Canberra, 31 pp.

Commonwealth of Australia (1998). *Australia's ocean policy: an issues paper.* Environment Australia, Canberra, 96 pp.

Condy, P. R., van Aarde, R. J. and Bester, M. N. (1978). The seasonal occurrence and behaviour of killer whales *Orcinus orca*, at Marion Island. *Journal of Zoology*, London 184: 449-64.

Copson, G., Scott, J. and Bosworth, P. (1994). Far out - the possibilities for Macquarie Island Biosphere Reserve. In *Marine protected areas and biosphere reserves: 'towards a new paradigm'.* Brunckhorst, D. J. (ed.). Australian Nature Conservation Agency, Canberra, pp. 79-80.

Costa, D. and Gales, N. (1991). Diving pattern and energetics of the Australian sea-lion, *Neophoca cinerea. Australian Mammal Society, Newsletter* Autumn 1991, p. 20.

Costa, D. P., Kretzmann, M., Thorson, P. and Higgins, L. (1988). *At-sea energetics, diving behavior and milk composition of Australian sea-lions,* Neophoca cinerea, *at Seal Bay, Kangaroo Island, South Australia: report of activities carried out during July and August 1988.* Unpublished report to South Australia Department of the Environment, 14 pp.

Costa, D. P., Rea, L. D., Kretzmann, M. and Thorson, P. H. (1990). *Seasonal changes in the diving pattern and energetics of the Australian sea-lion*, Neophoca cinerea. Unpublished report to South Australia Department of the Environment, 10 pp.

Costa, D. P., Swain, U. and Gales, N. (1991). Seasonal changes in the diving pattern and energetics of the Australian sea-lion, *Neophoca cinerea*. In *Abstracts of Ninth Biennial Conference on the Biology of Marine Mammals*, Chicago, Illinois, December 5-9, 1991, p.14.

Cousins, D. (1996). Tuberculosis in seals in Australia. In *Proceedings of the 1995 conference of the Australian Association of Veterinary Conservation Biologists*. Phelps, G. R. (ed.). Australian Association of Veterinary Conservation Biologists, Sydney, pp. 51-7.

Cousins, D. V., Williams, S. N., Reuter, R., Forshaw, D., Chadwick, B, Coughran, D., Collins, P. and Gales, N. (1993). Tuberculosis in wild seals and characterisation of the seal bacillus. *Australian Veterinary Journal* 70: 92-7.

Crawley, M. C. (1990). Genus *Arctocephalus*. In *The handbook of New Zealand mammals*. King, C. M. (ed.). Oxford University Press, Auckland, pp. 244-56.

Croxall, J. P. and Gentry, R. L. (eds) (1987). Status, biology, and ecology of fur-seals. Proceedings of an international symposium and workshop, Cambridge, England, 23-27 April 1984. *NOAA Technical Report* NMFS 51: 1-212.

Croxall, J. P. and Wace, N. (1995). Interactions between marine and terrestrial ecosystems. In *Progress in conservation of the Subantarctic islands*. Dingwall, P. R. (ed.). IUCN, Gland, Switzerland, pp. 115-20.

Daly, T. J. (1994). S*eals and sea-elephants: a tragedy of the Australian frontier*. BA (Hons) thesis, University of New South Wales, Sydney, 35pp.

David, J. H. M. (1987). Diet of the South African fur-seal (1974-1985) and an assessment of competition with fisheries in southern Africa. *South African Journal of Marine Science* 5: 693-713.

DeMaster, D. P. (1979). Weddell seal. In *Mammals in the seas. Vol II. Pinniped Species Summaries and Report on Sirenians*. FAO Fisheries Series No. 5, Food and Agriculture Organization, Rome, pp. 130-4.

Dennis, T. E. (1997). *Australian sea-lion surveys on The Pages islands, South Australia, during the 1997 breeding season, with reference to surveys commencing in 1987*. Report to the Department of Environment and Natural Resources, Wildlife Conservation Fund of South Australia, December 1997, 12 + viii pp.

Dennis, T. E. and Shaughnessy, P. D. (1996). Status of the Australian sea-lion, *Neophoca cinerea*, in the Great Australian Bight. *Wildlife Research* 23: 741-54.

Department of Conservation and Land Management (no date). *sea-lions*. Department of Conservation and Land Management, Como, WA, pamphlet.

Department of Conservation, Forests and Lands (1989). *Victoria's Marine Parks and Reserves. Protecting the treasure of ocean and shoreline*. DCFL, Melbourne, 32 pp.

Department of Parks, Wildlife and Heritage (1991). *Macquarie Island Nature Reserve management plan 1991*. Department of Parks, Wildlife and Heritage, Hobart, 57 pp.

Doidge, D. W. and Croxall, J. P. (1985). Diet and energy budget of the Antarctic fur-seal, *Arctocephalus gazella*, at South Georgia. In *Antarctic nutrient cycles and food webs*. Siegfried, W. R., Condy, P. R. and Laws R. M. (eds). Springer-Verlag, Berlin, pp. 543-50.

Doidge, D. W. and Croxall, J. P. (1989). Factors affecting weaning weight in Antarctic fur-seals *Arctocephalus gazella* at South Georgia. *Polar Biology* 9: 155-60.

Dzhamanov, G. Kh. (1990). Some aspects of the biology and distribution of ice-inhabiting seals near the Balleny Islands and east of the d'Urville Sea in 1986-87. *Morskie Mlekopitayushchie* 1990: 112-29. (English translation in Report of the meeting of the SCAR Group of Specialists on Seals, XXII SCAR, Bariloche, Argentina, 8-12 June 1992, pp. 44-57).

Erickson, A. W. and Hanson, M. B. (1990). Continental estimates and population trends of Antarctic ice seals. In *Antarctic ecosystems: ecological change and conservation*. Kerry, K. R. and Hempel, G. (eds). Springer-Verlag, Berlin, pp. 253-64.

Erickson, A. W., Siniff, D. B., Cline, D. R. and Hofman, R. J. (1971). Distributional ecology of Antarctic seals. In *Symposium on Antarctic ice and water masses*. Deacon, G. (ed.). SCAR, Cambridge, pp. 55-76.

FAO (1979). *Mammals in the seas*, Vol II. *Pinniped Species Summaries and Report on Sirenians*. FAO Fisheries Series No. 5, Food and Agriculture Organization, Rome.

Fletcher, L. and Shaughnessy, P. (1984). The current status of seal populations at Macquarie Island. *Tasmanian Naturalist* 79: 10-3.

Flinders, M. (1814). *A voyage to Terra Australis*. Nicol, London, 2 vols.

Forshaw, D. and Phelps, G. R. (1991). Tuberculosis in a captive colony of pinnipeds. *Journal of Wildlife Diseases* 27: 288-95.

Fowler, C. W. (1987). Marine debris and northern fur-seals: a case study. *Marine Pollution Bulletin* 18: 326-35.

Gales, N. J. (1990). *Abundance of Australian sea-lions* Neophoca cinerea *along the southern Australian coast, and related research*. Report to the Western Australian Department of Conservation and Land Management, South Australian National Parks and Wildlife Service and the South Australian Wildlife Conservation Fund, 27 + ix pp.

Gales, N. J. (1991). *New Zealand fur-seals and oil: an overview of assessment, treatment, toxic effects and survivorship. The 1991 Sanko Harvest oil spill*. Report to the Western Australian Department of Conservation and Land Management, 27 + viii pp.

Gales, N. J. and Cheal, A. J. (1992). Estimating diet composition of the Australian sea-lion (*Neophoca cinerea*) from scat analysis: an unreliable technique. *Wildlife Research* 19: 447-56.

Gales, N. J. and Costa, D. P. (1997). The Australian sea-lion: a review of an unusual life history. In *Marine mammal research in the Southern Hemisphere*. Hindell, M. and Kemper, C. (eds). Surrey Beatty and Sons, Chipping Norton, Sydney, pp. 78-87.

Gales, N. J., Adams, M. and Burton, H. R. (1989). Genetic relatedness of two populations of the southern elephant seal, *Mirounga leonina*. *Marine Mammal Science* 5: 57-67.

Gales, N. J., Coughran, D. K. and Queale, L. F. (1992a). Records of Subantarctic fur-seals *Arctocephalus tropicalis* in Australia. *Australian Mammalogy* 15: 135-8.

Gales, N. J., Shaughnessy, P. D. and Dennis, T. E. (1994). Distribution, abundance and breeding cycle of the Australian sea-lion *Neophoca cinerea* (Mammalia: Pinnipedia). *Journal of Zoology, London* 234: 353-70.

Gales, N. J., Cheal, A. J., Pobar, G. J. and Williamson, P. (1992b). Breeding biology and movements of Australian sea-lions, *Neophoca cinerea*, off the west coast of Western Australia. *Wildlife Research* 19: 405-16.

Gales, N. J., Williamson, P., Higgins, L. V., Blackberry, M.A. and James, I. (1997). Evidence for a prolonged post-implantation period in the Australian sea-lion *(Neophoca cinerea)*. *Journal of Reproduction and Fertility* 111: 159-63.

Gales, R. and Pemberton, D. (1994). Diet of the Australian fur-seal in Tasmania. *Australian Journal of Marine and Freshwater Research* 45: 653-64, [corrigendum] 1367.

Gales, R., Pemberton, D., Lu, C. C. and Clarke, M. R. (1993). Cephalopod diet of the Australian fur-seal: variation due to location, season and sample type. *Australian Journal of Marine and Freshwater Research* 44: 657-71.

Geraci, J. R. and Lounsbury, V. J. (1993). *Marine mammals ashore; a field guide for strandings*. Texas A & M Sea Grant College Program, Galveston, 305 pp.

Geraci, J. R. and Ridgway, S. H. (1991). On disease transmission between cetaceans and humans. *Marine Mammal Science* 7: 191-4.

Geraci, J. R., St Aubin, D. J., Barker, I. K., Webster, R. G., Hinshaw, V. S., Bean, W. J., Ruhnke, H. L., Prescott, J. H., Early, G., Baker, A. S., Madoff, S. and Schooley, R. T. (1982). Mass mortality of harbor seals: pneumonia associated with influenza A virus. *Science* 215: 1129-31.

Gilbert, J. R. and Erickson, A. W. (1977). Distribution and abundance of seals in the pack ice of the Pacific sector of the Southern Ocean. In *Adaptations within Antarctic ecosystems*. Llano, G. A. (ed.). Smithsonian Institution, Washington DC, pp. 703-40.

Gilbert, T. (1996). Contingency planning for wildlife during oil spills. *Waves, Newsheet of the Marine and Coastal Community Network* 3(2): 5.

Gilmartin, W. G., Delong, R. L., Smith, A. W., Sweeney, J. C., De Lappe, B. W., Riseborough, R. W., Griner, L. A., Dailey, M. D. and Peakall, D. B. (1976). Premature parturition in the California sea-lion. *Journal of Wildlife Diseases* 12: 104-15.

Goldsworthy, S. D. (1991). *Status report on eared seals (Otariidae) in Australia and its territories.* Prepared for the Australian National Parks and Wildlife Service, *Endangered* Species Program, 18 pp.

Goldsworthy, S. (1996). Progress report on Australian research on fur-seals. In *Report of the meeting of the SCAR Group of Specialists on Seals*, Scientific Committee on Antartctic Research, Cambridge, U. K., August 1996, pp. 22-4.

Goldsworthy, S. D. and Crawley, M. C. (1995). New Zealand fur-seal *Arctocephalus forsteri* (Lesson, 1828). In *The mammals of Australia*. Strahan, R. (ed.). Reed Books, Chatswood, pp. 675-7.

Goldsworthy, S. D. and Shaughnessy, P. D. (1989). Subantarctic fur-seals *Arctocephalus tropicalis* at Heard Island. *Polar Biology* 9: 337-9.

Goldsworthy, S. D. and Shaughnessy, P. D. (1994). Breeding biology and haul-out pattern of the New Zealand fur-seal, *Arctocephalus forsteri*, at Cape Gantheaume, South Australia. *Wildlife Research* 21: 365-76.

Goldsworthy, S. D. and Shaughnessy, P. D. (1995a). Subantarctic fur-seal *Arctocephalus tropicalis* (Gray, 1872). In *The mammals of Australia*. Strahan, R. (ed.). Reed Books, Chatswood, pp. 683-4.

Goldsworthy, S. D. and Shaughnessy, P. D. (1995b). Antarctic fur-seal *Arctocephalus gazella* (Peters, 1875). In *The mammals of Australia.* Strahan, R. (ed.). Reed Books, Chatswood, pp. 678-80.

Goldsworthy, S. D., Pemberton, D. and Warneke, R. M. (1997). Field identification of Australian and New Zealand fur-seals *Arctocephalus* spp., based in external characters. In *Marine mammal research in the Southern Hemisphere*. Hindell, M. and Kemper, C. (eds). Surrey Beatty and Sons, Chipping Norton, Sydney, pp. 63-71.

Goldsworthy, S. D., Wynen, L., Robinson, S. and Shaughnessy, P. D. (1998). The population status and hybridisation of three sympatric fur-seal species (*Arctocephalus* spp.) at Macquarie Island. Abstract, VII SCAR International Biology Symposium. *New Zealand Natural Sciences* 23 Supplement: 68.

Gray, D. (1991). Combating oil pollution of the sea. *Search* 22: 285-6.

Green, B., Fogerty, A., Libke, J., Newgrain, K. and Shaughnessy, P. (1993). Aspects of lactation in the crab-eater seal *(Lobodon carcinophagus)*. *Australian Journal of Zoology* 41: 203-13.

Green, K. and Burton, H. R. (1987). Seasonal and geographical variation in the food of Weddell seals, *Leptonychotes weddellii*, in Antarctica. *Australian Wildlife Research* 14: 475-89.

Green, K. and Burton, H. R. (1993). Comparison of the stomach contents of southern elephant seals, *Mirounga leonina*, at Macquarie and Heard Islands. *Marine Mammal Science* 9: 10-22.

Green, K. and Williams, R. (1986). Observations on food remains in faeces of elephant, leopard and crab-eater seals. *Polar Biology* 6: 43-5.

Green, K., Burton, H. R. and Watts, D. J. (1995). Studies of the Weddell seal in the Vestfold Hills, East Antarctica. *ANARE Research Notes* 93: 1-64.

