A population monitoring and research program to assist management of the Australian sea lion population at Seal Bay Conservation Park, Kangaroo Island

Photo: RR McIntosh

Draft Report to the South Australian Nature Foundation

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1 EXECUTIVE SUMMARY

Seals are the premier tourism attraction on Kangaroo Island and they underpin a regional multimillion dollar tourism industry. Its centrepiece is the Australian sea lion population at Seal Bay Conservation Park.

Monitoring of the trends in abundance of the population has been undertaken by the Department for Environment and Heritage (DEH) for over 30 years. Analyses of these data and the methodological basis of the surveys were not reviewed until recently, and determined that the population had been in decline for at least 20 years. This decline is continuing.

This report aims to provide stakeholders' with details of the monitoring and research program required to support the sustainable use of the Australian sea lion population at Seal Bay on Kangaroo Island. The report covers five topics including: a historical summary of research and monitoring of the sea lion colony; an evaluation of the current status of the population; a detailed appraisal of the ongoing management needs of the sea lion population in terms of population status, trends and demography, as well as targeted research programs; what an ongoing population management program should comprise of and what it would cost; and potential funding sources to support such a program.

The report recommends that sustainable use of the Australian sea lion population at Seal Bay should underpin the broader management objectives of the Seal Bay Conservation Park if it is to remain a sustainable tourism destination. A population monitoring and research program should be implemented that includes: 1) long-term monitoring of pup production, pup mortality and vital demographic rates, and 2) targeted projects that address specific data gaps and management needs. This program requires strong scientific leadership and management to ensure that results and methodologies are regularly reported upon and reviewed. Access restrictions, which presently impede monitoring and research activities at Seal Bay need to be reviewed.

For the population monitoring and research program to be effective, long-term recurrent funding will need to be secured. Options for cost-recovery from visitor fees and tourism operator licence fees should be investigated because alternate sources of funding are unlikely to be adequate to meet the real costs of population monitoring and research. Donations and sponsorships options should be investigated to supplement the costs of population monitoring and targeted research programs.

2 INTRODUCTION

Seal populations on Kangaroo Island form the basis of a valuable tourism industry, worth an estimated $72 million in 2001. Approximately 150,000 visitors come to the island each year (Kangaroo Island Tourism Optimisation Management Model (TOMM) Annual Report 2004-2005, http://tomm.info/reports_factsheets/annual_reports.aspx), most (~110,000) visit Seal Bay Conservation Park (Seal Bay hereon) and Flinders Chase National Park for opportunities to view populations of Australian sea lions (*Neophoca cinerea*) and New Zealand fur seals (*Arctocephalus forsteri*). As a consequence, observing wildlife forms the main activity of tourists on the island, involving 82% of all tourists surveyed in 2005/06, with 78% visiting Seal Bay (KI TOMM Visitor Exit Survey Report 2005/2006, http://tomm.info/media/contentresources/docs/TOMM_VES_2005-2006_FinalReport.pdf).

The species has recently been listed as *Threatened* (in the *Vulnerable* category) under the Australian Government *Environment Protection and Biodiversity Conservation* Act (1999). Based on the counts of pups, the Seal Bay population declined over a 20 year period until 2003 at 1.1% per breeding season (Shaughnessy et al. 2006) and has continued to decrease since then (McIntosh 2007).

The recently drafted National Parks and Wildlife (Protected Animals – Marine Mammals) Regulations 2007 noted that development of sustainable eco-tourism in South Australia is one of the goals of a number of South Australia's key strategic documents including 1) South Australia's Strategic Plan, 2) The Responsible Nature-based Tourism Strategy 2004-09 and 3) The SA Tourism Plan 2003-2008. South Australia's Strategic Plan details that in order to "halt the biodiversity decline, we must work together to protect South Australia's natural systems and where possible restore threatened plant and animal species and communities" (p 22, http://www.stateplan.sa.gov.au/). A key Biodiversity target is for no species loss (Target T3.1), a key performance measure being "no decline, and where possible an improvement in the regional status of known native species or the ecological communities form which they come from" (p. 23, http://www.stateplan.sa.gov.au/). The same document aspires to "increase visitor expenditure in South Australia's tourism industry from $3.7 billion in 2002 to $6.3 billion by 2014" (p 15, http://www.stateplan.sa.gov.au/). Clearly a declining Australian sea lion population at Seal Bay is contrary to the aspirations of the SA Strategic Plan, both in terms of halting biodiversity decline and increasing visitor expenditure.

Seal Bay is part of the Seal Bay Conservation Park situated on the south coast of Kangaroo Island, centred on 35.996 S, 137.327 E. The sea lion colony comprises four main areas (Figure 1) that are referred to as Pup Cove (2 km west of the visitor centre), the Western Prohibited Area (WPA), Main Beach, including the sand dunes and swales inland from Main Beach and the scrub behind the swales (referred to as the Road Reserve), and the Eastern Prohibited Area (EPA). Limestone promontories separate the WPA and EPA from Main Beach. Most pups are born in the WPA and at the western end of the Main Beach with smaller numbers of pups born in Pup Cove, inland from the WPA and Main Beach, in the dunes behind the eastern end of Main Beach, and in the EPA (McIntosh 2007). The WPA and EPA were declared in 1972 under the National Parks and Wildlife Act, 1972 (SA Government Gazette, December 7, 1972, pp. 2543-2544) for the “purposes of conserving the native animals on that portion of the Seal Bay Conservation Park described”.

A management plan for the Seal Bay Conservation Park exists (Anon. 1977) but its focus is the management of infrastructure, staff and visitors, and not on the natural assets that underpin the Park. Although significant advancements in our knowledge of the status, ecology and threats to the sea lion population at Seal Bay have resulted from research programs undertaken by staff from CSIRO and Universities in collaboration with Department for Environment and Heritage (DEH), there is currently no long-term monitoring and research strategy designed to safeguard seal populations for both biodiversity and economic needs. For example, pup numbers have been monitored for the last 30 years, but there is no program that provides ongoing assessment of pup production and population status. This is critical given that the population is declining and identified threatening processes (McKenzie et al. 2005, Page et al. 2004, Goldsworthy et al. 2007a, Goldsworthy and Page 2007) remain largely unmanaged.

There have been several discussions between managers from the Department for Environment and Heritage (DEH), researchers and other stakeholders over recent years, all of which have identified the need to fund a management, research and monitoring program at Seal Bay (e.g., McKenzie and Moss 2005). Given the recent listing of the species as *Threatened*, the documented decline in pup numbers, and the iconic status and importance of the Seal Bay sea lion population to the regional economy, it is imperative that a research and monitoring program be developed and implemented to assist the recovery of the sea lion population and to ensure the sustainability of ongoing tourism. This includes advising on day-to-day management, infrastructure placement and visitor access.

The broad aims of this study are to advise the SA Nature Foundation and other key stakeholders (eg. DEH) the research and monitoring program that is required to underpin the sustainable use and management of the Australian sea lion population at Seal Bay on Kangaroo Island. The study covers five topics, as follows:

- an historical summary of research and monitoring of the sea lion population,
- an evaluation of the current status of the population,
- a detailed appraisal of the ongoing monitoring and research needs of the seal lion population in terms of population status, trends and demography, as well as targeted research programs,
- what an ongoing population monitoring and research program should consist of and what it would cost, and
- potential funding sources to support such a program.