Green, K., Burton, H. R. and Williams, R. (1989). The diet of Antarctic fur-seals *Arctocephalus gazella* (Peters) during the breeding season at Heard Island. *Antarctic Science* 1: 317-24.

Green, K., Williams, R. and Burton, H. R. (1991). The diet of Antarctic fur-seals during the late autumn and early winter around Heard Island. *Antarctic Science* 3: 359-61.

Green, K., Williams, R., Handasyde, K. A., Burton, H. R. and Shaughnessy, P. D. (1990). Interspecific and intraspecific differences in the diets of fur-seals, *Arctocephalus* species (Pinnipedia: Otariidae), at Macquarie Island. *Australian Mammalogy* 13: 193-200.

Gwynn, A. M. (1953). The status of the leopard seal at Heard Island and Macquarie Island, 1948-1950. *A.N.A.R.E. Interim Reports* 3: 1-33.

Haebler, R. (1992). Disease risk to wildlife following reintroduction. In *Proceedings joint conference of the American Association of Zoo Veterinarians and the American Association of Wildlife Veterinarians.* Junge, R. E. (ed.). Oakland, p. 12.

Hamilton, J. E. (1939). A second report on the southern sea-lion, *Otaria byronia* (de Blainville). *Discovery Reports* 19: 121-64.

Harvey Johnston, T. and Mawson, P. M. (1945). Parasitic nematodes. *British Australian New Zealand Antarctic Research Expedition, 1929-1931, Reports Series B* 5: 73-160.

Harwood, J. and Hall, A. (1990). Mass mortality in marine mammals: its implications for population dynamics and genetics. *Trends in Ecology and Evolution* 5: 254-7.

Harwood, J. and Prime, J. H. (1978). Some factors affecting the size of British grey seal populations. *Journal of Applied Ecology* 15: 401-11.

Harwood, J. and Rohani, P. (1996). The population biology of marine mammals. In *Frontiers of population ecology.* Floyd, R. B., Sheppard, A. W. and De Barro, P. J. (eds). CSIRO Publishing, Melbourne, pp. 173-90.

Haynes-Lovell, K. (1994). *The incidental stranding of pinnipeds on the far northern New South Wales and southern Queensland coasts.* Australian Mammal Society: 1994 marine mammal symposium, p. 19 (Abstract and poster).

Heide-Jorgensen, M.-P., Harkonen, T., Dietz, R. and Thompson, P. M. (1992). Retrospective of the 1988 European seal epizootic. *Diseases of Aquatic Organisms* 13: 37-62.

Helle, E., Olsson, M. and Jensen, S. (1976). PCB levels correlate with pathological changes in seal uteri. *Ambio* 5: 261-3.

Hicks, B. D. and Worthy, G. A. J. (1987). Sealpox in captive grey seals (*Halichoerus grypus*) and their handlers. *Journal of Wildlife Diseases* 23: 1-6.

Higgins, L. V. (1990). *Reproductive behavior and maternal investment of Australian sea-lions.* PhD thesis, University of California, Santa Cruz, 126 pp.

Higgins, L. V. (1993). The nonannual, nonseasonal breeding cycle of the Australian sea-lion, *Neophoca cinerea*. *Journal of Mammalogy* 74: 270-4.

Higgins, L. V. and Gass, L. (1993). Birth to weaning: parturition, duration of lactation, and attendance cycles of Australian sea-lions (*Neophoca cinerea)*. *Canadian Journal of Zoology* 71: 2047-55.

Higgins, L. V. and Tedman, R. A. (1990). Effect of attacks by male Australian sea-lions, *Neophoca cinerea*, on mortality of pups. *Journal of Mammalogy* 71: 617-9.

Hindell, M. A. (1991). Some life-history parameters of a declining population of southern elephant seals, *Mirounga leonina*. *Journal of Animal Ecology* 60: 119-34.

Hindell, M. A. and Burton, H. R. (1987). Past and present status of the southern elephant seal (*Mirounga leonina*) at Macquarie Island. *Journal of Zoology, London* 213: 365-80.

Hindell, M. A. and Pemberton, D. (1997). Successful use of a translocation program to investigate diving behavior in a male Australian fur-seal, *Arctocephalus pusillus doriferus*. *Marine Mammal Science* 13: 219-28.

Hindell, M. A. and Slip, D. J. (1997). The importance of being fat: maternal expenditure in the southern elephant seal *Mirounga leonina*. In *Marine mammal research in the Southern Hemisphere*. Hindell, M. and Kemper, C. (eds). Surrey Beatty and Sons, Chipping Norton, Sydney, pp. 72-7.

Hindell, M. A., Burton, H. R. and Slip, D. J. (1991). Foraging areas of southern elephant seals, *Mirounga leonina*, as inferred from water temperature data. *Australian Journal of Marine and Freshwater Research* 42: 115-28.

Hindell, M. A., Slip, D. J. and Burton, H. R. (1994). Possible causes of the decline of southern elephant seal populations in the southern Pacific and southern Indian Oceans. In *Elephant seals: population ecology, behavior, and physiology.* Le Boeuf, B. J. and Laws, R. M. (eds). University of California Press, Berkeley, pp. 66-84.

Hofman, R. J. (1979). Leopard seal. In *Mammals in the seas. Vol II. Pinniped Species Summaries and Report on Sirenians.* FAO Fisheries Series No. 5, Food and Agriculture Organization, Rome, pp. 125-9.

Hofmeyr, G. J. G., Bester, M. N. and Jonker, F. C. (1997). Changes in population sizes and distribution of fur-seals at Marion Island. *Polar Biology* 17: 150-8.

House of Representatives Standing Committee on Transport, Communications and Infrastructure (1992). *Ships of shame: inquiry into ship safety.* AGPS, Canberra, 157 pp.

ICES (1994). *Report of the ICES workshop on the distribution and sources of pathogens in marine mammals.* ICES CM 1994/N:2 (cited by Harwood and Rohani 1996).

Ingham, S. E. (1960). The status of seals (Pinnipedia) at Australian Antarctic stations. *Mammalia* 24: 422-30.

Irvine, A., Bryden, M. M., Corkeron, P. J. and Warneke, R. M. (1997). A census of fur-seals at Montagu Island, New South Wales In *Marine mammal research in the Southern Hemisphere.* Hindell, M. and Kemper, C. (eds). Surrey Beatty and Sons, Chipping Norton, Sydney, pp. 56-62.

IUCN (1987). *The IUCN position statement on translocation of living organisms: introductions, re-introductions and re-stocking.* IUCN - The World Conservation Union, Gland, Switzerland, 20 pp.

IUCN (1993). *1994 IUCN red list of threatened animals.* B. Groombridge (ed.). IUCN - The World Conservation Union, Gland, Switzerland, 286 pp.

IUCN (1994). *IUCN red list categories.* IUCN - The World Conservation Union, Gland, Switzerland, 21 pp.

IUCN (1998). *Guidelines for re-introductions.* IUCN/SSC Re-introduction Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK, 10pp.

Iverson, S. J. (1993). Milk secretion in marine mammals in relation to foraging: can milk fatty acids predict diet? *Symposium of the Zoological Society of London* 66: 263-91.

Jacka, T. H. (1983). A computer data base for Antarctic sea ice extent. *ANARE Research Notes* 13: 1-54.

Johnstone, G. W. (1982). Zoology. In *Expedition to the Australian Territory of Heard Island and McDonald Islands 1980.* Veenstra, C. and Manning, J. (compilers). Division of National Mapping Technical Report 31, pp. 33-9.

Jones, M. M. (1994). *Fishing debris in the Australian marine environment.* Bureau of Resource Sciences, Canberra, 39 pp.

Kennedy, M. (ed.) (1990a). *Australia's endangered species: the extinction dilemma.* Simon and Schuster, Brookvale, Sydney, 192 pp.

Kennedy, S. (1990b). A review of the 1988 European seal morbillivirus epizootic. *Veterinary Record* 127: 563-7.

Kerley, G. I. H. (1985). Pup growth in the fur-seals *Arctocephalus tropicalis* and *A. gazella* at Marion Island. *Journal of Zoology, London* 205: 315-24.

Kerry, K. R., Shaughnessy, P., Chittleborough, R. G. and Ensor, P. (1987). *Distribution of breeding crab-eater seals in the Indian Ocean sector of the Antarctic.* Australasian Marine Mammal Symposium, Sydney, August 1987. (Abstract).

Keyes, M. C. (1965). Pathology of the northern fur-seal. *Journal of the American Veterinary Medical Association* 147: 1090-5.

King J. E. (1959). A note on the specific name of the Kerguelen fur-seal. *Mammalia* 23: 381.

King, J. E. (1969). The identity of the fur-seals of Australia. *Australian Journal of Zoology* 17: 841-53.

King, J. E. (1976). On the identity of three young fur-seals (genus *Arctocephalus*) stranded in New Caledonia (Mammalia: Pinnipedia). *Beaufortia* 25: 97-105.

King, J. E. (1983). *Seals of the world.* British Museum (Natural History), London 2nd ed., 240 pp.

King, J. B. and Marlow, B. J. (1979). Australian sea-lion. In *Mammals in the seas. Vol II. Pinniped Species Summaries and Report on Sirenians.* FAO Fisheries Series No. 5, Food and Agriculture Organization, Rome, pp. 13-5.

Kirkwood, R., Pemberton, D. and Copson, G. (1992). *The conservation and management of seals in Tasmania.* Unpublished report, Department of Parks, Wildlife and Heritage, Hobart, 48 pp.

Kooyman, G. L. (1981). *Weddell seal, consumate diver.* Cambridge University Press, Cambridge, x + 135pp.

Lavigne, D. M. and Schmitz, O. J. (1990). Global warming and increasing population densities: a prescription for seal plagues. *Marine Pollution Bulletin* 21: 280-4.

Laws, R. M. (1979a). Southern elephant seal. In *Mammals in the seas. Vol II. Pinniped Species Summaries and Report on Sirenians.* FAO Fisheries Series No. 5, Food and Agriculture Organization, Rome, pp. 106-9.

Laws, R. M. (1979b). Crab-eater seal. In *Mammals in the seas. Vol II. Pinniped Species Summaries and Report on Sirenians.* FAO Fisheries Series No. 5, Food and Agriculture Organization, Rome, pp. 115-9.

Laws, R. M. (1984). Seals. In *Antarctic ecology.* Laws, R. M. (ed.). Academic Press, London., vol. 2: 621-715.

Laws, R. M. and Hofman, R. J. (1979). Ross seal. In *Mammals in the seas. Vol II. Pinniped Species Summaries and Report on Sirenians.* FAO Fisheries Series No. 5, Food and Agriculture Organization, Rome, pp. 120-4.

Laws, R. M. and Taylor, R. J. F. (1957). A mass dying of crab-eater seals, *Lobodon carcinophagus* (Gray). *Proceedings of the Zoological Society of London* 129: 315-24.

Le Boeuf, B. J. (1991). Pinniped mating systems on land, ice and in the water: emphasis on the Phocidae. In *The behaviour of pinnipeds.* Renouf, D.(ed.). Chapman and Hall, London, pp. 45-65.

Lento, G. M., Haddon, M., Chambers, G. K. and Baker, C. S. (1997). Genetic variation of Southern Hemisphere fur-seals (*Arctocephalus* spp.): investigation of population structure and species identity. *Journal of Heredity* 88: 202-208.

Lento, G. M., Mattlin, R. H., Chambers, G. K. and Baker, C. S. (1994). Geographic distribution of mitochondrial cytochrome *b* DNA haplotypes in New Zealand fur-seals (*Arctocephalus forsteri*). *Canadian Journal of Zoology* 72: 293-9.

Ling, J. K. (1987). New Zealand fur-seal, *Arctocephalus forsteri,* (Lesson), in South Australia. *NOAA Technical Report NMFS* 51: 53-5.

Ling, J. K. (1992). *Neophoca cinerea. Mammalian Species* 392: 1-7.

Ling, J. K. and Walker, G. E. (1978). An 18-month breeding cycle in the Australian sea-lion? *Search* 9: 464-5.

Ling, J. K. and Walker, G. E. (1979). Seal studies in South Australia: progress report for the period April 1977 to July 1979. *South Australian Naturalist* 54: 68-78.

Llewellyn, L., Ellis, M., Martin, J. and Ferguson, A. (1994). *Atlas of New South Wales wildlife: marine mammals and reptiles.* New South Wales National Parks and Wildlife Service, Hurstville, 26 pp.

Malik, S., Wilson, P. J., Smith, R. J., Lavigne, D. M. and White, B. N. (1997). Pinniped penises in trade: a molecular-genetic investigation. *Conservation Biology* 11: 1365-74.

Marine Parks and Reserves Selection Working Group (1994). *A representative marine reserve system for Western Australia: report of the Marine Parks and Reserves Selection Working Group.* Department of Conservation and Land Management, Como, 222 pp.

Mattlin, R. H., Gales, N. J. and Costa, D. P. (1998). Seasonal dive behaviour of lactating New Zealand fur-seals (*Arctocephalus forsteri*). *Canadian Journal of Zoology* 76: 350-60.

Mawson, P.R. and Coughran, D. K. (in prep.). Management of sick, injured and dead pinnipeds in Western Australia 1980-1996.

McCann, T. S. and Doidge, D. W. (1987). Antarctic fur-seal, *Arctocephalus gazella. NOAA Technical Report NMFS* 51: 5-8.

McCauley, R. D. (1994). Seismic surveys. In *Environmental implications of offshore oil and gas development in Australia.* Swan, J. M., Neff, J. M. and Young, P. C. (eds). Australian Petroleum Exploration Association, Sydney, pp. 19-121.

McNally, J. and Lynch, D. D. (1954). *Notes on the food of Victorian seals.* Unpublished report, Office of the Director of Fisheries and Game, Melbourne, Fauna Report No. 1, 16 pp.

Micco, H. M. (1971). *King Island and the sealing trade 1802. A translation of Chapters XXII and XXIII of the narrative by Francois Péron published in the official account of the voyage of discovery to the southern lands undertaken in the Corvettes* Le Géographe, Le Naturaliste *and the schooner* Casuarina, *during the years 1800 to 1804, under the command of Captain Nicolas Baudin.* Roebuck, Canberra, 51 pp.

Murray, M. D. (1981). The breeding of the southern elephant seal, *Mirounga leonina* L, on the Antarctic continent. *Polar Record* 20: 370-1.