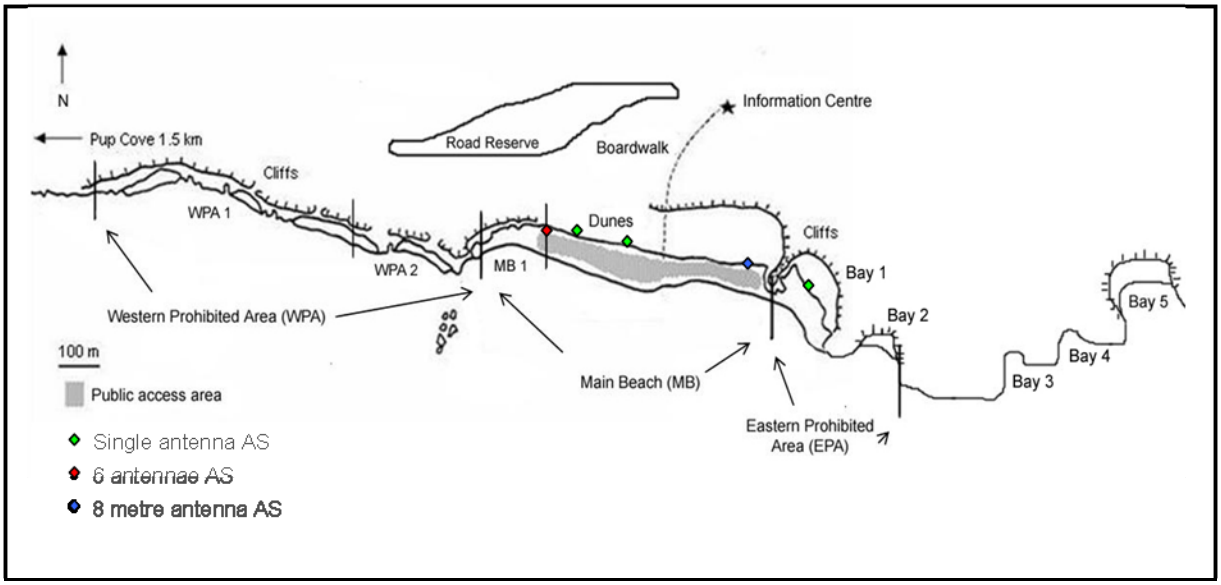

Figure 1. Map of Seal Bay breeding colony, Kangaroo Island, extended to Bay 5, east of the EPA. Western Prohibited area, Main Beach and Eastern Prohibited area comprise the main areas of the site. Positions of the automated scanners (AS) and the antenna type are noted by the coloured diamonds.

3 HISTORICAL SUMMARY OF RESEARCH AND MONITORING OF THE AUSTRALIAN SEA LION COLONY AT SEAL BAY

This section provides a summary of research and monitoring that has been undertaken on the Australian sea lion colony at Seal Bay. It is set out approximately chronologically.

3.1 Life history

John Ling and Greg Walker of the South Australian Museum, Adelaide studied various aspects of life history of Australian sea lions between 1975 and 1979 (Ling and Walker 1976, 1977, 1979), including:

- population censuses at Seal Bay
- movements of animals on Kangaroo Island from sightings of pups tagged at Seal Bay
- weight and length of sea lions at Seal Bay (Walker and Ling 1981)
- status of the species in South Australia
- determination of the breeding season at Seal Bay and Dangerous Reef, including documentation of an 18-month breeding cycle (Ling and Walker 1978).

3.2 Reproductive behaviour and maternal strategies

Leslie Higgins began her PhD study at Seal Bay in December 1985 under the supervision of Dan Costa, University of California at Santa Cruz. Her study extended over four breeding seasons (Higgins 1990); some of the outcomes were:

- duration of the interval between breeding seasons was refined to 17.6 months (Higgins 1993)
- timing of events between birth and weaning was documented (Higgins and Gass 1993)
- foraging trips of adult females lasted approximately 2 days initially and increased during lactation
- adult males did not maintain territories continuously during the breeding season
- attacks on pups by adult male sea lions were documented (Higgins and Tedman 1990).

3.3 Milk composition

The composition of Australian sea lion milk at Seal Bay was examined by Kretzmann et al. (1991), and Gales et al. (1996). Key findings were:

- mean proximate composition of milk was 31% lipid, 57% water, 10% protein and 0.9% ash
- milk fat content increased during lactation and was inversely proportional to water content
- milk had a higher lipid content during the second half of lactation (39%) compared with the first half (26%)
- there was great variation between samples that was partly related to pup age.

3.4 Reproduction - prolonged implantation period

Concentrations of progesterone and oestradiol were measured in the blood of 96 adult female sea lions at Seal Bay during pregnancy (Gales et al. 1997). Concentration of both hormones increased markedly about 3.5 months after the probable date of mating and reached peak values 5 months after parturition. Timing of the increase indicates that the blastocyst reactivates and implants after 3.5 to 5 months of pregnancy, and that embryonic diapause is of similar duration to that of other seal species. This suggests a prolonged post-implantation period (placental gestation) of up to 14 months for the Australian sea lion.

3.5 Diving behaviour and diving energetics

The diving behaviour and physiology of Australian sea lions was first investigated at Seal Bay by Costa and Gales (2003). Australian sea lions are benthic feeders and maximise the time spent at or near the bottom:

- adult females dive almost continuously while at sea;
- they maximise time spent at or near the benthos: 61% of each dive and 35% of their time at sea are at the deepest 20% of their dives;
- mean dive depths ranged from 41 to 83m, maximum dive depths ranged from 60-105m;
- energetic costs of foraging are high relative to other otariid seals, mean at-sea field metabolic rate are 7.05 ± 0.99 W kg^{-1}.

3.6 Ontogeny of diving behaviour

Shannon Fowler began a PhD study under the supervision of Dan Costa at University of California at Santa Cruz in 2000 (Fowler et al. 2006, 2007, in press). She studied the physiological ontogeny of diving ability and the ontogeny of diving and foraging behaviour in young sea lions and showed that:

- dive depth and duration increased with age, although the increase was slow;
- neither pups nor juveniles reached the depth or dive duration, or the home ranges of adults;
- juveniles have to work harder than adults when foraging because they are weaned before they reach full diving capability;
- females did not travel with their offspring at sea, suggesting young Australian sea lions learn foraging behaviours independently;
- both dive depth and duration appear to be impacted by the slow development of oxygen stores.

For species that operate close to, or indeed above their estimated physiological maximum, the capacity to increase dive depth, duration, or foraging effort would be limited. Restricted to shallow coastal waters, pups and juveniles are more likely to be disproportionately impacted by human activities. With limited available foraging habitat, young Australian sea lions appear particularly vulnerable to environmental alterations resulting from fisheries and/or climate change.

3.7 Behavioural response of sea lions to tourists

Terijo Arianna-Lovasz investigated the behavioural response of sea lions on Main Beach at Seal Bay in order to establish guidelines for approach distances by visitors (Arianna-Lovasz et al. 2005). Her study was done under the supervision of David Croft at University of New South Wales and Graeme Moss of the SA Department for Environment and Heritage, and is not yet completed.

At the currently recommended minimum approach distance of 6 m, 28% of sea lions on the tourist beach exhibited a change in behaviour, compared with 51% in an area that is usually undisturbed by humans. Adult males reacted at the greatest average distance (7.7 m) and juvenile males responded at the shortest average distance (5.2 m), although there was no significant difference between any of the age-sex classes.

3.8 Vocalizations

Isabelle Charrier and Rob Harcourt (Macquarie University, Sydney) studied sea lion vocalisations in mothers and pups during February 2005 (Charrier and Harcourt 2006). They showed that several acoustic parameters were highly specific between individuals.

Discriminant analysis correctly assigned calls to individual mothers and pups with an average classification rate of 65% and 77%, respectively.

3.9 Monitoring of entangled sea lions

Brad Page and colleagues collated data on entanglements on Australian sea lions and New Zealand fur seals on Kangaroo Island (Page et al. 2004). Data for Seal Bay covered each year between 1988 and 2002 and was mostly collected by interpretive staff there, and coordinated by Mel Berris. The incidence of entanglement for sea lions was 1.3% in 2002, which was the third highest rate reported for a seal species. The incidence did not decrease after governments and fishing industry associations introduced guidelines to reduce the impact of fishing on non-target species. Monofilament netting, as used in the bottom-set shark gill-net fishery was found on seals most frequently.