Nordøy, E. S., Folkow, L. and Blix, A. S. (1995). Distribution and diving behaviour of crab-eater seals (*Lobodon carcinophagus*) off Queen Maud Land. *Polar Biology* 15: 261-8.

Norman, R. J. de B. (1996). Disease in free-living Australian seals: an examination of the knowledge gulf. In *Proceedings of the 1995 conference of the Australian Association of Veterinary Conservation Biologists.* Phelps, G. R. (ed.). Australian Association of Veterinary Conservation Biologists, Sydney, pp. 41-50.

Olsen, O. W. and Lyons, E. T. (1965). Life cycle of *Uncinaria lucasi* Stiles, 1901 (Nematoda: Ancylostomatidae) of fur-seals, *Callorhinus ursinus* Linn., on the Pribilof Islands, Alaska. *Journal of Parasitology* 51: 689-700.

Øritsland, T. (1970). Sealing and seal research in the south-west Atlantic pack ice, Sept. - Oct. 1964. In *Antarctic ecology.* Holdgate, M. W. (ed.). Academic Press, London, vol. 1, pp 367-76.

Øritsland, T. (1977). Food consumption of seals in the Antarctic pack ice. In *Adaptations within Antarctic ecosystems.* Llano, G. A. (ed.). Smithsonian Institution, Washington DC, pp. 749-68.

Pemberton, D. (1989). *The interaction between seals and fish farms in Tasmania.* Unpublished report, Department of Lands, Parks and Wildlife, Hobart, 96 pp.

Pemberton, D. (1996a). *Princess Melikoff Trust; marine mammal research report 1995-96.* Unpublished report, Parks and Wildlife Service, Hobart.

Pemberton, D. (1996b). *Port Lincoln tuna farms; dolphins, seals, sharks and seabirds.* Unpublished report, Parks and Wildlife Service, Hobart, 8 pp.

Pemberton, D. and Kirkwood, R. J. (1994). Pup production and distribution of the Australian fur-seal, *Arctocephalus pusillus doriferus,* in Tasmania. *Wildlife Research* 21: 341-52.

Pemberton, D. and Shaughnessy, P. D. (1993). Interaction between seals and marine fish-farms in Tasmania, and management of the problem. *Aquatic Conservation* 3: 149-58.

Pemberton, D. and Skira, I. J. (1989). Elephant seals in Tasmania. *Victorian Naturalist* 106: 202-4.

Pemberton, D., Brothers, N. P. and Kirkwood R. (1992). Entanglement of Australian fur-seals in man-made debris in Tasmanian waters. *Wildlife Research* 19: 151-9.

Prendergast, R. (1994). The rehabilitation of leopard seals. *Zoo News* 14: 8-9.

Prendergast, R. and Johnson, S. (1996). Plastic pollution and the Australian fur-seal *(Arctocephalus pusillus doriferus*): research and public education. In *Proceedings of the ARAZPA/ASZK conference, Perth, Western Australia, April 1995.* Read, E. (ed.). Perth Zoo, Perth, pp. 148-55.

Punt, A. E. and Butterworth, D. S. (1995). The effects of future consumption by the Cape fur-seal on catches and catch rates of the Cape hakes. 4. Modelling the biological interaction between Cape fur-seals *Arctocephalus pusillus pusillus* and the Cape hakes *Merluccius capensis* and *M. paradoxus. South African Journal of Marine Science* 16: 255-85.

Reddacliff, G. and Lim, L. (1990). *Infectious disease monitoring in captive and wild pinnipeds (with particular reference to tuberculosis).* Final report: Project No. 8889/23. Australian National Parks and Wildlife Service, Canberra, 36 + xvii pp.

Reijnders, P. J. H. (1986). Reproductive failure in common seals feeding on fish from polluted coastal waters. *Nature* 324: 456-7.

Reijnders, P., Brasseur, S., van der Toorn, J., van der Wolf, P., Boyd, I., Harwood, J, Lavigne, D. and Lowry, L. (1993). *Status survey and conservation action plan: seals, fur-seals, sea-lions, and walrus.* IUCN, Gland, Switzerland, 88 pp.

Repenning, C. A., Peterson, R. S. and Hubbs, C. L. (1971). Contributions to the systematics of the southern fur-seals, with particular reference to the Juan Fernández and Guadalupe species. In *Antarctic pinnipedia.* Burt, W. H. (ed.). American Geophysical Union, Washington DC, pp. 1-34.

Ridgway, S. H. and Harrison, R. J. (eds) (1981a). *Handbook of marine mammals; the walrus, sea-lions, fur-seals and sea otter.* Academic Press, London, vol. 1, 235 pp.

Ridgway, S. H. and Harrison, R. J. (eds) (1981b). *Handbook of marine mammals; seals.* Academic Press, London, vol. 2, 359 pp.

Robinson, A. C. and Dennis, T. E. (1988). The status and management of seal populations in South Australia. In *Marine mammals of Australasia - field biology and captive management.* Augee, M. L. (ed.). Royal Zoological Society of NSW, Sydney, pp. 87-104.

Robinson, A. J. and Kerr, P. J. (in press). Poxvirus infections of wild mammals. In *Infectious diseases of wild mammals*, 3rd edition. Williams, B., Barker, I. and Thorn, T. (eds). Iowa State University Press, Ames, Iowa.

Rodahl, K. (1943). Notes on the prevention and treatment of "spekk finger". *Polar Record* 4: 17-8.

Rogers, T. L., Cato, D. H. and Bryden, M. M. (1996). Behavioral significance of underwater vocalizations of captive leopard seals, *Hydrurga leptonyx. Marine Mammal Science* 12: 414-27.

Rounsevell, D. (1988). Periodic irruptions of itinerant leopard seals within the Australasian sector of the Southern Ocean, 1976-86. *Papers and Proceedings of the Royal Society of Tasmania* 122: 189-91.

Rounsevell, D. and Eberhard, I. (1980). Leopard seals, *Hydrurga leptonyx* (Pinnipedia), at Macquarie Island from 1949 to 1979. *Australian Wildlife Research* 7: 403-15.

Rounsevell, D. and Pemberton, D. (1994). The status and seasonal occurrence of leopard seals, *Hydrurga leptonyx,* in Tasmanian waters. *Australian Mammalogy* 17: 97-102.

SCAR (1993). Twenty-second meeting of SCAR: San Carlos de Bariloche, Argentina, 15-19 June 1992. *SCAR Bulletin* 108: 1-9.

Scott, J. (1994). *Marine conservation at Macquarie Island: a marine conservation strategy and an account of the marine environment.* Parks and Wildlife Service, Hobart, 141 pp.

Seal, U. S., Erickson, A. W., Siniff, D. B. and Hofman, R. J. (1971). Biochemical, population genetic, phylogenetic and cytological studies of Antarctic seal species. In *Symposium on Antarctic ice and water masses.* Deacon, G. (ed.). SCAR, Cambridge, pp. 77-95.

Serventy, V. N. (1953). The Archipelago of the Recherche, Part 4: Mammals. *Australian Geographical Society Reports* 1: 40-8.

Shaughnessy, P. D. (1969). Transferrin polymorphism and population structure of the Weddell seal *Leptonychotes weddelli* (Lesson). *Australian Journal of Biological Sciences* 22: 1581-4.

Shaughnessy, P. D. (1991). *Status report on true seals (Phocidae) in Australia and the Southern Ocean.* Prepared for the Australian National Parks and Wildlife Service, Endangered Species Program, 16 pp.

Shaughnessy, P. D. (1992). New mammals recognised for Australia - Antarctic and Subantarctic fur-seals *Arctocephalus* species. *Australian Mammalogy* 15: 77-80.

Shaughnessy, P. (1994). *Increases in some Australian marine mammal populations.* Australasian Wildlife Management Society, 7th Annual Conference, Alice Springs, December 1994, Abstract, p. 17.

Shaughnessy, P. D. (1995). *Abundance of New Zealand fur-seal* Arctocephalus forsteri *pups at Cape Gantheaume and Cape du Couedic colonies, Kangaroo Island, South Australia in 1994/1995.* Report to South Australian National Parks and Wildlife Service, 48 pp.

Shaughnessy, P. D. (1997). *Abundance of New Zealand fur-seals* Arctocephalus forsteri *at some colonies in South Australia, 1995/96.* Report to South Australian National Parks and Wildlife Service, Department of Environment and Natural Resources, 41 pp.

Shaughnessy, P. D. and Burton, H. R. (1986). fur-seals *Arctocephalus* spp. at Mawson Station, Antarctica, and in the Southern Ocean. *Polar Record* 23: 79-81.

Shaughnessy, P. D. and Davenport, S. R. (1996). Underwater videographic observations and incidental mortality of fur-seals around fishing equipment in south-eastern Australia. *Marine and Freshwater Research* 47: 553-6.

Shaughnessy, P. D. and Fletcher, L. (1987). fur-seals, *Arctocephalus* spp., at Macquarie Island. *NOAA Technical Report NMFS* 51: 177-88.

Shaughnessy, P. D. and Goldsworthy, S. D. (1990). Population size and breeding season of the Antarctic fur-seal *Arctocephalus gazella* at Heard Island - 1987/88. *Marine Mammal Science* 6: 292-304.

Shaughnessy, P. and Goldsworthy, S. (1993). Feeding ecology of southern fur-seals (*Arctocephalus* spp.) and their management at Heard and Macquarie Islands. *Proceedings of the National Institute of Polar Research Symposium on Polar Biology, Japan* 6:173-5.

Shaughnessy, P. D. and Kerry, K. R. (1989). Crab-eater seals *Lobodon carcinophagus* during the breeding season: observations on five groups near Enderby Land, Antarctica. *Marine Mammal Science* 5: 68-77.

Shaughnessy, P., Dennis, T. and Seager, P. (1997). *Abundance, seasonality of breeding and rate of entanglement of Australian sea-lions* (Neophoca cinerea) *at colonies on the west coast of South Australia.* Report to Environment Australia, Biodiversity Group, 18 + xii pp.

Shaughnessy, P. D., Goldsworthy, S. D. and Libke, J. A. (1995a). Changes in the abundance of New Zealand fur-seals, *Arctocephalus forsteri,* on Kangaroo Island, South Australia. *Wildlife Research* 22: 201-15.

Shaughnessy, P. D., Shaughnessy, G. L. and Fletcher, L. (1988a). Recovery of the fur-seal population at Macquarie Island. *Papers and Proceedings of the Royal Society of Tasmania* 122: 177-87.

Shaughnessy, P. D., Shaughnessy, G. L. and Keage, P. L. (1988b). Fur-seals at Heard Island: recovery from past exploitation? In *Marine Mammals of Australasia - field biology and captive management.* Augee, M. L. (ed.). Royal Zoological Society of NSW, Sydney, pp. 71-7.

Shaughnessy, P. D., Stirling, I. and Dennis, T. E. (1996). Changes in the abundance of New Zealand fur-seals, *Arctocephalus forsteri,* on the Neptune Islands, South Australia. *Wildlife Research* 23: 697-709.

Shaughnessy, P. D, Testa, J. W. and Warneke, R. M. (1995b). Abundance of Australian fur-seal pups, *Arctocephalus pusillus doriferus,* at Seal Rocks, Victoria, 1991-92 from Petersen and Bayesian estimators. *Wildlife Research* 22: 625-32.

Shaughnessy, P. D., Gales, N. J., Dennis, T. E. and Goldsworthy, S. D. (1994). Distribution and abundance of New Zealand fur-seals, *Arctocephalus forsteri,* in South Australia and Western Australia. *Wildlife Research* 21: 667-95.

Shaughnessy, P. D., Semmelink, A., Cooper, J. and Frost, P. G. H. (1981). Attempts to develop acoustic methods of keeping Cape fur-seals *Arctocephalus pusillus* from fishing nets. *Biological Conservation* 21: 141-58.

Shomura, R. S. and Yoshida, H. O. (eds) (1985). Proceedings of the workshop on the fate and impact of marine debris. *NOAA Technical Memorandum NMFS SWFC* 54: 580 pp.

Siniff, D. B. and Bengtson, J. L. (1977). Observations and hypotheses concerning the interactions among crab-eater seals, leopard seals, and killer whales. *Journal of Mammalogy* 58: 414-6.

Siniff, D. B. and Stone, S. (1985). The role of the leopard seal in the tropho-dynamics of the Antarctic marine ecosystem. In *Antarctic nutrient cycles and food webs.* Siegfried, W. R., Condy, P. R. and Laws, R. M. (eds). Springer-Verlag, Berlin, pp. 555-60.

Skinner, J. D. and Klages, N. T. W. (1994). On some aspects of the biology of the Ross seal *Ommatophoca rossii* from King Haakon VII Sea, Antarctica. *Polar Biology* 14: 467-72.

Skinner, J. D. and Westlin-van Aarde, L. (1989). Aspects of reproduction in female Ross seals (*Ommatophoca rossii). Journal of Reproduction and Fertility* 87: 67-72.

Slip, D. J. (1995). The diet of southern elephant seals (*Mirounga leonina*) from Heard Island. *Canadian Journal of Zoology* 73: 1519-28.

Slip, D. J., Hindell, M. A. and Burton, H. R. (1994a). Diving behavior of southern elephant seals from Macquarie Island: an overview. In *Elephant seals: population ecology, behavior, and physiology.* Le Boeuf, B. J. and Laws, R. M (eds). University of California Press, Berkeley, pp. 253-70.

Slip, D. J., Green, K., Burton, H. R., Mitchell, P. J and Adams, M. (1994b). Allozyme variation in the leopard seal, *Hydrurga leptonyx. Australian Mammalogy* 17: 1-5.

Smith, A. W. and Boyt, P. M. (1990). Caliciviruses of ocean origin: a review. *Journal of Zoo and Wildlife Medicine* 21: 3-23.

Smith, P. (1997). *Management manual for marine mammals in NSW.* New South Wales National Parks and Wildlife Service, Hurstville, 98 pp. + 5 appendices.

Smith, R. I. L. (1988). Destruction of Antarctic terrestrial ecosystems by a rapidly increasing fur-seal population. *Biological Conservation* 45: 55-72.

Spielman, D. (1994). Marine mammals stranding. In *Wildlife; The T. G. Hungerford refresher course for veterinarians.* University of Sydney Post-Graduate Committee in Veterinary Science, Sydney. Proceedings 233, pp 299-335.