3.10 Monitoring of predation by white sharks

Injuries to sea lions at Seal Bay were recorded by interpretive officers at Seal Bay from 1988 to 2002 (Shaughnessy et al. 2007). Data were collated and checked by Terry Dennis and Mel Berris and showed that:

- 182 sea lions with injuries were recorded, at an average of 1.0 per month (s.d. 1.3);
- the number per year varied from 5 to 25;
- the incidence of injuries was highest in summer and autumn (December to May);
- the highest incidence was in January with 17%; this coincides with the higher proportion of white shark records around Kangaroo Island in summer and autumn than in other seasons (Bruce 1992);
- adult females and juveniles were injured most frequently, with 38% and 26%, respectively.

3.11 Monitoring using colony counts

Irregular and incomplete colony counts were conducted by various NPWSA staff and by researchers from 1962, including John Ling and colleagues in the 1970s. Regular monthly colony counts were begun by Terry Dennis in 1982. A more rigorous counting protocol was established in 1985 by Terry Dennis. From 1983, colony counts were conducted by interpretive staff at Seal Bay under the leadership of:

- Terry Dennis, February 1983-1988;
- Anthony Maguire, 1988-1996;

- Mel Berris, 1996-2003;
- Clarence Kennedy (Senior Guide), 2004-2007.

Those colony counts included the EPA (a ground count) and Pup Cove (from the cliff top).

From about 1995, Peter Shaughnessy encouraged NPWSA staff:

- to count dead pups;
- to avoid using the term 'pup' for young animals with their mothers after the first pup of the new cohort had been recorded; such animals should then be referred to as juveniles.

3.12 Monitoring trends in pup abundance based on colony counts

Monthly colony counts of pups at Seal Bay that are likely to have included peak pup numbers are available from 1973 (Shaughnessy et al. 2006). Data for live pups counted in the period 1973 to 2002-03 showed that the mean interval between pupping seasons was 532 ± 31 days (i.e., 17.5 months) (Shaughnessy et al. 2006).

A counting protocol was established in 1985 by Terry Dennis. Analyses of data for the maximum count of live pups in the period 1985 to 2002-03 showed:

- an average of 144 live pups per season;
- an annual decrease of 0.77% per year, or 1.14% per breeding cycle;
- a decrease of 12.6% for the overall period;
- correlation of the maximum pup count for the season with the duration of inter-breeding intervals, such that more pups were counted following shorter breeding intervals than following longer intervals.

3.13 Estimate of pup numbers using mark-recapture

Pup numbers were estimated at Seal Bay in late June 2003 by mark-recapture using a modified Petersen procedure (McIntosh et al. 2006a). Pups were marked with TIRIS microchips and by clipping hair on the rump. The identifying microchips were used to test for unequal catchability and to estimate the number of marked pups available for recapture (n = 74). The mark-recapture estimate was made after peak pup production, in the seventh month of the pupping season. The mark-recapture estimates averaged 144.1, which was 1.87 times the estimate from direct counting of live pups in the mark-recapture area (average of 77).

The best estimate of the number of pups at Seal Bay in the 2002-03 pupping season, incorporating the mark-recapture estimate, was 230 (95% confidence limits 203-257).

Pup numbers have also been estimated using the mark-recapture estimate procedure in the 2004 and 2005-06 pupping seasons (McIntosh 2007).

3.14 Marking sea lions at Seal Bay

A number of research programs have involved tagging of Australian sea lions at Seal Bay. These are summarised below:

(i) Tagging
Animals have been tagged with external flipper tags applied to the trailing edge of fore-flippers, as indicated below.

Years	Researcher	Type of tag	Number tagged
1975-78	John Ling et al.	Allflex & monel	362 pups
1986-90	Lesley Higgins	Roto & Dalton tags	170, mostly pups
1988-91	Nick Gales	Allflex	30 adult females
2001-02	Shannon Fowler	Allflex	50 pups
2005-06	Isabelle Charrier	Allflex	50 pups

(ii) Scars
In 1988, Lesley Higgins began using scars to identify individuals during her PhD research.

(iii) Resights of tags and scars
1988 to current: Seal Bay staff have recorded resights of scarred animals and tagged animals on Main Beach daily. They also recorded daily weather observations, dead animals seen and interesting or unusual behaviour. Data are stored in an ACCESS database and in historical log-book records at Seal Bay.

(iv) Microchipping
Microchipping of pups with implanted radio-frequency identification (RFID) tags was introduced in 1991 by Terry Dennis. 50-60 pups of both sexes were chipped each breeding season up to 2001 (Table 1). Nick Gales microchipped adult and juvenile animals in 1989. In the last three breeding seasons (2002-03, 2004 and 2005-06), R. McIntosh and colleagues with DEH staff have microchipped pups as part of her PhD research project (Table 1). Pups of

the last three cohorts were microchipped in most of the colony, including bays to the east of the EPA. Pups were not captured in Pup Cove or the EPA, but some were captured on the fringes of the EPA. At the end of the 2005-06 pupping season, at least 947 pups had been microchipped at Seal Bay, as well as some older animals.

(v) Scanning sea lions for microchips

- began in 1989;
- Seal Bay staff are trained (for up to 10 sessions);
- prior to 2006, one member of staff was rostered, generally once a fortnight for up to 4 hours;
- currently scanning is the responsibility of the Senior Guide at Seal Bay;
- the activity is sporadic and is focused predominantly in one area of the colony, the dunes inland from Main Beach (ie. effort is not standardised).

Table 1. Numbers of sea lion pups microchipped with RFID tags at Seal Bay (1989-2006).

Breeding season	No. pups microchipped
1989-90	15
1991	58
1992-93	62
1994	49
1995-96	50
1997	57
1998-98	58
2000	51
2001-02	53
2002-03	148
2004	202
2005-06	144

3.15 Demography

Rebecca McIntosh began a PhD study of population demography of the sea lions in 2000 under the supervision of Simon Goldsworthy (formerly of La Trobe University, Melbourne) and Peter Shaughnessy (South Australian Museum) (McIntosh 2007). She utilised records of

previously marked animals, including those with flipper tags, microchips and wounds from shark bites, and enhanced the program of marking pups with TIRIS microchips (Table 1). Numbers of scans of microchipped animals have been increased greatly using automatic data recorders at the inland side of Main Beach at Seal Bay. Data from these sources have been analysed to provide information on vital parameters such as survival rates, age at first reproduction and age-specific pregnancy rates. Some animals have been aged using growth layer groups in cementum of teeth; a single pair of lines is laid down annually. Longevity has been estimated at 26 years for females and 21.5 for males.

McIntosh improved the census techniques of live and dead pups by counting more frequently than had been done in previous seasons, by recording births and also by estimating pup numbers using a mark-recapture technique. Her studies covered three breeding seasons: 2002-03, 2004, 2005-06.

Some findings from McIntosh (2007) include:

- mortality was high in pups < 2 months old: 31% were dead by the end of the pupping season;
- in pups where the cause of death was determined, trauma through interactions with conspecifics was the main cause;
- a method to age Australian sea lions was developed using teeth;
- females first pupped at a mean age of 5 years (range = 3.8 - 6.1 years), with a mean age of breeding females of 11 years, with a maximum breeding longevity of 24 years.
- adult males were known to attend females by 14.6 ± 0.75 years and the oldest male identified was 21.5 years;
- growth between ages 1 and 20 years in males and between 1 and 24 in females matched sex-specific breeding patterns; males attain increasingly larger sizes to increase their likelihood of successfully competing for mates and females attain maximum (asymptotic) size when they start reproducing;
- annual survival of pups of eight cohorts aged 0.2 to 1.5 years ranged from 0.31 to 0.65 and was lower than the survival rates of juveniles > 1.5 years of age and adults (female: 0.96, male: 0.89);
- low cohort survival was correlated with the extreme El Niño of 1997-98;
- a life history table was produced and population projections modelled, based on the life history data obtained in the thesis. The analysis resulted in a 20% probability of extinction of the Seal Bay population within 128 years. When the level of pup survival was increased by 13% the declining population trajectory was stabilised. The inclusion of extreme climate anomalies such as extreme El Niño events increased the likelihood

of the population reaching quasi-extinction (with only 10 females remaining in the population).

3.16 Investigation of the health and disease status

In 2006, Dr Rachael Gray and Professor Paul Canfield, from the Faculty of Veterinary Science at Sydney University began a study into the current health and disease status of the Australian sea lion and the role of disease in sea lion mortality. The main aims of the project are to improve our knowledge of the health status of the Australian sea lion at Seal Bay and at other colonies in South Australia; to determine the incidence of disease in different Australian sea lion populations; and to ascertain the role of disease in causing mortality within different Australian sea lion populations.

Individual health of sea lions will be determined using body condition, physical examination, analysis of blood, examination of faeces for parasites, and the findings of post-mortem examinations performed on animals found dead within the colony to determine cause of death. Field work will involve several field seasons at Seal Bay and at other colonies within South Australia to sample individuals, and will include the collection of biological samples including blood, tissue samples from dead individuals found in the colony, hair, as well as observations on body condition and the findings of basic physical examinations.

The initial focus of this project is to determine the health and disease status of Australian sea lion pups. It is anticipated that future projects will involve sampling other age cohorts to establish baseline data and health and disease status, as well as the collection of samples in future years to facilitate ongoing monitoring of the health and disease status of this species.

3.17 Diet

Gales and Cheal (1992) identified that few hard parts remained in the scats of Australian sea lions. Using identifiable hard-parts of prey from scats, stomachs and regurgitates, Australian sea lions are known to be generalist predators that utilise prey near the benthos.

McIntosh et al. (2006b) undertook a dietary investigation of Australian sea lions at Seal Bay based on opportunistic collection of regurgitates and digestive tracts from recently deceased animals. Cephalopod remains were abundant, most of which were octopus (40% biomass reconstruction), giant cuttlefish (30%) and ommastrephid squids (14% biomass reconstruction). Fish species recovered included leatherjackets, flathead, swallowtail and

common bullseye, school whiting and yellowtail mackerel. Remains of southern rock lobster, swimmer crabs, little penguins and shark egg cases were also recovered.

Kristian Peters (PhD student Adelaide University and SARDI Aquatic Sciences) is currently undertaking a study using faecal DNA analysis to better understand the diets of Australian sea lions. Seal Bay forms one of his main survey sites where annual and seasonal differences in diets will hopefully be elucidated.

3.18 Population genetics

Richard Campbell undertook an investigation into the population genetics of Australian sea lions using mitochondrial and nuclear DNA markers for his PhD (Campbell 2003). This included samples collected from the Seal Bay population. Genetic markers revealed highly subdivided populations, sex-biased dispersal and strong regional divisions. Most importantly he identified extreme levels of female natal site fidelity that resulted in very high levels of genetic differentiation, both at macro and micro geographic scales, with fixed differences among populations separated by as little as 20km (Campbell 2003).

4 EVALUATION OF THE CURRENT STATUS OF THE POPULATION AND POTENTIAL THREATENING PROCESSES

4.1 Status of the population at Seal Bay based on trends of live pup counts

For the 13 pupping season between 1985 and 2002-03, analysis of data for the maximum count of live pups each season showed an annual decrease of 0.77% per year, or 1.14% per breeding cycle, which amounted to a decrease of 12.6% for the period (Shaughnessy et al. 2006, figure 2). The average count of live pups for that period was 144 per season.

By including the highest live pup counts for the next two seasons, 2004 and 2005-06, McIntosh (2007) showed that the general decline was still apparent, although less than that reported in Shaughnessy et al. (2006) at 0.69% per year (Figure 2).

4.2 Estimates of pup abundance at Seal Bay

In three recent breeding seasons, pup production has been estimated by mark-recapture, which gives a better estimate of abundance than direct counting. The first of these mark-recapture procedures was undertaken in June 2003, near the end of the 2002-03 pupping season (McIntosh et al. 2006a). For the whole colony in June 2003:

- the best estimate was 230 pups, which included the mark-recapture estimate and the count of dead pups
- the corresponding estimate using direct counts of live pups was 163
- the ratio of these two estimates for the colony is 1 : 1.41.

For live pups in June 2003:

- the mark-recapture estimate alone averaged 144 pups
- the direct counts averaged 77
- the ratio of these two estimates of live pups is 1 : 1.87.

Similar results were obtained by McIntosh (2007) for the next two pupping seasons (2004 and 2005-06, Figure 2).

4.3 Threats and impediments to growth of sea lion populations

The most notable feature of the sea lion population at Seal Bay is the continuing evidence for declining numbers. The principal cause(s) of this decline are unclear at this stage. McKenzie et al. (2005) detailed a range of potential impediments to the growth of Australian sea lions populations. They concluded that with respect to natural factors, the species' unique reproductive biology, population demography and philopatry may limit the rate at which populations may grow and disperse, but are not seen as ultimate factors that drive population change. They ranked the remaining natural and anthropogenic factors according to four key population-regulating attributes: 1) mortality rates, 2) prey availability, 3) foraging habitat suitability and availability, and 4) breeding habitat suitability and availability. In addition, they noted the main trophodynamic forcing direction on the species: bottom-up (when populations size is limited by the availability of prey) or top-down control (when population size is limited by predation). McKenzie et al. (2005) concluded that anthropogenic and top-down (mortality driven) factors were the most likely to cause a decline in Australian sea lion populations, and of these, fishery bycatch and entanglement were the only factors for which there was supporting evidence, at least in parts of the species' range. They noted, however, that these conclusions should be interpreted in the context of the limited quantitative data that were available for most factors at the time of writing their report. All of the factors identified have the potential to affect the growth of Australian sea lion populations (past, present and future), individually, additively and interactively at different locations and at different times (McKenzie et al. 2005).

Subsequent to the study of McKenzie et al. (2005) a better understanding of the nature of the risk associated with fishery bycatch has been evaluated by Goldsworthy et al. (2007a) and Goldsworthy and Page (2007). Fishery bycatch now represents the most critical management issue for the sustainability of the Seal Bay Australian sea lion population.