Stamation, K. (1996). *Assessment of an Australian fur-seal* (Arctocephalus pusillus doriferus) *colony and seal watching activities at Cape Bridgewater, Victoria.* B. Sc. (Hons) thesis, Deakin University, Warrnambool, 50 + lii pp.

St Aubin, D. J. (1990). Physiologic and toxic effects on pinnipeds. In *Sea mammals and oil: confronting the risks.* Geraci, J. R. and St Aubin, D. J. (eds). Academic Press,. San Diego, pp. 103-27.

St Aubin, D. J., Geraci, J. R. and Lounsbury, V. J. (1996). Rescue, rehabilitation, and release of marine mammals: an analysis of current views and practices. Proceedings of a workshop held in Des Plaines, Illinois, 3-5 December 1991. *NOAA Technical Memorandum NMFS OPR* 8: 65 pp.

Stirling, I. (1969). Tooth wear as a mortality factor in the Weddell seal, *Leptonychotes weddelli. Journal of Mammalogy* 50: 559-65.

Stirling, I. (1971). Population aspects of Weddell seal harvesting at McMurdo Sound, Antarctica. *Polar Record* 15: 653-67.

Stockton, J. (1982). Seals in Tasmanian prehistory. *Proceedings of the Royal Society of Victoria* 94: 53-60.

Strahan, R. (ed.). (1995). *The mammals of Australia.* Reed Books, Chatswood, 756 pp.

Sweeney, J. (1978). Infectious diseases of body systems. In *Zoo and wild animal medicine.* Fowler, M. E. (ed.). W. B. Saunders, Philadelphia, pp. 589-92.

Task Force (1996). *Report of Gulf of Maine Aquaculture-pinniped Interaction Task Force.* Unpublished report submitted to National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland. 69 pp.

Taylor, R. H. (1992). New Zealand fur-seals at the Antipodes Islands. *Journal of the Royal Society of New Zealand* 22: 107-22.

Testa, J. W. and Siniff, D. B. (1987). Population dynamics of Weddell seals *(Leptonychotes weddelli)* in McMurdo Sound, Antarctica. *Ecological Monographs* 57: 149-65.

Testa, J. W., Oehlert, G., Ainley, D. G., Bengtson, J. L., Siniff, D. B., Laws, R. M. and Rounsevell, D. (1991). Temporal variability in Antarctic marine ecosystems: periodic fluctuations in the phocid seals. *Canadian Journal of Fisheries and Aquatic Science* 48: 631-9.

Testa, J. W., Siniff, D. B., Croxall, J. P. and Burton, H. R. (1990). A comparison of reproductive parameters among three populations of Weddell seals *(Leptonychotes weddellii*). *Journal of Animal Ecology* 59: 1165-75.

Thompson, P. J., Cousins, D. V., Gow, B. L., Collins, D. M., Williamson, B. H. and Dagnia, H. T. (1993). Seals, seal trainers, and mycobacterial infection. *American Review of Respiratory Diseases* 147: 164-7.

Tierney, T. J. (1977). Disease and injury in the southern elephant seal. *Australian Veterinary Journal* 53: 91-2.

Tikhomirov, E. A. (1975). Biology of the ice forms of seals in the Pacific section of the Antarctic. *Rapports et Procès-Verbaux des Réunions Conseil International pour l'Exploration de la Mer* 169: 409-12.

Tynan, C. (1996). Characterization of oceanographic habitat of cetaceans in the southern Indian Ocean between 82° - 115° E: cruise report from World Ocean Circulation Experiment (WOCE) 18S and 19S. *NOAA Technical Memorandum NMFS-AFSC* 64: 53 pp.

UNEP (1992). *Marine mammal/fisheries interactions: analysis of cull proposals.* Report of the meeting of the Scientific Advisory Committee of the Marine Mammals Action Plan. United Nations Environment Programme, Liege, Belgium, 30 pp.

Vedros, N. A., Smith, A. W., Schoenewald, J., Migaki, G. and Hubbard, R. C. (1971). Leptospirosis epizootic among California sea-lions. *Science* 172: 1250-1.

Viggers, K. L., Lindenmayer, D. B. and Spratt, D. M. (1993). The importance of disease in reintroduction programmes. *Wildlife Research* 20: 687-98.

Volkman, J. K., Miller, G. J., Revill, A. T. and Connell, D. W. (1994). Oil spills. In *Environmental implications of offshore oil and gas development in Australia.* Swan, J. M., Neff, J. M. and Young, P. C. (eds). Australian Petroleum Exploration Association, Sydney, pp. 509-695.

Walker, G. E., and Ling, J. K. (1981). Australian sea-lion *Neophoca cinerea* (Péron, 1816). In *Handbook of marine mammals; the walrus, sea-lions, fur-seals and sea otter.* Ridgway, S. H. and Harrison, R. J. (eds). Academic Press, London, vol. 1, pp. 99-118.

Warneke, R. M. (1966). Seals of Westernport. *Victoria's Resources* 8: 44-6.

Warneke, R. M. (1975). Dispersal and mortality of juvenile fur-seals *Arctocephalus pusillus doriferus* in Bass Strait, southeastern Australia. *Rapports et Procès-Verbaux des Réunions Conseil International pour l'Exploration de la Mer* 169: 296-302.

Warneke, R. M. (1982). The distribution and abundance of seals in the Australasian region, with summaries of biology and current research. In *Mammals in the seas, Vol. IV. Small Cetaceans, Seals, Sirenians and Otters.* FAO Fisheries Series No. 5, Food and Agriculture Organization, Rome, pp. 431-75.

Warneke, R. M. (1988). *Report on an aerial survey of Australian fur-seal sites in Victoria and Tasmania during the 1986 breeding season.* Report to Australian National Parks and Wildlife Service, July 1988, 17 + xvii pp.

Warneke, R. M. (1995a). Australian fur-seal *Arctocephalus pusillus* (Schreber, 1775). In *The mammals of Australia.* Strahan, R. (ed.). Reed Books, Chatswood, pp. 680-2.

Warneke, R. M. (1995b). Family Otariidae. In *Mammals of Victoria; distribution, ecology and conservation.* Menkhorst, P. W. (ed.). Oxford University Press, Melbourne, pp. 244-50.

Warneke, R. M. (1995c). Family Phocidae. In *Mammals of Victoria; distribution, ecology and conservation.* Menkhorst, P. W. (ed.). Oxford University Press, Melbourne, pp. 251-6.

Warneke, R. M. and Shaughnessy, P. D. (1985). *Arctocephalus pusillus*, the South African and Australian fur-seal: taxonomy, evolution, biogeography, and life history. In *Studies of sea mammals in south latitudes.* Ling, J. K. and Bryden, M. M. (eds). South Australian Museum, Adelaide, pp. 53-77.

Webster, R. G., Geraci, J., Petursson, G. and Skirnisson, K. (1981). Conjunctivitis in human beings caused by influenza A virus of seals. *New England Journal of Medicine* 304: 911.

Williams, R. and Ensor, P. H. (1988). Extensive research needed to assess fish resources around Heard Island. *Australian Fisheries* 47(2): 2-4.

Williams, R. and McEldowney, A. (1990). A guide to the fish otoliths from waters off the Australian Antarctic Territory, Heard and Macquarie Islands. *ANARE Research Notes* 75: 1-173.

Wood Jones, F. (1925a). The eared seals of South Australia. *Records of the South Australian Museum* 3: 9-16.

Wood Jones, F. (1925b). *The mammals of South Australia, part III.* Government Printer, Adelaide, pp. 271-458.

Woodley, T. H. and Lavigne, D. M. (1993). Potential effects of incidental mortalities on the Hooker's sea-lion (*Phocarctos hookeri*) population. *Aquatic Conservation* 3: 139-48.

Woods, R., Cousins, D. V., Kirkwood, R. and Obendorf, D. L. (1995). Tuberculosis in a wild Australian fur-seal (*Arctocephalus pusillus doriferus*) from Tasmania. *Journal of Wildlife Diseases* 31: 83-6.

Woods, R., Vogelnest, L., Phelps, G., Hulst, F., D'Ettore, A., Eyre, L., and Burton, H. (in prep.). Rehabilitation, release and post-release monitoring of an emaciated, vagrant southern elephant seal (*Mirounga leonina*).

Appendix I

Respondents and those concerned with the study and conservation of Australian seals

I.1 Respondents to the Draft Seal Action Plan

Kim Beasley, Royal Melbourne Zoological Gardens
Michael Bryden, University of Sydney
Geoff Copson, Tasmanian Parks and Wildlife Service, Department of Primary Industries, Water and Environment
Terry Dennis, Department of Environment, Heritage and Aboriginal Affairs, South Australia
Tony Flaherty, Marine and Coastal Community Network, South Australia
Nick Gales, Department of Conservation, New Zealand, and Department of Conservation and Land Management, Western Australia
Simon Goldsworthy, University of Tasmania
Hec Goodall, Pet Porpoise Pool, Coffs Harbour
Christine Hopkins, Australasian Species Management Program
J. D. Kelly, Zoological Parks Board of New South Wales
Max Kitchell, Department of Natural Resources and Environment, Victoria (now with Tasmanian Parks and Wildlife Service)
Leighton Llewellyn, New South Wales National Parks and Wildlife Service
Trevor Long, Sea World Enterprises
Katrina Maguire, Australian Fisheries Management Authority
William Meikle, Taronga Zoo
Keiran McNamara, Department of Conservation and Land Management, Western Australia
David Pemberton, Tasmanian Parks and Wildlife Service, Department of Primary Industries, Water and Environment
Sharon Pretty, Environment Australia, Biodiversity Group
Graham Ross, Environment Australia, Australian Biological Resources Study
David Rounsevell, Tasmanian Parks and Wildlife Service (now with Queensland Department of Environment and Heritage)
Irynej Skira, Tasmanian Parks and Wildlife Service
Robert Warneke, Warneke Marine Mammal Services
Sachi Wimmer, Australian Fisheries Management Authority

I.2 Bodies and individuals concerned with the biology, ecology and conservation of Australian seals

Government Agencies

Commonwealth

Australian Antarctic Division
Australian Fisheries Management Authority
Bureau of Resource Sciences
Environment Australia

State Nature Conservation Agencies

New South Wales	National Parks and Wildlife Service
Queensland	Department of Environment and Heritage
South Australia	National Parks and Wildlife, Department of Environment, Heritage and Aboriginal Affairs
Tasmania	Parks and Wildlife Service, Department of Primary Industries, Water and Environment
Victoria	Department of Natural Resources and Environment
Western Australia	Department of Conservation and Land Management

State Fisheries Agencies

New South Wales	New South Wales Fisheries
Queensland	Department of Primary Industries, Land Use and Fisheries
South Australia	Department of Primary Industries and Resources
Tasmania	Department of Primary Industries, Water and Environment
Victoria	Department of Natural Resources and Environment
Western Australia	Department of Fisheries

Other State Organisations

New South Wales	Australian Museum
South Australia	South Australian Museum
Tasmania	Queen Victoria Museum and Art Gallery, Launceston Tasmanian Museum and Art Gallery, Hobart
Victoria	Museum of Victoria
Western Australia	Western Australian Museum

Overseas Government Organisations

New Zealand	Department of Conservation, Wellington Museum of New Zealand, Wellington
USA	Marine Mammal Commission, Washington DC

Zoos and Aquaria

Adelaide Zoo
Coffs Harbour Pet Porpoise Pool, Coffs Harbour
Darling Harbour Aquarium, Sydney
Manly Ocean World, Sydney
Perth Zoo
Royal Melbourne Zoological Gardens, Melbourne
Sea World Enterprises, Surfers Paradise
Taronga Zoo, Sydney
Underwater World, Mooloolaba
Underwater World, Perth

Non-government Organisations

Australian Conservation Foundation
Australasian Regional Association of Zoological Parks and Aquaria:
- Aquatic Specialist Group
- Australasian Species Management Program (ASMP)
- ASMP, Pinniped Taxon Advisory Group (TAG)

Organisation for the Research and Rescue of Cetaceans in Australia (ORRCA)
Scientific Committee on Antarctic Research (SCAR), Group of Specialists on Seals
World Wide Fund for Nature (WWF)

Universities

Australian National University
Macquarie University
Monash University
Murdoch University
University of Melbourne
University of Otago (NZ)
University of Sydney
University of Tasmania
University of Western Australia

Individuals

Allen, R., SA Department of Environment, Heritage and Aboriginal Affairs, Port Lincoln
Anderson, G. R. V., Environment Australia, Portfolio Marine Group
Arnould, J., Macquarie University
Backhouse, G., Victoria Department of Natural Resources and Environment
Beasley, K., Melbourne Zoo
Best, H., Department of Conservation, Wellington, New Zealand
Best, L., SA Department of Environment, Heritage and Aboriginal Affairs
Brothers, N., Tasmanian Parks and Wildlife Service
Bryden, M. M., University of Sydney
Burton, H. R., Australian Antarctic Division
Campbell, R., University of Western Australia
Cato, D., Defence Science and Technology Organisation
Cawthorn, M. W., Marine mammal consultant, Wellington, New Zealand
Constable, R., NSW National Parks and Wildlife Service, Narooma
Cooper, P. D., Australian National University
Coughran, D., WA Department of Conservation and Land Management
De la Mare, W., formerly Australian Antarctic Division
Dennis, T. E., Wildlife consultant, Kingscote, SA
D'Ettore, A., Taronga Zoo, Sydney
Dixon, J., Museum of Victoria
Ellis, R., SA Department of Environment, Heritage and Aboriginal Affairs, Flinders Chase National Park
Eyre, L., Taronga Zoo, Sydney, Pinniped TAG Coordinator
Fortescue, M., Environment Australia, Norfolk Island
Gales, N. J., WA Department of Conservation and Land Management, formerly at Department of Conservation, New Zealand
Gales, R., Tasmanian Parks and Wildlife Service
Gibson, L., Australian Museum, Sydney
Goldsworthy, S. D., University of Tasmania
Green, K., NSW National Parks and Wildlife Service, Cooma
Harcourt, R., Macquarie University
Hindell, M. A., University of Tasmania
Irvine, A. D., Taronga Zoo, Sydney, and University of Sydney
Kirkwood, R., Phillip Island Nature Park
Kemper, C. M., South Australian Museum
Lake, S., Australian Antarctic Division