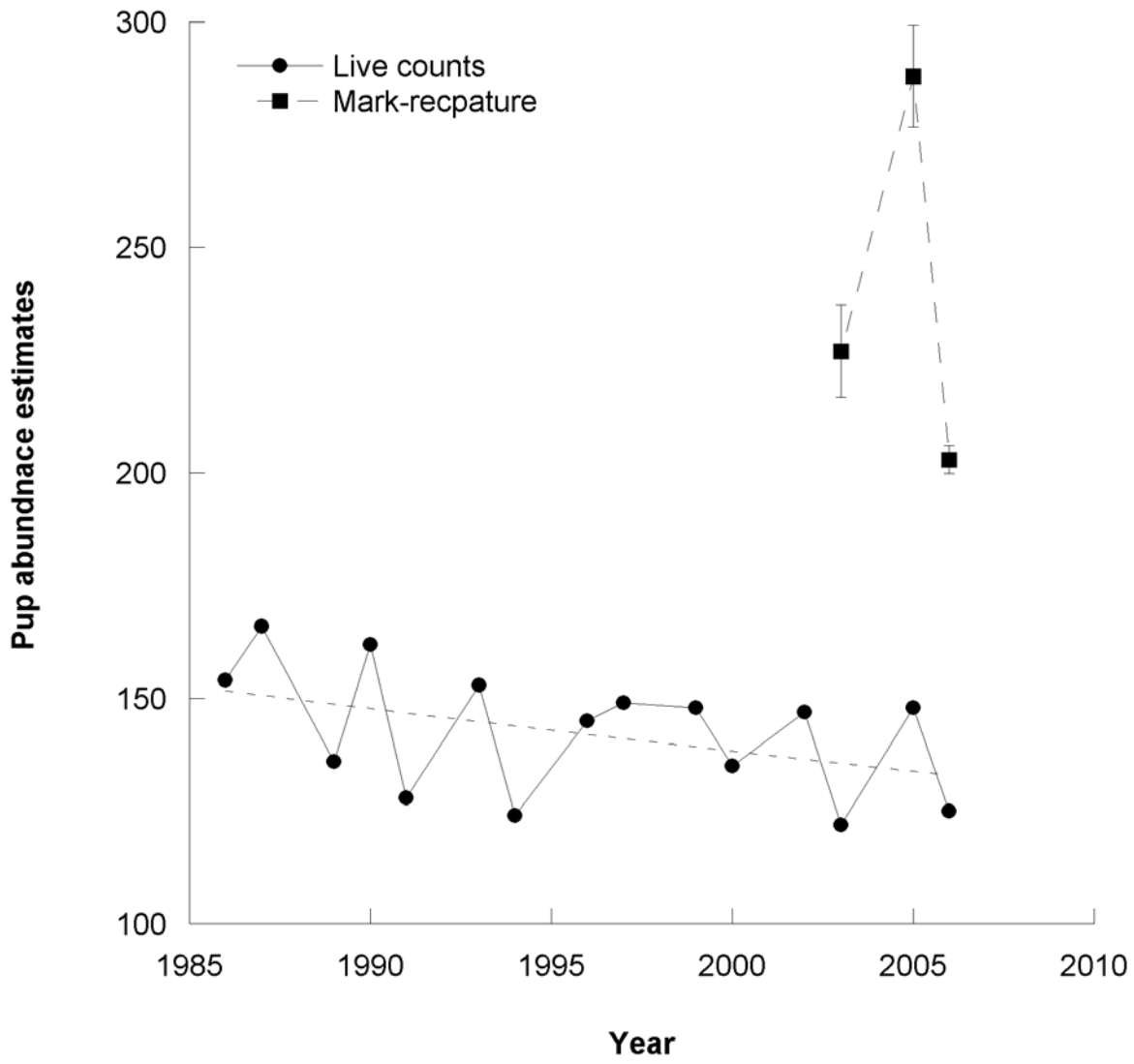

Figure 2. Trends in numbers of Australian sea lion pups at Seal Bay, 1985 to 2005-06, based on live counts of pups (with exponential curve), and mark-recapture estimates of live pups and cumulative dead pups 2002-03 to 2005-066 (data from Shaughnessy et al. 2006, McIntosh 2007)

5 APPRAISAL OF ONGOING POPULATION MONITORING, RESEARCH AND MANAGEMENT NEEDS FOR AUSTRALIAN SEA LIONS AT SEAL BAY

The sea lion colony at Seal Bay has special status because it is an iconic tourism destination that underpins an important regional tourism industry and because it supports one of the largest populations of the species. If it is to continue as a sustainable tourism destination, the ongoing viability of the population will need to be ensured. This will require the population to be actively managed, including monitoring and predicting population size and trajectory (status and trends in abundance), and identifying and actively managing any threats or threatening processes. Sound economic and environmentally-based management of the population should ensure that its use is sustainable into the future.

5.1 The last 30 years

During the last 30 years, the focus at Seal Bay has been on visitor management and commercial operations. The management plan for the Seal Bay Conservation Park (Anon. 1977) focuses on the management of infrastructure, staff and visitors, and not on the sea lion population. Over this period the management of visitors at Seal Bay has become more regulated, and infrastructure and facilities improved significantly including sealed road access and car park, board walks, toilet facilities, information centre and shop. Annual visitor numbers have significantly increased over this period from <40,000 in the late 1980s to an average of about 100,000 since mid-1990s (see Figure 3). Staffing levels to manage visitors and maintain infrastructure have also increased over this period.

Ongoing monitoring of the sea lion population is clearly recommended in the management plan for Seal Bay; it is included as a means of implementing the first objective of the plan (Anon. 1977, p. 28): “The sea-lion population should be closely monitored, on a regular basis. Monitoring can be largely based on regular head counts as in the past decade, but tagging and associated counting methods should also be employed to provide an accurate check on numbers”. Ongoing population censuses at Seal Bay were also recommended in the consultancy report to the Australian Government Department of Environment and Heritage entitled “Understanding the impediments to the growth of Australian sea lion populations” (McKenzie et al. 2005, p. 76).

Over the last 30 years there has been limited and variable funding and human resources engaged by DEH to monitor the sea lion population at Seal Bay. As a consequence, the effort and consistency in monitoring methods has also varied considerably. For example, data on pup abundance has been collected for most breeding seasons since 1973-74 (see Dennis 2005, McIntosh et al. 2006a, Shaughnessy et al. 2006). However, analysis of these data by Shaughnessy et al. (2006) identified significant limitations and much of it could not be used meaningfully.

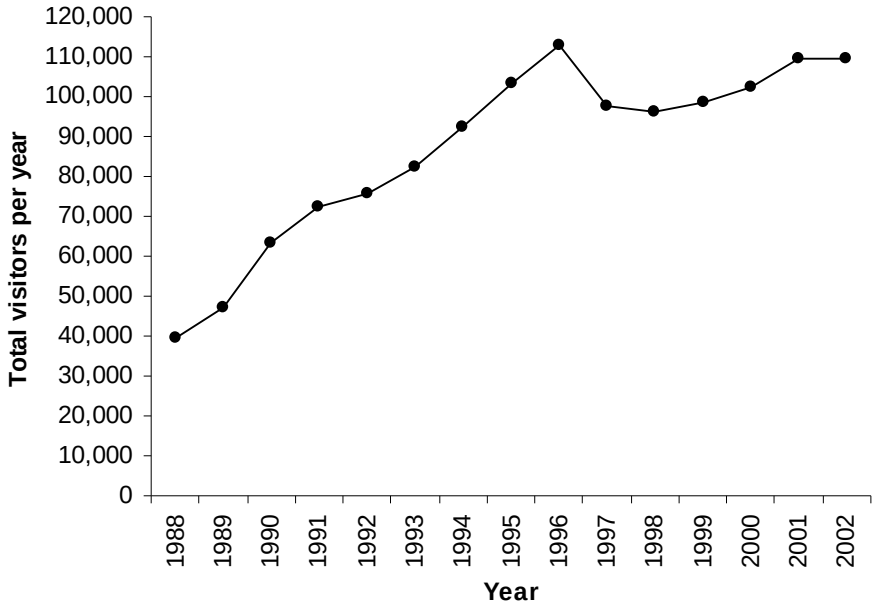

Figure 3. Visitation statistics, Seal Bay Conservation Park 1988-2002 (data from SA DEH).

Most of the data collected have been on live pup counts, and it is now known that such indices of abundance significantly underestimate pup production, by as much as 187% (McIntosh et al. 2006a). The lack of focus and commitment of resources to population monitoring have resulted in limited ongoing methodological evaluation to ensure that the data are providing adequate monitoring of the population. Such evaluation has only been done recently by University and Government based researchers. Given the vagaries in the data available to date, the best appraisal of indices of pup abundance over the last 20 plus years is that the population has been in steady decline (Shaughnessy et al. 2006). As we know that methods used to survey pup abundance over the last 30 years are inappropriate, recent efforts have been made to develop more appropriate methods to monitor the population (McIntosh et al. 2006a, McIntosh 2007, Shaughnessy et al. 2006).

A number of observations can be made following this 30 year period:

- The focus of management of the Seal Bay Conservation Park has been and still is, on visitors, and the facilities and infrastructure to support and manage commercial operations, not on the sea lion population.
- Investment in population monitoring over the last 30 years has been inadequate and ill-directed. This has resulted in:
    - inappropriate survey methods being developed and used,
    - no ongoing evaluation and analysis of data or methodologies,
    - no formal assessment or process to evaluate and report on the status and trends in abundance in the population,
    - a failure to detect systemic population decline until recently, and
    - limited implementation of research findings into day-to-day management activities.

As regretful as this population decline is, it is fortunate that it has been detected before it has had permanent ramifications on the sustainability of the population at Seal Bay, and the longer-term economic viability of tourism at Seal Bay.

5.2 The future

Although significant advances in our knowledge of the status, ecology and threats to the sea lion population at Seal Bay have resulted from research programs undertaken by staff from Government research agencies (eg. CSIRO and SARDI) and Universities in collaboration with Department for Environment and Heritage (DEH), there are no integrated long-term research and management strategies that aim to safeguard the seal population for both biodiversity and economic needs. Beyond requirements to ensure that the *Threatened* Australian sea lion is managed in accord with State and Federal legislation, there are important social and economic benefits that underpin the need for adequate population conservation and management. These include direct benefits to the regional tourism industry and broader business community. Further, revenue generated by the park is used by DEH to fund broader conservation and biodiversity programs in other parts of the state.

Clearly, securing the future of the Australian sea lion population at Seal Bay is in the interests of the tourism and business community, and in the social interests of the Australian and international community. There is hence a strong need to ensure that an effective and rigorous population monitoring and research program (involving monitoring and research) is developed and implemented at Seal Bay. Below we summarise what an integrated population management program should include. This is broadly separated into ‘long-term’ and ‘targeted-

' programs. We also discuss some of the current impediments to population management that should be addressed.

5.3 Identifying the needs of a population monitoring and research program

In developing a population monitoring and research program for Seal Bay, it will be important to clearly define the program goals and to develop key performance measures. It is not our intention to define these specifically here, but broadly the goals of a population management should include the following:

That the Australian sea lion population at Seal Bay be managed to ensure that:

I. the requirements under State and Australian Government threatened and protected species legislation are met;
II. the level of commercial use of the population for tourism is not adversely impacting the population and is sustainable;
III. the population remains viable into the future.

Key performance indicators should at least include the following.

1. Status and trends in abundance in the Seal Bay Australian sea lion population are monitored regularly and adequately.
2. Threatening processes are identified, monitored and managed.
3. Population decline is arrested.
4. Population size increases or stabilises at sustainable levels.
5. Monitoring and research programs have practical benefits for managing the population, and/or enhancing educational opportunities for visitors and the broader public.
6. Monitoring and research are adequately resourced, managed, reported upon and reviewed.

Long-term monitoring

Population status and trends in abundance

The number of pups that are born per breeding season that survive to weaning is the most critical and perhaps readily measured reproductive performance parameters in sea lion populations. These data provide an instantaneous measure of the number and quality of offspring able to be produced by a population, and integrate information of the size, age-structure and fecundity of populations, and the environmental conditions during the gestation and lactation period. However, pup production and weaning rates are not straightforward to

measure. The Australian sea lion breeding season is lengthy, lasting up to 9 months in duration, and to adequately estimate number of births and deaths requires some level of ongoing surveys throughout the breeding season to ensure that appropriate estimates can be calculated. A problem with past monitoring programs has been that surveys of pup abundance by direct counting have only estimated part of the pup production, and retrospective analyses have identified that counting significantly underestimates pup production (McIntosh et al. 2006a, McIntosh 2007, Shaughnessy et al. 2006). Direct counting methods are prone to underestimation due to *sightability* and *availability biases*, and only provide point estimates of numbers that do not have confidence limits. At Seal Bay, almost 50 % of pups can be hidden from view during direct counting procedures (McIntosh et al. 2006a). Recently, mark-recapture methods using the Petersen estimate have improved estimates of Australian sea lion pup production at some large colonies, and have addressed some of the under-estimation caused by *sightability biases* (Goldsworthy et al. 2007b, McIntosh et al. 2006a, McIntosh 2007). Goldsworthy et al. (2007b) utilised individual resight histories of pups and Cormack-Jolly-Seber (CJS) models in conjunction with standard mark-recapture methods to further improve estimates of pup production in large sea lion populations.

For the Seal Bay population under the current access restrictions, McIntosh (2007) recommended estimating pup production from a count of live pups in Pup Cove, added to CJS mark-recapture estimates, along with the cumulative count of dead pups to that date. Ultimately the best estimates of pup production and mortality would be derived from recording of new births and deaths, which is possible at Seal Bay with twice weekly surveys of the colony, but would require access to all areas throughout the breeding season.

Monitoring of pup production and mortality would involve:

- Regular and frequent surveys of new births (with their location) and deaths (number and cause) during the breeding season.
- Hair-clip marking (see Figure 4), tagging (internal RFID tags), sexing and measuring (mass & length) of pups.
- Regular re-sighting efforts to determine which individuals are alive (Figure 5).
- Regular mark-recapture surveys undertaken throughout the breeding season.
- Strong scientific management and coordination of surveys.
- Results reported upon and reviewed shortly after each breeding season.

Population demography – monitoring of vital rates

Data from Seal Bay and other Australian sea lion colonies indicate that a high level of variability in pup production between breeding seasons may be typical in this species. As

such, changes in the pup production across successive breeding seasons may not provide accurate measures of population status. Changes in population vital rates, such as age-specific and cohort survival and recruitment provide better measures of the longer-term demographic vulnerability of populations, and provide a better means to forecast future population trajectories.

The benefits of having an individually-marked, known-aged population at Seal Bay have been embraced by DEH and previous researchers that have undertaken studies at Seal Bay. In 1991, the tagging of pups using implantable RFID or PIT tags commenced, in conjunction with a regular resight (scanning) program (see Figure 5). Between 1991 and 2001, 50-60 pups were chipped each breeding season. Since 2002-03, the number chipped has increased to between 144 and 202 per season (Table 1). In additional to regular hand-held scanning, a number of automated recording stations comprising of RFID flat-bed aerials have been placed in the sand along major sea lion paths between the beach and dune areas. This has greatly increased the numbers of resight records of tagged animals, and improvements to these passive recording systems are proposed.

McIntosh (2007) has undertaken the most comprehensive demographic analyses of the species, principally from resight records of marked animals at Seal Bay. Important information relating to the maintenance of the Seal Bay sea lion population can be gained from maintaining this demographic program. It provides a context for pup abundance data, and provides a means to examine the role of environmental factors in regulating sea lion survival and fecundity, and for developing population models, from which future changes in population trajectories can be predicted. With increased numbers of pups being tagged within each cohort, and the increased resighting probability as a consequence of passive receivers placed within the colony, high quality resight data is being obtained readily and cost-effectively.

An on-going demographic program would aim to achieve two goals:

- determine breeding season and cohort-specific survival rates; and
- determine breeding season and cohort-specific fecundity rates.

The achievement of these goals would require:

- RFID tagging of all pups of each cohort;
- ongoing passive re-sighting from a network of aerials and data-loggers;
- active re-sighting program (using a hand-held aerial), especially for females and mother-pup pairs during each breeding season (to monitor fecundity and maternity);
- strong scientific leadership and management with results reported upon and reviewed regularly.

Figure 4. An Australian sea lion pup displaying hair clipped across its rump, indicating that it has been micro-chipped (Photo R. McIntosh).

Figure 5. Scanning for mircrochips in Australian sea lions at Seal Bay (Photo R. McIntosh).

Targeted projects

To complement long-term monitoring programs, there will be a need for targeted research to support ongoing population management. The most critical of these will be those that aim to identify the cause(s) of decline in the population, and understand more about threatening processes with a view to monitor and mitigate them. The management of key anthropogenic factors, such as fisheries interactions of sea lions, is a priority. Natural causes of mortality, particularly the role and significance of disease and parasites, are poorly understood.