Lea, M.-A., formerly University of Tasmania, now at University of Sydney
Ling, J., Clare, SA
Mandelc, F., NSW National Parks and Wildlife Service
Mawson, P., WA Department of Conservation and Land Management
McMahon, C., Australian Antarctic Division
McNamara, K., WA Department of Conservation and Land Management
Menkhorst, P., Victoria Department of Natural Resources and Environment
Norman, R. J. de B., formerly University of Melbourne, now at Massey University, NZ
Obendorf, D., Tasmanian Department of Primary Industry, Water and Environment
Pemberton, D., formerly Tasmanian Parks and Wildlife Service, now at Tasmanian Museum and Art Gallery
Pirzl, R., Environment Australia, Biodiversity Group
Prendergast, R., Melbourne Zoo
Priddel, D., NSW National Parks and Wildlife Service
Queale, L., South Australian Museum
Robinson, A., SA Department of Environment, Heritage and Aboriginal Affairs
Rogers, T., Australian Marine Mammal Research Centre, Taronga Zoo, Sydney
Ross, G. J. B., Environment Australia, Australian Biological Resources Study
Rounsevell, D., formerly Tasmanian Parks and Wildlife Service, now at Qld Department of Environment and Heritage
Seager, P., SA Department of Environment, Heritage and Aboriginal Affairs, Berri
Skira, I., Tasmanian Parks and Wildlife Service
Slip, D. J., Australian Antarctic Division
Southwell, C., Australian Antarctic Division
Thiele, D., formerly Environment Australia, Biodiversity Group, now Deakin University, and private consultant
Troy, S. K., formerly Parks Victoria, now with Cooperative Research Centre for Ecologically Sustainable Development of the Great Barrier Reef
Twyford, K., SA Department of Environment, Heritage and Aboriginal Affairs, Kingscote
Vogelnest, L., Taronga Zoo, Sydney
Warneke, R. M., Warneke Marine Mammal Services, Tasmania
Warner, A., SA Department of Environment, Heritage and Aboriginal Affairs, Penneshaw
Woods, R., Western Plains Zoo, Dubbo
Wyre, G., WA Department of Conservation and Land Management

Appendix II

1994 IUCN Categories and Criteria

In November 1994, IUCN proposed a new set of definitions for Red List categories (IUCN 1994). These definitions and the associated criteria were applied in the assessment of species conservation status in this Action Plan.

II.1 The Categories (IUCN 1994: 13-14)

Extinct

A taxon is *Extinct* when there is no reasonable doubt that the last individual has died.

Extinct in the Wild

A taxon is *Extinct in the Wild* when it is known only to survive in cultivation, in captivity or as a naturalised population (or populations) well outside the past range. A taxon is presumed extinct in the wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

Critically Endangered

A taxon is *Critically Endangered* when it is facing an extremely high risk of extinction in the wild in the immediate future, as defined by any of the criteria (A to E) [see below].

Endangered

A taxon is *Endangered* when it is not *Critically Endangered* but is facing a very high risk of extinction in the wild in the near future, as defined by any of the criteria (A to E).

Vulnerable

A taxon is *Vulnerable* when it is not *Critically Endangered* or *Endangered* but is facing a high risk of extinction in the wild in the medium-term future, as defined by any of the criteria (A to D).

Lower Risk

A taxon is *Lower Risk* when it has been evaluated, does not satisfy the criteria of any of the categories *Critically Endangered*, *Endangered* or *Vulnerable*. Taxa included in the *Lower Risk* category can be separated into three subcategories:

1. ***Conservation Dependent.*** 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.
2. ***Near Threatened.*** Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for *Vulnerable*.
3. ***Least Concern.*** Taxa which do not qualify for Conservation Dependent or Near Threatened.

Data Deficient

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 is lacking. *Data Deficient* is therefore not a category of threat or *Lower Risk*. 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 *Data Deficient* and *Threatened* status. If the range of a taxon is suspected to be relatively circumscribed, if a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

Not Evaluated

A taxon is *Not Evaluated* when it has not yet been assessed against the criteria.

II.2 The Criteria (IUCN 1994: 15-21)

Critically Endangered

A taxon is *Critically Endangered* when it is facing an extremely high risk of extinction in the wild in the immediate future, as defined by any of the following criteria (A to E):

A. Population reduction in the form of either of the following:

1. An observed, estimated, inferred or suspected reduction of at least 80% over the last 10 years or three generations, whichever is the longer, based on (and specifying) any of the following:
   - (a) direct observation
   - (b) an index of abundance appropriate for 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, hybridisation, pathogens, pollutants, competitors or parasites.
2. A reduction of at least 80%, projected or suspected to be met within the next ten years or three generations, whichever is the longer, based on (and specifying) any of (b), (c), (d) or (e) above.

B. Extent of occurrence estimated to be less than 100 km^2 or area of occupancy estimated to be less than 10 km^2, and estimates indicating any two of the following:

1. Severely fragmented or known to exist at only a single location.
2. Continuing decline, observed, inferred or projected, in any of the following:
   - (a) extent of occurrence
   - (b) area of occupancy
   - (c) area, extent and/or quality of habitat
   - (d) number of locations or subpopulations
   - (e) number of mature individuals.
3. Extreme fluctuations in any of the following:
   - (a) extent of occurrence
   - (b) area of occupancy
   - (c) number of locations or subpopulations
   - (d) number of mature individuals.

C. Population estimated to number less than 250 mature individuals and either:

1. An estimated continuing decline of at least 25% within 3 years or one generation, whichever is longer or
2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals and population structure in the form of either:
   - (a) severely fragmented (ie. no subpopulation estimated to contain more than 50 mature individuals)
   - (b) all individuals are in a single subpopulation.

D. Population estimated to number less than 50 mature individuals.

E. Quantitative analysis showing the probability of extinction in the wild is at least 50% within 10 years or 3 generations, whichever is the longer.

Endangered

A taxon is *Endangered* when it is not *Critically Endangered* but is facing a very high risk of extinction in the wild in the near future, as defined by any of the following criteria (A to E):

A. Population reduction in the form of either of the following:

1. An observed, estimated, inferred or suspected reduction of at least 50% over the last 10 years or three generations, whichever is the longer, based on (and specifying) any of the following:
   - (a) direct observation
   - (b) an index of abundance appropriate for 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, hybridisation, pathogens, pollutants, competitors or parasites.
2. A reduction of at least 50%, projected or suspected to be met within the next ten years or three generations, whichever is the longer, based on (and specifying) any of (b), (c), (d) or (e) above.

B. Extent of occurrence estimated to be less than 5000 km^2 or area of occupancy estimated to be less than 500 km^2, and estimates indicating any two of the following:

1. Severely fragmented or known to exist at no more than five locations.
2. Continuing decline, inferred, observed or projected, in any of the following:
   - (a) extent of occurrence
   - (b) area of occupancy
   - (c) area, extent and/or quality of habitat
   - (d) number of locations or subpopulations
   - (e) number of mature individuals.
3. Extreme fluctuations in any of the following:
   - (a) extent of occurrence
   - (b) area of occupancy
   - (c) number of locations or subpopulations
   - (d) number of mature individuals.

C. Population estimated to number less than 2,500 mature individuals and either:

1. An estimated continuing decline of at least 20% within 5 years or 2 generations, whichever is longer, or
2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals and population structure in the form of either
   - (a) severely fragmented (ie. no subpopulation estimated to contain more than 250 mature individuals)
   - (b) all individuals are in a single subpopulation.

D. Population estimated to number less than 250 mature individuals.

E. Quantitative analysis showing the probability of extinction in the wild is at least 20% within 20 years or 5 generations, whichever is the longer.

Vulnerable

A taxon is *Vulnerable* when it is not *Critically Endangered* or *Endangered* but is facing a high risk of extinction in the wild in the medium-term future, as defined by any of the following criteria (A to E):

A. Population reduction in the form of either of the following:

1. An observed, estimated, inferred or suspected reduction of at least 20% over the last 10 years or three generations, whichever is the longer, based on (and specifying) any of the following:
   - (a) direct observation
   - (b) an index of abundance appropriate for 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, hybridisation, pathogens, pollutants, competitors or parasites.
2. A reduction of at least 20%, projected or suspected to be met within the next ten years or three generations, whichever is the longer, based on (and specifying) any of (b), (c), (d) or (e) above.

B. Extent of occurrence estimated to be less than 20,000 km^2, or area of occupancy estimated to be less than 2000 km^2 and estimates indicating any two of the following:

1. Severely fragmented or known to exist at no more than ten locations.
2. Continuing decline, inferred, observed or projected, in any of the following:
   - (a) extent of occurrence
   - (b) area of occupancy
   - (c) area, extent and/or quality of habitat
   - (d) number of locations or subpopulations
   - (e) number of mature individuals.
3. Extreme fluctuations in any of the following:
   - (a) extent of occurrence
   - (b) are of occupancy
   - (c) number of locations or subpopulations
   - (d) number of mature in dividuals.

C. Population estimated to number less than 10,000 mature individuals and either:

1. An estimated continuing decline of at least 10% within 10 years or 3 generations, whichever is longer, or

2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals and population structure in the form of either

(a) severely fragmented (ie. no subpopulation estimated to contain more than 1000 mature individuals)

(b) all individuals are in a single subpopulation.

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

1. Population estimated to number less than 1000 mature individuals.

2. Population is characterised by an acute restriction in its area of occupancy (typically less than 100 km^2) or in the number of locations (typically less than 5). Such a taxon would thus be prone to the effects of human activities (or stochastic events whose impact is increased by human activities) within a very short period of time in an unforeseeable future, and is thus capable of becoming Critically *Endangered* or even Extinct in a very short period.

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

Appendix III

Australian legislation relevant to seals

Seals at colonies on the Australian coast, on nearby islands and in Australian mainland waters generally within three nautical miles of the coast are managed by State nature conservation and fisheries agencies. Beyond that and within the Exclusive Economic Zone (EEZ) to about 200 nautical miles around the Australian coast they are the responsibility of the Commonwealth and managed by Environment Australia.

Heard Island and the neighbouring McDonald Islands are managed as an Australian External Territory by the Australian Antarctic Division. Seals there (and other fauna and flora) are the responsibility of the Antarctic Division. A management plan has been prepared for the Heard Island Wilderness Reserve (Australian Antarctic Division 1995). Around Heard Island, seals are protected by the Heard Island and McDonald Islands Environment Protection and Management Ordinance as far out as the limit of territorial waters (12 nautical miles). Beyond that to about 200 nautical miles within the EEZ, they are protected under regulations for which Environment Australia is responsible.

Macquarie Island is managed by the Tasmanian government as a nature reserve through the *National Parks and Wildlife Act 1970*, which provides protection to the seals there. Around Macquarie Island, seals are protected by Tasmanian regulations and, beyond that to about 200 nautical miles within the EEZ, by regulations for which Environment Australia is responsible.

All of these regulations prohibit harvesting or molesting seals.

South of 60°S, seals are protected under regulations to the *Antarctic Treaty (Environment Protection) Act 1980*, which are administered by the Australian Antarctic Division. These implement the international Convention for the Conservation of Antarctic Seals, 1972, which was formulated under the Antarctic Treaty System. The Convention sets modest harvest limits for three of the species that occur in Antarctic waters, leopard, crab-eater and Weddell seals, and protects southern fur-seals, southern elephant seals and Ross seals. The Australian regulations are more stringent; they prohibit Australians from taking seals in the Antarctic.

Legislation pertinent to the management of Australian seals is summarised in Table III.1. In addition, there are many other pieces of legislation that are relevant to seals, especially seals that are ashore. Examples are legislation pertaining to the prevention of cruelty to animals, to occupational health and safety, and to veterinary surgeons. They are not included in the table.

Table III.1. Legislation pertinent to the management of seals in the Australian region

Jurisdiction	Responsible agency	Legislation
Commonwealth	Australian Antarctic Division	*Antarctic Treaty (Environment Protection) Act 1980*, in particular the *Antarctic Seals Conservation Regulations 1986* made under the Act
		Antarctic Marine Living Resources Conservation Act 1981
		Environment Protection and Management Ordinance, 1987 made under the *Heard Island and McDonald Islands Act 1953*
	Australian Fisheries Management Authority	*Fisheries Management Act 1991*
	Environment Australia	National Parks and Wildlife Regulations in force under the *National Parks and Wildlife Conservation Act 1975*
		Wildlife Protection (Regulation of Exports and Imports) Act 1982
		Endangered Species Protection Act 1992
New South Wales	National Parks and Wildlife Service	*National Parks and Wildlife Act 1974*
South Australia	Department of Environment, Heritage and Aboriginal Affairs	*National Parks and Wildlife Act 1972*
	Department of Primary Industries and Resources	*Fisheries Act 1982* *Fisheries (Miscellaneous) Amendment Act 1991*
Tasmania	Department of Primary Industry, Water and Environment	*National Parks and Wildlife Act 1970* *Living Marine Resources Management Act 1995*
		Threatened Species Protection Act 1995
Victoria	Department of Natural Resources and Environment	*Wildlife Act 1975* *Flora and Fauna Guarantee Act 1988*
Western Australia	Department of Conservation and Land Management	*Wildlife Conservation Act 1950* *Conservation and Land Management Act 1984*
		Acts Amendment (Marine Reserves) Act 1997

Appendix IV

Seals ashore beyond breeding colonies and regular haul-out sites

IV.1 Seals ashore away from regular sites

Seals that come ashore (haul-out) on the Australian coast away from colonies and regular haul-out sites may be resting in unusual places, possibly (but not necessarily) because they are sick. These incidents are often referred to as 'strandings'. The word is not always appropriate for seals because it implies an assumption based on incomplete understanding, namely, that the seal has not come ashore of its own volition and that it requires assistance. That may be the case, but need not be. Seals are amphibious animals, and they may be ashore on a beach or on rocks for many reasons, and may not require assistance. The word "stranding" is appropriate for cetaceans that come ashore, in that they need help if they are to return to the sea. For seals beyond their normal range, the terms 'vagrant' or 'extra-limital' are more appropriate than 'stranding'. Nevertheless, there is no doubt that 'stranding' and 'stranded' will continue in general use for seals, and they will be used here for convenience.