Knowledge of basic biological and ecological aspects of the species is still poor. Given that the reproductive biology of Australian sea lions is unique among pinnipeds, the factors that are important in maintaining populations of other species may not be the same for Australian sea lions, hence a better understanding of the selective processes and environmental factors that have shaped their unusual reproductive biology is important. Ensuring the long-term sustainability of the Seal Bay population may also require management of their foraging habitat and prey resources (which may involve spatial and temporal management of fishing effort). Knowledge of the species' foraging habitats and prey, especially sex and age differences, and how diet and foraging locations vary with season and year is poor. There is also a need to ensure that visitor disturbance and commercialisation are ecologically sustainable and sensitive.

There is an important role that research can play in educating the public about the biology and ecology of Australian sea lions, and more broadly about the management of threatened marine species. Given that Seal Bay is Australia's largest sea lion tourism site, that South Australia has about 80% of the sea lion population, and that the Australian Government Seal Lion Recovery Plan is due to be released in late 2007, there is an opportunity for the public focus of the recovery of this species to be at Seal Bay. This provides unique educational and marketing opportunities.

Targeted researchs could include:

- studies on foraging habitat and diets, including sex and age and season and year differences;
- studies on disease and parasites;
- threatening processes: identification, monitoring and mitigation (eg. fisheries interactions);
- reproductive ecology;
- visitor interaction issues;

Current impediments to population management

Presently, the WPA and Main Beach areas are accessible for research purposes (including pup surveys) according to permit approval. Access to the EPA is more restricted. Access by researchers is only permitted when DEH staff undertake their monthly count of sea lions and sea lions cannot be captured at any time in the EPA. These restrictions do not apply for the removal of entanglements and the necropsy or collection of dead individuals.

The greater restrictions applied to access to the EPA are locally applied and not referred to in the management plan (Anon. 1977), nor its amendment in 1993, nor in the declaration of the prohibited areas (SA Government Gazette, 7 December 1992, p. 2543-2544). Zoning and access restrictions should be focused around the management of visitors and their potential impacts on the site and the sea lion population; they should not impede population monitoring and research. These restrictions significantly reduce the accuracy of the recommended pup production assessment methods, including direct counts of new births and deaths, and mark-recapture estimates (McIntosh 2007).

Presently, research and monitoring are restricted to being conducted between 9am and 5pm, when interpretive staff are at Seal Bay. This restricts access to sea lions on the Main Beach and adjacent areas, which are in sight of visitors. Before-and after-hours access for research and monitoring would increase efficiency of monitoring work (pup surveys, scanning etc), enable work to be undertaken in the cool of the day, and reduce the potential for conflict between population management and impacts on visitor experience. This has been allowed in the past provided a Seal Bay staff member was on location and the researchers carried a GRN radio.

Currently, all research and monitoring activities undertaken on sea lions require a permit from DEH and an appropriate Animal Ethics Committee approval. Further advice on how research activities are to be undertaken relative to visitor tours at Seal Bay is given by the Seal Bay Site Manager, Senior Guide and the regional Conservation Programs Manager. These procedures are the most appropriate avenue for ensuring the monitoring and research activities undertaken are appropriate and sensitive, and that impacts on visitor experiences are minimal.

Recommendations:

- Access for research and monitoring in the EPA should be available under permit conditions as they are for the WPA.

- a re-evaluation of the extent of Prohibited Areas within the Seal Bay Conservation Park needs to be undertaken to ensure all areas of critical breeding habitat of Australian sea lions are included;
- access for research and monitoring before and after the hours that interpretive staff are at Seal Bay, should be available under permit;
- specific conditions and guidelines for research and monitoring of Australian sea lions at Seal Bay need to be agreed upon, and included in research permits.

6 WHAT WOULD AN ONGOING POPULATION MONITORING PROGRAM COMPRISE, AND WHAT WOULD IT COST?

The monitoring and research activities associated with population management at Seal Bay should be jointly managed by scientists at SARDI Aquatic Sciences and the Conservation Programs Manager, DEH Kangaroo Island. SARDI Aquatic Sciences is the appropriate research provider because several researchers in that group (and others associated with it) have considerable experience working with Australian sea lions at Seal Bay and elsewhere in South Australia.

The long-term population monitoring program recommended for the sea lion population at Seal Bay comprises three elements:

- assessment of pup production and mortality each breeding season;
- determination of breeding season and cohort-specific fecundity rates; and
- determination of season and cohort-specific survival rates.

Assessment of pup production and mortality requires censuses during breeding seasons, which occur about every 17.5 months and last between 6-9 months (with 90% of pups being born over a 4.7 month period (Shaughnessy et al. 2006). Determination of season and cohort-specific fecundity rates requires scanning of females for microchips during breeding seasons. Determination of survival rates requires the scanning of sea lions at Seal Bay throughout the year using both automated and hand-held scanners.

Much of the rationale justifying monitoring and research approaches has been detailed in the previous section. Here we detail the practical aspects of what personnel and financial resources would be required to achieve the needs identified for long-term monitoring. Times and costs are meant to be indicative.

We provide three scenarios. The first details personnel and financial resources that are required to monitor the Australian sea lion population at Seal Bay. The second scenario includes monitoring pup production at the Seal Slide and The Pages islands populations (ie. including the monitoring of all sea lion populations in the Kangaroo Island region). The third scenario includes monitoring all seal populations in the Kangaroo Island region (ie. including New Zealand fur seal and Australian fur seal breeding populations in the Kangaroo Island region). The latter scenarios are included because management of seals for tourism and conservation on Kangaroo Island should include monitoring and managing all seal species at all sites. Budget scenarios are indicative only and approximate current costs (ie. they do not

take into account inflation in future years). Details of in-kind contributions from both DEH and SARDI are not included.

Scenario 1: Population management program for sea lions at Seal Bay

Work-plan

Project management: Jointly managed by SARDI (Goldsworthy) and the Conservation Programs Manager, DEH Kangaroo Island (KI).

Assessment of pup production and mortality: during each breeding season, monitor of breeding areas at Seal Bay twice per week to detect additional newborn and dead pups. This activity can be undertaken by a single person. Handling of pups for micro-chipping requires two people for 3-4 days each month over a four month period. Mark-recapture exercises should be undertaken as part of colony surveys each week after pup marking has commenced.

Assessment of fecundity rates: during the twice-weekly surveys, females are scanned for microchips using a hand-held scanner to determine which of them has pupped.

Assessment of breeding season and cohort survival: survival rates of micro-chipped seals can be monitored by scanning during the twice-weekly surveys and through passive scanning by automated scanners placed throughout the colony (Figure 1).

Annual Budget

Note: The budget provides estimates of annual costs. As sea lions breed approximately every 1.5 years, budget lines are presented as annual costs by multiplying by 0.67.

Budget items	Days	FTE	Funded	In-kind
Personnel				
DEH Conservation Programs Manager	10	0.05	$ 4,811	Yes
DEH P01-3 (9d/m during breeding season (9m), 3 d/m rest of year (9m) + 10d planning/data management)	83	0.40	$ 32,698	
SARDI Principal Research Scientist	30	0.14	$ 21,404	
SARDI PO1-3 (5d x 4 trips/breeding season, 20d planning, data management, analysis)	33	0.16	$ 13,158	
Travel				
Ferry and vehicle x 4 trips @ $240/trip x 0.67			$ 640	
Vehicle mileage 900 km/trip x 4 trips @ $1.20/km x 0.67			$ 2,880	
Accommodation & food for RO 16 d @$100/d x 0.67			$ 1,067	
Travel to KI for Principal Scientist @$150/trip per year			$ 150	
Operating				
RFID tags 250 @ $8 x 0.67			$ 1,333	
RDFI readers and maintenance			$ 6,000	
SARDI Overheads - discounted rate			$ 22,465	
DEH operating costs			$ 11,000	
Reporting costs			$ 900	
Total per annum (excluding in-kind)			$ 113,694	

Scenario 2: Population management program for all sea lion colonies in the Kangaroo Island region

Work-plan

Project management: as per scenario 1.