Many seal species are increasing in abundance, and the use of beaches and near-shore islands by people is also increasing. Reports of seals ashore beyond their normal range also seem to be increasing, as demonstrated by recent compilations of Subantarctic fur-seal sightings on the Australian coast (Gales *et al.* 1992a, G. J. B. Ross, pers. comm.). Several State nature conservation agencies maintain databases of wandering seals that come ashore. Publications that have resulted from such databases are:

- for New South Wales, Llewellyn *et al.* (1994)
- for Victoria, Warneke (1995b, 1995c)
- for Tasmania, Rounsevell and Pemberton (1994), Kirkwood *et al.* (1992, section 7), Pemberton and Skira (1989)
- for Western Australia, Mawson and Coughran (in prep.).

A database is also maintained in South Australia (C. Kemper, pers. comm.). Analysis of such data enables trends in the incidence of strandings to be determined and may reveal interesting information on the causes of death of the stranded animals, for example tuberculosis in Western Australia (Mawson and Coughran in prep.).

Suggested research and management actions

- Enhance the procedure within States for recording seals that come ashore beyond their normal range by improving communications between field officers and database managers.
- Co-ordinate methods used and information collected in recording schemes of different State agencies.
- Raise awareness among officers of nature conservation agencies, fisheries agencies and non-government agencies that deal with distressed animals. Provide them with background information on seal species likely to come ashore, and action they should take, including:
  - a guide to identifying species that are likely to come ashore
  - a guide to the likely behaviour of such seals
  - a guide on how to handle such situations
  - instructions on how to catch seals and remove entanglements
  - equipment for catching seals
  - guidance on how to protect people from seals, and vice versa.
- Produce a pamphlet for the public outlining action to take when a seal is sighted ashore.

IV.2 Handling stranded seals that appear to be in distress

Stranded seals may be in distress, in that they may be injured, undernourished or harassed by members of the public or by dogs. Officers of nature conservation agencies, fisheries agencies and non-government organisations that deal with distressed animals can expect increasing numbers of reports of stranded seals. Several documents provide background information on seal species likely to come ashore and guidance on how to handle distressed seals:

- the field guide prepared by Geraci and Lounsbury (1993)
- the section on seals in the *Management manual for marine mammals in NSW* (Smith 1997)
- the advice in *Seals of Tasmania* (Pemberton 1996a).

There are four obvious courses of action for handling seals ashore, which are not mutually exclusive:

- leave alone
- provide veterinary care on the beach
- catch and rehabilitate
- euthanase.

In choosing one of these options, account has to be taken of many factors: the number of seals and their condition, status of the species, remoteness of the locality and its accessibility, availability and suitability of transport, abilities and experience of those in attendance, and availability of veterinary care and holding facilities.

It is important to stress that it is illegal for members of the public (and scientists) to handle or harass a seal without a permit. It can also be dangerous, and the safety of the public needs to be addressed by advising them of how dangerous seals can be, despite the friendly images conveyed by the media.

IV.2.1 Leave alone

If the seal looks healthy or if it is moulting, it is best left alone. This includes not chasing it into the sea; such action is dangerous because seals can be mobile on land and can inflict serious injury by biting. To interfere with a leopard seal that is ashore to rest or an elephant seal ashore to moult would be counter-productive. Stranded seals should be reported to the local nature conservation agency or police. A list of agencies and other bodies interested in seals ashore is included in Appendix I. People who feel obliged to "do something", should endeavour to keep other people and dogs at a distance until an authorised person arrives.

There is no need to wet the seal as there is with stranded cetaceans, if it is obviously overheating and in distress it needs far more attention than cooling. Seals that are overheating will generally take steps to ameliorate the problem by seeking shade or water. Animals should not be fed because of the likelihood of providing inappropriate or contaminated food, and the danger to the feeder.

Seals can recover from major flesh wounds that heal well without human intervention. Unless there is convincing evidence that a seal is in distress (see IV.2.3 below), the 'leave alone' option should be preferred. When such a seal is ashore close to a town or city, it may provide a (temporary) education resource.

IV.2.2 Provide veterinary care on the beach

This option is feasible where veterinarians experienced with seals are available. Consequently, it is likely to be limited to the vicinity of coastal cities, and is unlikely to be useful in remote areas. It requires nature conservation agencies and other bodies to have either an experienced veterinarian on call, or one who can be contacted readily.

IV.2.3 Catch and rehabilitate

If the seal is in obvious distress, or has come ashore where its safety or that of the public cannot be reasonably assured, capture and rehabilitation is an option, and one of the groups listed in Appendix I should be contacted. Signs of distress include obvious emaciation, hyperventilating (possibly caused by a plastic bag caught in an airway), a large wound (possibly caused by a boat propeller, harpoon or a shark), discharge from the nose and being entangled in fishing gear or other anthropogenic material.

The catch and rehabilitate option is often conducted by zoos, aquaria and other bodies (eg the RSPCA), sometimes at the request of local wildlife authorities and as a result of significant community interest and expectations generated by the media. Capture and rehabilitation are not straightforward operations and should only be undertaken by institutions with appropriate facilities and experienced staff that have been approved by State nature conservation agencies.

Prendergast (1994) briefly reviewed rehabilitation for captive display and release in Australia, and described the case of a leopard seal at Melbourne Zoo in 1992. This is good for zoo staff in that it broadens their experience and outlook. Furthermore, it is humane to provide assistance to animals in distress.

The relevance of the underlying philosophy of capture and rehabilitation needs to be put into perspective though, because such actions are expensive and can be complicated. Consequently, they should only be undertaken when there is good likelihood of success. Since most seal species that breed in or visit Australian waters are reasonably abundant, the concept of rehabilitating a seal should be seen as an animal welfare or humane action and not as a conservation measure. One might argue that capturing and rehabilitating a Subantarctic fur-seal or a southern elephant seal could be considered as a conservation measure, because they are considered as *Endangered* and as *Vulnerable*, respectively, in Australian waters in this Action Plan. Since the overall population levels of these two species number in the hundreds of thousands and the origins of the animals that strand in Australia is unknown, the conservation value of rehabilitating such animals is doubtful.

Rehabilitation of seals is fraught with difficulties. Two examples are the stress imposed in capturing an animal, and the possibility of disease transfer after release. The case of tuberculosis several years ago (see Appendix V) should be a strong reminder to those who seek to rehabilitate seals in captivity of problems that may arise. Consequently, only trained and experienced persons from reputable institutions should be permitted to capture and rehabilitate seals considered to be in distress, with approval from the responsible nature conservation agency.

After a seal has been rehabilitated, the question arises of what to do with it: is it better to retain it in captivity or release it? A decision on this matter should be made before the animal is captured. Captivity should only be considered an option when an animal's physical capabilities are severely impaired as a result of injury, starvation or dehydration. It should only be considered at facilities that are well set up and have clearly established reasons for holding rehabilitated animals, including the ability to:

- provide a prolonged period of veterinary care
- avoid development of imprinting and dependency behaviours
- raise awareness among the public about the biology of seals or about marine debris
- provide access to research workers
- develop methodologies useful for the maintenance of *endangered* species.

If it is intended to release a rehabilitated seal, it is essential that it be sufficiently healthy. A workshop on rescue, rehabilitation and release of marine mammals sponsored by the U. S. Marine Mammal Commission and the U. S. National Marine Fisheries Service in December 1991 recommended that guidelines should be developed for this purpose (St Aubin *et al.* 1996). They should include "a set of medical determinations by species, with appropriate reference ranges for blood constituents and other clinical measures, morphometric limits (weight and length at age), a checklist for physical examination and a means for scoring behavioural attributes that would influence survival in the wild" (St Aubin *et al.* 1996, p. 16).

If a rehabilitated seal is to be reintroduced into the natural environment, it must have a strong likelihood of surviving. Many of the seals that come ashore in unusual places are young, recently weaned animals, and have not yet demonstrated an ability to survive independently. They can be provided with their nutritional requirements temporarily in captivity. Whether or not they are capable of fending for themselves on a second attempt at independence in the wild is another matter. In other words, do seals that have been rehabilitated and released survive long enough after release to have made the effort worthwhile? There has been little research directed at this question. Nine sea-lions from Atlantis Marine Park were released on Daw Island, Recherche Archipelago and tracked for ten days (N. J. Gales, *in litt.*), but there is no information on their subsequent survival. A young male Australian fur-seal was observed in good health at Seal Rocks, Victoria in November 1991, eight months after release from Melbourne Zoo (K. Beasley, *in litt.*).

Seals that are rehabilitated and released should at least be tagged and a central register of tag numbers should be maintained by a Commonwealth agency (see Appendix VI). More information would be obtained from radio tracking such animals, as in one of the above examples. But that is expensive, and many people would argue that such funds would be better directed at similar studies of wild, healthy seals.

Another question that arises if it is decided to release a rehabilitated seal is where to release it. Should it be released where it was caught or should it be transferred to a colony of the same species? The latter option may involve a long journey; for example, it might mean taking a rehabilitated leopard seal to the pack ice.

The likelihood of transmitting disease from rehabilitated seals to wild populations should be taken into account when contemplating releases. This matter is discussed in section 4.7.6. In order to decrease the likelihood of infection being transferred to breeding colonies, it is recommended that rehabilitated seals be released close to the site of capture. If that is impractical, consultation may be required between the holding facility and State nature conservation agency. But it is important that rehabilitated seals not be released at a breeding colony. If it is planned to release a rehabilitated seal, the release should be made as soon as practicable to decrease the likelihood of the seal becoming dependent on its providers.

Translocation of living organisms has been considered by IUCN and is the topic of a Position Paper issued in September 1987 (IUCN 1987). Little of it is pertinent to the transfer of rehabilitated seals to breeding colonies. It does entertain the option of restocking as a "humanitarian effort to release or rehabilitate captive animals", which is often the situation with stranded seals in Australia. It suggests that such releases should be limited to situations where there is no danger of infecting wild populations of the same species with new diseases, which accords with the arguments presented above. More recent IUCN/SSC guidelines (1998) are similarly concerned with re-establishment of populations of threatened species rather than re-introducing rehabilitated animals. The emphasis on the health of animals to be released, and the need to avoid introducing foreign pathogens to wild populations remains.

IV.2.4 Euthanase

In some cases this may be the most humane, pragmatic course and hence the preferred option. Before a decision is made to euthanase a seal, its body condition needs to be assessed by an experienced person; preferably a wildlife veterinarian or a nature conservation officer experienced with pinnipeds. Seals can recover from ghastly looking bites and other injuries, provided they are left alone. On the other hand, those with chronic respiratory problems should be euthanased. Technical guidelines need to be developed for assessing compromised seals in regard to options for intervention, including euthanasia. The guidelines should be developed by interested wildlife veterinarians, biologists, animal care organisations and State nature conservation agencies.

When the decision is made to kill a stranded seal, efforts should be made to advise museum staff and researchers to ask if they desire specimens from it for their collection or for analysis.

Suggested research and management actions

- Establish a list of institutions with approved facilities and with experienced staff approved to handle seals considered to be in distress.
- Establish criteria for the retention of rehabilitated stranded seals in zoos and aquaria, including effective quarantine.
- If a decision is made to release a rehabilitated seal, it should be released promptly and near the capture site; if impractical, consultation may be required between the holding facility and State nature conservation agency. It should not be released at a breeding colony.
- Develop guidelines to determine when rehabilitated seals are healthy enough to release.
- Develop guidelines to determine infectious agents that may be transferred to the wild with rehabilitated seals, and how they should be diagnosed and treated.
- Investigate the fate of seals that are rehabilitated and released.
- When the decision is made to kill a stranded seal, efforts should be made to advise museum staff and to ask if they desire specimens from it for their collections.
- Establish in a Commonwealth agency a central register of tags that have been applied to seals in Australia and of their resightings (see Appendix VI). Record information on movements of rehabilitated seals and of seals tagged in colonies.

Appendix V

Transmissible diseases

Four diseases that are known to be transferred from seals to humans are discussed, because of the danger of transmission to people who handle seals and do not take appropriate precautions.

V.1 Tuberculosis

Tuberculosis (TB) has been reported from New Zealand fur-seals and Australian sea-lions in Australia. Among humans it has been reported from an animal trainer at an aquarium, where transmission was most likely via aerosol from a barking or sneezing seal (Forshaw and Phelps 1991). TB is treated in more detail in section 4.7.

V.2 Seal finger

Seal finger or spekk finger is a severely painful infection with associated swelling of the finger. It can lead to a permanent disability if left untreated. It also results in swollen lymph nodes in the axilla when the hand or arm is afflicted, or the inguinal region when a lower limb is afflicted. A break in the skin is necessary for the infection to become established. Micro-organisms that have been associated with seal finger are *Erysipelothrix rusiopathae* and *Mycoplasma*, which can be treated with penicillin and tetracycline respectively (Spielman 1994). Seal finger also responds to doxycycline (eg vibramycin) and to some other drugs (T. Long, *in litt.*, Cawthorn 1994). Rodahl (1943) noted that people with an aversion to hot water and soap were most prone to seal finger. His implied advice is still pertinent.

V.3 Influenza

Influenza A virus was reported with an epizootic of pneumonia in harbour seals Phoca vitulina on the north-east coast of the USA in 1979-80 (Geraci *et al.* 1982). Humans were affected with conjunctivitis after close contact with experimental harbour seals infected with influenza A virus (Webster *et al.* 1981).

V.4 Seal pox

Seal pox has been reported in captive and wild California sea-lions *Zalophus californianus*, in wild northern fur-seals *Callorhinus ursinus* and in southern sea-lions *Otaria byronia*, harbour seals *Phoca vitulina* and grey seals *Halichoerus grypus* (reviewed by Robinson and Kerr in press). It is a proliferative skin disease, showing skin nodules about 1-2 cm in diameter. Most lesions appear around the head, neck and flippers, and are self-limiting within several months (Sweeney 1978).

Cases have been reported among biologists working with seals at Macquarie Island (D. J. Lugg, Australian Antarctic Division, pers. comm.) and in technicians handling infected grey seals (Hicks and Worthy 1987). The pathology, diagnosis and treatment of seal pox is summarised by Robinson and Kerr (in press).

Suggested management and research actions

- Ensure that personnel likely to handle seals (ie zoo and aquaria staff, nature conservation agency staff) are aware of transmissible diseases and how to treat them.
- Heed the advice from Geraci and Ridgway (1991, p. 192) relative to cetaceans: "exercise the same hygienic safeguards - before and after - as one would when dealing with a pet or domesticated animal."
- Determine the prevalence of TB in wild populations of Australian seals.
- Test seals taken into zoos and aquaria for TB and other diseases.
- Test seals captured at fish farms for TB and other diseases

Appendix VI

Central (national) marking register

Marks are applied to several species of seal by researchers in Australia and its Antarctic and Subantarctic regions. An incomplete list of such activity during the 1980s and 1990s is at Table VI.1. Most marked animals were pups, but some studies have included adults and subadults. Most marking has involved tags applied to a web in the hind-flipper of phocid seals or to the trailing edge of the fore-flipper of otariid seals. Other marking techniques that have been used are freeze branding and hot-iron branding on the skin, and transponder chips embedded sub-dermally.

Among the aims of marking studies are to allow the study of movement patterns, accumulate a pool of known-age animals for demographic studies, and facilitate the study of behaviour and foraging ecology (mainly directed at adult seals).

No attempt has been made within Australia to coordinate this activity, such as through the establishment of a central registry or an overseeing committee. A move in this direction has been the reporting of tagging effort by researchers in the Antarctic and Subantarctic to the Antarctic Pinniped Tagging and Marking Database, maintained under the auspices of the SCAR Group of Specialists on Seals by Dr John Bengtson of the National Marine Mammal Laboratory, Seattle, USA.

An example of confusion that can arise when marking of animals is not coordinated includes the use of tags of the same colour containing the same numbering system. This is likely to happen since field researchers prefer to use only three or four characters on individual tags to enhance the likelihood of them being read at a distance. Similarly, the two State conservation agencies active with Australian sea-lions are using different transponder systems: South Australia uses a Destron system whereas Western Australia uses a Trovan system. Consequently, the transponder chip of a sea-lion that moved between these States would not be recorded, even if an effort were made to read its chip. In this context, it should be pointed out that both agencies utilise these transponder systems for several species of fauna and that sea-lions were not the driving force in purchasing the systems.

The formation of a central registry of seal marking activities is recommended. Advantages of a centralised registry include the following.

- It would be a point of reference to avoid duplication of marks in concurrent marking programs. This would be helpful to State and Commonwealth agencies which have responsibility for seal populations, and assist in the coordination of any future interstate, national and even international projects.
- It would be a source of information and contacts in regard to assessments of marking and attachment techniques. This would be helpful to committees assessing research funding applications and to Ethics Committees considering animal welfare aspects of proposed research projects involving tagging, branding and attachment of transmitters and recorders.
- It would assist in directing recovery information to taggers.

Implementation of a central marking register would, of course, depend on agreement between State and Commonwealth agencies. The *Management manual for marine mammals in NSW* encourages such coordination (Smith 1997, p. 50). A similar registry is maintained for birds and bats by the Australian Bird and Bat Banding Scheme at Environment Australia, Biodiversity Group.

Table VI.1. Marks applied to seals in Australia and its Antarctic and Subantarctic regions during the 1980s and 1990s.

Species	Mark	Location	Person(s) responsible
Australian sea-lion	Tag	Seal Bay, Kangaroo Is.	T. Dennis, SA NPW, L. Higgins, U. of California, Santa Cruz
	Tag	WA	N. Gales, Murdoch U. & Atlantis Marine Park
	Transponder	Seal Bay, Kangaroo Is.	M. Berris, T. Dennis, SA NPW
	Transponder	West coast, WA	D. Coughran, P. Mawson, WA CALM
New Zealand fur-seal	Tag	Maatsuyker Is.	R. Kirkwood, D. Pemberton, TASPAWS
	Tag	Kangaroo Is.	P. Shaughnessy, CSIRO, S. Goldsworthy, Monash U., S. Troy, Melbourne U.
	Tag	Recherche Archipelago	WA CALM, N. Gales, Murdoch U. & Atlantis Marine Park
Australian fur-seal	Tag	Bass Strait islands	R. Kirkwood, D. Pemberton, TASPAWS
	Tag	Seal Rock, Lady Julia Percy Is.	R. Warneke, P. Shaughnessy, CSIRO
Antarctic fur-seal	Tag	Macquarie Is.	S. Goldsworthy, U. Tasmania, P. Shaughnessy, CSIRO
	Tag	Heard Is.	S. Goldsworthy, U. Tasmania, K. Green, Australian Antarctic Division, P. Shaughnessy, CSIRO
Subantarctic fur-seal CSIRO	Tag	Macquarie Is.	S. Goldsworthy, U. Tasmania, P. Shaughnessy,
Southern elephant seal	Brand	Macquarie Is.	H. Burton, Australian Antarctic Division
	Tag	Macquarie Is., Heard Is.	M. Hindell, U. Tasmania , H. Burton, D. Slip, Australian Antarctic Division
	Tag	near Casey	H. Burton, Australian Antarctic Division
	Tag	Vestfold Hills	H. Burton, Australian Antarctic Division
Leopard seal	Tag	Macquarie Is., Heard Is	H. Burton, Australian Antarctic Division, D. Rounsevell, TASPAWS
Crab-eater seal	Tag	pack ice	P. Shaughnessy, CSIRO, C. Southwell, Australian Antarctic Division
Weddell seal	Tag	Vestfold Hills	H. Burton, Australian Antarctic Division
Ross Seal	Tag	pack ice	P. Shaughnessy, CSIRO

Appendix VII

Location and status of seal colonies on the Australian coast

A list of all known breeding colonies and haul-out sites of each species of pinniped on the Australian coast was compiled by Warneke (1982). For the Australian fur-seal, a brief description of breeding colonies and haul-out sites was provided by Warneke (1988), including sketch maps of breeding colonies. For the Australian sea-lion and the New Zealand fur-seal, haul-out sites were listed by Gales (1990) and Shaughnessy *et al.* (1994).

For colonies on the Australian coast, sites where pups have been reported, the status of each colony and the relevant management authority are listed here in:

- Table VII.1, for Australian sea-lions
- Table VII.2, for New Zealand fur-seals
- Table VII.3, for Australian fur-seals.

Management of islands where navigational aids are installed is being progressively transferred from the Australian Maritime Safety Authority (AMSA) to State land management and nature conservation agencies. In most cases, AMSA retains authority for a small portion of the island surrounding their structure(s). The New Zealand fur-seal colony at Eclipse Island is listed in Table VII.2 as being managed by AMSA, but its status is currently under negotiation (D. Coughran, pers. comm.).

Hauloff Rock in Western Australia, which supports breeding colonies of both Australian sea-lions and New Zealand fur-seals, is currently vacant crown land. Action should be taken to include it in the reserve system of the Department of Conservation and Land Management.

Table VII.1. Breeding colonies of the Australian sea-lion on the Australian coast and the responsible management authority. Alternative names are given for some islands. The number of islands in some groups is given in brackets after the island name.

Colony	Latitude °S	Longitude °E	Land classification	Management authority**
South Australia				
North Pages Is.	35 46	138 18	Conservation Park	SA NPW
South Pages Is.	35 46	138 18	Conservation Park	SA NPW
Seal Bay, Kangaroo Island	36 00	137 20	Prohibited Area	SA NPW
North Casuarina Islet	36 05	136 42	National Park	SA NPW
Peaked Rock (2)	35 11	136 29	Conservation Park	SA NPW
North Is.	35 07	136 28	Conservation Park	SA NPW
English Is.	34 38	136 12	Conservation Park	SA NPW
Dangerous Reef (3)	34 49	136 13	Conservation Park	SA NPW
Smith Is.	34 59	136 02	Conservation Park	SA NPW
Albatross Is.	35 04	136 11	National Park	SA NPW
South Neptune Is. (north)	35 20	136 07	Conservation Park	SA NPW
Liguanea Is.	35 00	135 37	Conservation Park	SA NPW
Four Hummocks Is. (north)	34 46	135 02	Conservation Park	SA NPW
Price Is.	34 43	135 17	Conservation Park	SA NPW
Rocky (North) Is.	34 16	135 16	Conservation Park	SA NPW
Dorothee Is.	34 00	134 15	Conservation Park	SA NPW
Pearson Is.	33 57	134 16	Conservation Park	SA NPW
Ward Is.	33 45	134 18	Conservation Park	SA NPW
West Waldegrave Is.	33 36	134 47	Conservation Park	SA NPW
Jones Is.	33 11	134 22	Conservation Park	SA NPW
Olive Is.	32 43	133 59	Conservation Park	SA NPW
Small rock NE of Franklin #	32 26	133 42	Conservation Park	SA NPW
Small rock S of Franklin #	32 28	133 39	Conservation Park	SA NPW
Lounds Is.	32 17	133 22	Conservation Park	SA NPW
Fenelon Is.	32 35	133 17	Conservation Park	SA NPW
West Is.	32 31	133 15	Conservation Park	SA NPW
Purdie Is.	32 17	133 14	Conservation Park	SA NPW
Middle Nuyts Reef	32 07	132 08	Conservation Park	SA NPW
Western Nuyts Reef	32 07	132 08	Conservation Park	SA NPW
Great Australian Bight, B1	31 00	131 04	National Park	SA NPW
Great Australian Bight, B2	31 00	130 35	National Park	SA NPW
Great Australian Bight, B3	31 00	130 09	National Park	SA NPW
Great Australian Bight, B4	31 00	130 04	National Park	SA NPW
Great Australian Bight, B5	31 00	130 03	National Park	SA NPW
Great Australian Bight, B6	31 00	129 46	National Park	SA NPW
Great Australian Bight, B7	31 00	129 30	National Park	SA NPW
Great Australian Bight, B8	31 00	129 23	National Park	SA NPW
Great Australian Bight, B9	31 00	129 18	National Park	SA NPW
Number of colonies in SA 38				
Western Australia				
Great Australian Bight, B10	31 00	126 01	Nature Reserve	WA CALM
Spindle Is. #	33 44	124 10	Class A reserve	WA CALM
Ford (Halfway) Is.	33 46	124 02	Class A reserve	WA CALM
Six Mile Is.	33 39	123 59	Class A reserve	WA CALM
Round Is.	34 06	123 53	Class A reserve	WA CALM
Cooper Is.	34 14	123 37	Class A reserve	WA CALM
Salisbury Is.	34 22	123 33	Class A reserve	WA CALM
Poison Creek Is.	33 55	123 20	Class A reserve	WA CALM
Wickham (Stanley) Is.	34 01	123 17	Class A reserve	WA CALM
Glennie Is.	34 06	123 06	Class A reserve	WA CALM
Taylor Is. 3	3 55	122 52	Class A reserve	WA CALM
Twin Peaks Is., SW Rock E of	33 59	122 54	Class A reserve	WA CALM
Kermadec (Wedge) Is.	34 05	122 50	Class A reserve	WA CALM
Kimberley Is.	33 57	122 28	Class A reserve	WA CALM
MacKenzie Is.	34 12	122 06	Class A reserve	WA CALM
Little Is.	34 28	122 00	Class A reserve	WA CALM
Rocky (Investigator) Is.	34 05	120 55	Class A reserve	WA CALM
West Is.	34 06	120 29	Class A reserve	WA CALM
Red Islet	34 02	119 47	Class A reserve	WA CALM
Middle Doubtful Is.	34 22	119 35	Class A reserve	WA CALM
Hauloff Rock	34 42	118 40	Vacant crown land	WA Dept of Lands
Buller Is.	30 39	115 06	Class A reserve	WA CALM
North Fisherman Is.	30 08	114 56	Class A reserve	WA CALM
Beagle Is.	29 48	114 52	Class A reserve	WA CALM
Houtman Abrolhos, Suomi Is.	28 00	114 00	Class A reserve	WA Dept of Fisheries
Houtman Abrolhos, Alexander Is.	28 00	114 00	Class A reserve	WA Dept of Fisheries
Houtman Abrolhos, Gilbert Is.	28 00	114 00	Class A reserve	WA Dept of Fisheries
Houtman Abrolhos, Serventy Is.	28 00	114 00	Class A reserve	WA Dept of Fisheries
Number of colonies in WA 28				

Unofficial name ** Acronyms are explained in Appendix IX.2

Sources: Gales *et al.* (1994), Dennis and Shaughnessy (1996), Shaughnessy *et al.* (1997).

Table VII.2. Breeding locations of the New Zealand fur-seal on the Australian coast and the responsible management authority. The number of breeding sites or islands at some breeding locations is given in brackets after its name.

Colony	Latitude °S	Longitude °E	Land classification	Management authority**
South Australia				
Cape Gantheaume, Kangaroo Is.	36 04	137 28	WPA+	SA NPW
Cave Point , Kangaroo Is.#	36 01	136 58	WPA+	SA NPW
Cape Bouguer, Kangaroo Is.	36 03	136 55	WPA+	SA NPW
North Casuarina Islet	36 05	136 42	National Park	SA NPW
Cape du Couedic (5)	36 04	136 42	National Park	SA NPW
South Neptune Is. (2)	35 20	136 07	Conservation Park	SA NPW
North Neptune Is. (2)	35 14	136 04	Conservation Park	SA NPW
Liguanea Is.	35 00	135 37	Conservation Park	SA NPW
Little Hummock Is. #	34 45	135 05	Conservation Park	SA NPW
Four Hummocks Is. (2)	34 46	135 02	Conservation Park	SA NPW
Greenly Is.	34 39	134 45	Conservation Park	SA NPW
Rocky (South) Is.	34 49	134 42	Conservation Park	SA NPW
Ward Is. (3)	33 45	134 18	Conservation Park	SA NPW
Number of colonies in SA 13				
Western Australia				
Daw (Christmas) Is.	33 51	124 06	Class A reserve	WA CALM
New Year Is.	33 52	124 06	Class A reserve	WA CALM
Cranny Is. #	33 43	124 05	Class A reserve	WA CALM
Cooper Is.	34 14	123 37	Class A reserve	WA CALM
Salisbury Is.	34 22	123 33	Class A reserve	WA CALM
Beaumont Is.	34 06	122 33	Class A reserve	WA CALM
Draper Is.	34 12	122 30	Class A reserve	WA CALM
Finger Is.	34 07	122 21	Class A reserve	WA CALM
Libke Is.	34 13	122 04	Class A reserve	WA CALM
Hood Is.	34 09	122 03	Class A reserve	WA CALM
Seal Rock (Recherche Archipelago)	34 01	121 40	Class A reserve	WA CALM
Rocky (Investigator) Is.	34 05	120 55	Class A reserve	WA CALM
West Is.	34 06	120 29	Class A reserve	WA CALM
Doubtful Is. (2)	34 22	119 35	Class A reserve	WA CALM
Hauloff Rock	34 42	118 40	Vacant crown land	WA Dept of Lands
Eclipse Is.	35 11	117 53	Lighthouse reserve	AMSA
Flinders Is.	34 25	115 12	Class A reserve	WA CALM
Number of colonies in WA 17				
Tasmania				
Maatsuyker Is.	43 38	146 17	World Heritage Area	TASPAWS
Macquarie Is.	54	159	Nature Reserve	TASPAWS
Number of colonies in Tas 2				

Unofficial name   + Wilderness Protection Area
** Acronyms are explained in Appendix IX.2

Sources: Shaughnessy *et al.* (1994); Brothers and Pemberton (1990); P. Lambert, WA Department of Conservation and Land Management (pers. comm.); Goldsworthy *et al.* (1998).

Table VII.3. Breeding colonies of the Australian fur-seal on the Australian coast and the responsible management authority.

Colony	Latitude °S	Longitude °E	Land classification	Management authority**
Tasmania				
Moriarty Rocks	40 36	148 16	Nature Reserve	TASPAWS
Wright Rock	39 36	147 32	Nature Reserve	TASPAWS
Judgement Rocks	39 30	147 08	Nature Reserve	TASPAWS
Tenth Is.	39 57	146 59	Nature Reserve	TASPAWS
West Moncoeur Is.	39 14	146 31	Nature Reserve	TASPAWS
Reid Rocks	40 15	144 10	Nature Reserve	TASPAWS
Number of colonies in Tas 6				
Victoria				
The Skerries	37 45	149 31	National Park	Parks Victoria
Kanowna Is.	39 10	146 18	National Park	Parks Victoria
Seal Rocks	38 32	145 06	Wildlife Reserve	Phillip Is. Nature Park
Lady Julia Percy Is.	38 25	142 00	Wildlife Reserve	Parks Victoria
Number of colonies in Vic 4				

** Acronyms are explained in Appendix IX.2

Sources: Warneke (1988, 1995b), Pemberton and Kirkwood (1994), Pemberton (1996a).

Appendix VIII

Species referred to in the text (other than Australian pinnipeds)

Common name	Taxon name/information
Adelie penguin	*Pygoscelis adeliae*
Atlantic salmon	*Salmo salar*
Australian salmon	*Arripis trutta*
baleen whales	whales of the suborder Mysticeti; filter feeders, mainly plankton
beaked whales	whales of the suborder Odontoceti, family Ziphiidae; feed on fish or squid
Californian sea-lion	*Zalophus californianus*
cephalopods	members of the order Cephalopoda; including squid, cuttlefish, octopuses
Gould's squid	*Nototodarus gouldii*
grey seal	*Halichoerus grypus*
Cape hake (Sth Africa)	*Merluccius capensis* and *M. paradoxus*
harbour seal	*Phoca vitulina*
herring or tommy ruff	*Arripis georgicus*
hoki	*Macruronus novaezeelandiae*
Hooker's sea-lion or New Zealand sea-lion	*Phocarctos hookeri*
hookworms	members of the phylum Nematoda; parasitic worms
icefish	members of the family Channicthyidae, including *Champsocephalus gunnari*
jack mackerel	*Trachurus declivis*
killer whale	*Orcinus orca*
krill	*Euphausia superba*
leatherjackets	members of the family Monacanthidae
little penguin	*Eudyptula minor*
lobsters, rock lobsters	members of the family Palinuridae
microorganism associated with seal finger	*Erysipelothrix rusiopathae*
mycoplasma	group of simple, almost sub-microscopic prokaryotic microorganisms; obligate intracellular parasites; associated with seal finger
myctophids	fish of the genera *Electrona* and *Gymnoscopelus*
mysids	members of the order Mysidacea; free swimming crustaceans
nitre bush	*Nitraria schoberi*; plant species
northern elephant seal	*Mirounga angustirostris*
northern fur-seal	*Callorhinus ursinus*
Patagonian toothfish	*Dissostichus eleginoides*
phytoplankton	aquatic plants, mostly diatoms, that drift with water movements; photosynthesise and form the basis of aquatic food chains
puffer fish	members of the family Toxodontidae
rainbow trout	*Salmo gairdneri*
redbait	*Emmelichthys nitidus*
ringed seal	*Phoca hispida*
sharks	members of the subclass Elasmobranchii; numerous families
South African fur-seal	*Arctocephalus pusillus pusillus*
southern right whale	*Eubalaena australis*
southern sea-lion	*Otaria byronia*
squid	cephalopods of the order Teuthoidea
Steller sea-lion	*Eumetopias jubatus*
stingrays	members of the family Dasyatidae
Tuberculosis bacteria	*Mycobacterium tuberculosis*
tuna	*Thunnus* spp.; members of the family Scombridae
walrus	*Odobenus rosmarus*
white shark	*Carcharadon carcharias*

Appendix IX

Glossary and Abbreviations

IX.1 Glossary of terms

annulus	A ring
anthropogenic	Originating from or relating to humans
antigenically	(Substance capable of) causing an immune response with the formation of antibodies
aquaculture	Commercial husbandry of fish or other aquatic organisms
audiogram	Diagram showing frequencies of the hearing range of an animal
Australian Fishing Zone (AFZ)	Proclaimed zone between 3 and 200 nautical miles seaward of the baselines,within which Australia is obliged to conserve and manage the fisheries and controls domestic and foreign access to fish resources; the AFZ also applies to Macquarie, Heard and McDonald Islands but not to the Australian Antarctic Territory
axilla	Of or in the region of the armpit
bacula (pl)	Penis bone of some mammals, including seals
bait bands	Heat sealed plastic bands used to hold bait boxes together
beach seine	Net set in an arc surrounding schooling fish operated from shore
benthic	Of or from the bottom sediments of marine (or freshwater) ecosystems, ie the sea floor
berley(ing)	(Use of) broadcast bait to attract target species
blastocyst	Mammalian embryo soon after division of the egg, when it is a hollow sphere of cells ready for implantation in the uterine wall
brash ice	Small fragments of floating ice, not more than 2m across; the wreckage of other forms of ice
by-catch	Species caught incidentally to the target species in fishing
cake ice	Flat pieces of ice (of varying size) surrounded by water
calicivirus	Family of single-stranded RNA viruses
cohort	Group of individuals of the same age, group of offspring born at the same time
conspecifics	Individuals of the same species
DNA paternity analysis	Use of DNA to establish the identity of the male parent of an animal
drop-line	Mainline anchored vertically in the water, to which 10-100 smaller lines (snoods) with a hook on the end are attached
electrophoresis	Migration of charged particles in a solution or solid medium under the influence of an electrical field
embryonic diapause	Temporary cessation in the growth of an embryo
endemic	Restricted to a particular geographic region
energetics	(Study of) energy requirements and use of animals
epizootic	Outbreak of disease among a population of animals
Exclusive Economic Zone (EEZ)	Area between the lines 12 and 200 nautical miles seaward of the territorial sea baselines and the declared extensions based on natural prolongation of the continent; within the 200 n. mile area Australia has the right to explore

	and exploit living and non-living resources, and in the extensions non-living resources; over the whole area it has the obligation to protect and conserve the marine environment; applied also to Australia's external territories including the Australian Antarctic Territory; declared under the UN Convention on the Law of the Sea
exponential rate of change	Rate of change calculated as a fixed percentage of the starting value; amount of change in a period = (starting value + interest from previous periods) x rate of change
fast ice	Sea ice that remains fast to the coast, to an ice front or over shoals
fin-fish	Bony fish, but including (cartilaginous) sharks and some rays
gill-net	Panel or panels of nets held vertically in the water column, designed to ensnare fish by the gills
haul-out	A place on land or ice where seals leave the water, not necessarily for breeding
inguinal	Of or in the region of the groin
introgression	Hybridisation of species, and display by individuals of some characteristics of one of the species
isozymes	Enzymes that exist in two or more forms (can be separated by electrophoresis)
lavage	Method for initiating regurgitation, for analysis of animal's diet
leptospirosis	Contagious disease caused by a spirochaete of the genus Leptospirosa; transmissible from marine mammals to humans
lipids	Body fats, one major function of which is energy storage
long-line	Fishing line consisting of many hooks or lures which may be set on the bottom or drifting; often set over a distance of many kilometres
mark-recapture	Technique where a sample of the population is captured, marked and released; in subsequent sampling some marked animals will be captured or resighted allowing population size to be estimated
mesh-net	Net of varying size mesh used to ensnare fish
mitochondrial DNA	Circular DNA, independent of nuclear DNA, transmitted from females to their offspring with no contribution from the male parent
morbillivirus	Group of large, enveloped, single-stranded RNA viruses
morphometrics	(Study of) measurements of physical characteristics of animals
near-synoptic	Observations made at almost the same time
oestrous	Pertaining to or emanating from oestrus
oestrus	Part of the female reproductive cycle in which animals are reproductively receptive
okta	A one eighth coverage of sea ice (or of clouds)
otariid(s)	Seal species of the family Otariidae; eared seals
otoliths	Bony structure from the inner ear of vertebrates, eg fish
pack ice	Sea ice formed from floating ice of varying ages and sizes that has been packed together; any area of sea ice other than fast ice
pagophilic	Ice inhabiting; species that breed on pack ice
parturient, parturition	Relating to the act or event of birth
pelage	Covering of fur or hair in mammals
pelagic	Applied to organisms that inhabit the open sea; living at the surface or middle depths of the ocean
peri-antarctic	The region surrounding the antarctic
phenotype	Observed physical properties of an organism, a combination of genetic inheritance and environmental influences
phocid(s)	Seal species of the family Phocidae; earless or true seals
pinnipeds	Seals, sea-lions and walrus; species of the order Pinnipedia
piscivorous	Of animals, those whose diet is predominantly fish
polygynous	Mating pattern where males have more than one female partner per season
post-partum	Period immediately following birth
proboscis	Trunk-like tubular extension of the snout
pupping	Period in which seals in a colony give birth to their young
purse seine	Nets operated from a vessel at the sea surface, first surrounding schooling fish then closing off the bottom of the net to prevent escape
serial monogamy	Mating pattern where males have several partners but only one at a time
set-net	Anchored net of varying size mesh to ensnare fish
tetracycline	Group of antibiotic drugs
toxicity	Capacity of a material to cause adverse effects in living organisms
transponder chips	Small silicon chips inserted under the skin that are used to uniquely identify animals and can be used to track movements
trawl	Fishing with a weighted net (usually) dragged along the sea floor, performed at depths from a few metres to about 1500m
troll	To fish with lines, using baits or lures, that are dragged behind or beside a moving boat
trophic level	Position in the energy/food chain in an ecosystem, ie from production through different levels of consumers
vesicula exanthema	A skin rash with fluid filled pustules, or a disease in which this is a symptom
zoonotic	Transmission of a disease from animals to humans

IX.2 Abbreviations and acronyms

AAT	Australian Antarctic Territory
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AGPS	Australian Government Publishing Service
AMSA	Australian Maritime Safety Authority
ANCA	Australian Nature Conservation Agency (now Environment Australia, Biodiversity Group)
ATS	Antarctic Treaty System
CCAMLR	Convention for the Conservation of Antarctic Marine Living Resources
CCAS	Convention for the Conservation of Antarctic Seals
CITES	Convention on International Trade in *Endangered* Species of Wild Fauna and Flora
EEZ	Exclusive Economic Zone
ESP	*Endangered* Species Protection Act 1992
ESSS	*Endangered* Species Scientific Subcommittee
GAB	Great Australian Bight
GABMP	Great Australian Bight Marine Park
ICES	International Council for the Exploration of the Sea
IUCN	The World Conservation Union, formerly the International Union for the Conservation of Nature and Natural Resources
NSW NPWS	New South Wales National Parks and Wildlife Service
SA NPW	South Australian National Parks and Wildlife
SCAR	Scientific Committee for Antarctic Research
SSG IUCN SSC	Seal Specialist Group of the IUCN Species Survival Commission
TAG	Taxon Advisory Group (of the Australasian Species Management Program)
TASPAWS	Tasmanian Parks and Wildlife Service
TB	Tuberculosis
TDR	Time-Depth Recorder
UNEP	United Nations Environment Program
WA CALM	Western Australian Department of Conservation and Land Management

Appendix X

Sources of information on seals and human interactions

Five pamphlets containing guidance on appropriate behaviour and relevant information for fishers and the general public are described briefly here.

Marine debris kills

It provides information on the biology of Australian fur-seals, summarises steps that have been taken to lessen interactions between fur-seals and fisheries in Tasmania, and encourages fishers not to discard rubbish from boats but to return it to bins in harbours.

Catch fish not birds

It describes how seabirds are killed in several fisheries; gill nets, drop line, longline - midwater set, longline - bottom set, trawl, aquaculture - finfish and trolling. It also includes practical suggestions aimed at saving fishers time and money, and at protecting seabirds.

Both pamphlets are published by
  Tasmanian Parks and Wildlife Service,
  GPO Box 44A, Hobart, TAS 7001
  fax 03 6233 3477.

Sea-lions

It provides information on the biology of Australian sea-lions, advises people how to behave in their presence, emphasises that these seals are dangerous, and that they occur on beaches and islands near Perth.

Published by
  Department of Conservation and Land Management,
  PO Box 104, Como, WA 6152
  fax 08 9334 0278.

New Zealand fur-seals - still at risk

It summarises interactions between New Zealand fur-seals and New Zealand fisheries, includes a map of New Zealand showing breeding sites and winter haul-out sites, and provides advice on how to behave at a seal colony.

Published by
  Royal Forest and Bird Protection Society,
  PO Box 631, Wellington, New Zealand
  fax +64 4 385 7373.

Encountering marine mammals in Alaska

It explains what people should and shouldn't do and how they should act when they encounter dead or live marine mammals in each of several situations; frightening them away from fishing gear, handling animals entangled in fishing gear or entangled in marine debris, approaching animals to view them, and dealing with stranded or dead animals.

Published by
  Alaska Sea Grant College Program,
  University of Alaska,
  138 Irving II Building, Fairbanks,
  Alaska, 99775-5040, USA
  fax +1 907 474 6285.