Assessment of breeding season pup production and mortality: as per scenario 1 for Seal Bay. For the Seal Slide, five surveys per breeding season, by two people for at least 4 of the surveys (to capture and mark pups). For The Pages Islands, four surveys per breeding season are required. Pups need to be tagged (on the fore-flippers) over three visits, with re-sight surveys and mark-recapture undertaken during each survey. Access to The Pages islands is via helicopter.

Assessment of fecundity rates and of breeding season and cohort survival: as detailed in scenario 1 for Seal Bay. There are no plans at this stage to undertake long-term demographic studies at other sea lion colonies in the region. Some Seal Slide pups will be micro-chipped each season, and if they visit Seal Bay they are likely to be identified through active or passive scanning.

Annual Budget

Note: The budget provides estimates of annual costs. As sea lions breed approximately every 1.5 years, some budget lines are presented as annual costs by multiplying by 0.67.

Budget items	Days	FTE	Funded	In-kind
Personnel				
DEH Conservation Programs Manager	20	0.10	$ 9,621	Yes
DEH P01-3 (Scenario 1+ 5d Seal Slide & 8d The Pages/season + 15d management/coordination)	97	0.46	$ 38,213	
DEH OPS 2-3 Ranger (The Pages 8d)	8	0.04	$ 2,229	Yes
SARDI Principal Research Scientist	40	0.19	$ 28,538	
SARDI PO1-3 (Scenario 1 + 4d Seal Slide + 8d The Pages/season +25d planning/data management/analysis)	47	0.22	$ 18,516	
Travel				
Ferry and vehicle =scenario 1			$ 640	
Vehicle mileage = scenario 1 + 150 km x 4 trips @ $1.20/km Seal Slide			$ 3,360	
Accommodation for RO = scenario 1 + 4 d @$100/d			$ 1,333	
Travel to KI for SPM = scenario 1 + 1 trip @$150/trip			$ 300	
Operating				
The Pages -helicopter Cape Willoughby to Pages + operating, 4 trips x @$2,700 per 1.5 years			$ 7,236	
RFID tags 250 @ $8 x 0.67			$ 1,333	
RDFI readers and maintenance			$ 6,000	
Flipper tags 500 tags/ breeding season @$1.20/tag			$ 400	
SARDI Overheads - discounted rate			$ 30,585	
DEH operating costs			$ 11,000	
Reporting costs			$ 1,000	
Total per annum (excluding in-kind)			$ 148,455	

Scenario 3: Population management program for all pinnipeds in the Kangaroo Island region

Work-plan

Project management: as per scenario 1.

Assessment of per breeding season pup production and mortality: as per scenario 2 for Australian sea lion colonies. For New Zealand fur seals, pup production is assessed annually at Cape Gantheaume (including Berris Point and Cape Linois) and Cape du Couedic. Surveys are undertaken in late January, immediately following the breeding season. Australian fur seals have recently been recorded breeding on North Casuarina Island (Shaughnessy and Goldsworthy 2007). This population should also be monitored annually.

Assessment of fecundity rates and of breeding season and cohort survival: as detailed in scenario 1 for Seal Bay.

Annual Budget

Note: The budget provides estimates of annual costs. As sea lions breed approximately every 1.5 years, some budget lines are presented as annual costs by multiplying by 0.67.

Budget items	Days	FTE	Funded	In-kind
Personnel				
DEH Conservation Programs Manager	20	0.10	$ 9,621	Yes
DEH P01-3 (Scenario 2 plus 20d NZFS surveys + 25d planning & coordination)	127	0.60	$ 50,032	
DEH OPS 2-3 Ranger (The Pages 8d, NZFS surveys 6 staff x 6d)	44	0.21	$ 12,257	Yes
SARDI Principal Research Scientist	50	0.24	$ 35,673	
SARDI PO1-3 (Scenario 2 plus 14 d NZFS surveys, 30d planning & coordination)	66	0.31	$ 26,001	
Travel				
Ferry and vehicle =scenario 1 + 1 trip			$ 880	
Vehicle mileage = scenario 2 + 1000km @ $1.20/km NZFS surveys			$ 4,560	
Accommodation for RO = scenario 2 + 7 d @$100/d (NZFS surveys)			$ 2,033	
Travel to KI for SPM = scenario 2 + 1 trip @$150/trip			$ 450	
Operating				
The Pages -helicopter Cape Willoughby to Pages + operating, 4 trips x @$2,700 + and North Casuarina @$1,800			$ 8,200	
Operating costs NZFS surveys			$ 8,500	
RFID tags 250 @ $8 x 0.67			$ 1,333	
RDFI readers and maintenance			$ 6,000	
Flipper tags 500 tags/ breeding season @$1.20/tag			$ 400	
SARDI Overheads - discounted rate			$ 40,088	
DEH operating costs			$ 11,000	
Reporting costs			$ 1,500	
Total per annum (excluding in-kind)			$ 197,450	

7 POTENTIAL FUNDING SOURCES TO SUPPORT AN ONGOING POPULATION MANAGEMENT PROGRAM

Monitoring of the Seal Bay population has been funded through a variety of sources. These have included some discretionary funding by the Kangaroo Island Conservation Programs Manager (DEH) for staff time to undertake monthly counts (eg. Seal Bay Senior Guide, 2 d/week), and to purchase RFID tags to assist in maintenance of the pup tagging program. Most resources have come from funds directed through external research programs, provided by the SA Wildlife Conservation Fund (DEH), the Nature Foundation of SA, the National Heritage Trust (through the Australian Government Department of Environment and Water Resources), and the Sea World Research and Rescue Foundation and CSIRO. However, these programs and the funding tied to them have been for targeted (period-defined) projects. There is presently no recurrent and directed funding through DEH to maintain and manage long-term monitoring of the Seal Bay Australian sea lion population or any other seal colonies in the region. The current arrangement is inadequate and options to secure funding need to be explored. This chapter provides some options that should be considered in order to guarantee recurrent funding to secure the various population monitoring scenarios detailed in the previous chapter. These options generally fall into five categories: 1) State Government funding, 2) Australian Government funding, 3) non-Government grants, 4) donations and sponsorship, and 5) cost-recovery (eg. visitor entry and commercial tour operator fees).

7.1 Potential funding sources

State Government funding

Some DEH State Government funding, as well as National Heritage Trust (NHT) funding through the State Natural Resource Management (NRM) Board, is allocated to conservation and management programs on Kangaroo Island each year, managed at the regional level by the Conservation Programs Manager, Kangaroo Island. Examples include funding for threatened species (eg. glossy-black cockatoos, and threatened plants) and pest species management of both native (eg. koala) and introduced biota (eg. weeds, goats, pigs and deer). Some of these funds have come through NRM, Threatened Species Network (TSN) or SA Wildlife Conservation Fund (WCF) grants. DEH discretionary fund grants are used to assist some programs. In the past, some of these funds have been directed toward seal monitoring, both at Seal Bay and to cover some of the costs for annual New Zealand fur seal surveys (eg. ~$2,000 annual operating budget, provision of staff to assist with surveys). Although funding may be available to support some targeted projects, recurrent funding for the

costs of maintaining a long-term monitoring program are unlikely to be secured from these sources.

Australian Government funding

Australian Government funding for Australian sea lion research is through the Department of the Environment and Water Resources (DEWR). There are two main competitive funding programs relevant within DEWR: the Marine Species Recovery and Protection (MSRP) grants Program, which is a component of the National Recovery Plans, Marine and Terrestrial Program of the NHT; and the Australian Centre for Applied Marine Mammal Science (ACAMMS) which has been funded in part through the Commonwealth Environment Research Facility (CERF) program. Both funding bodies provide grants for period-defined (12 month) projects. ACAMMS is planning to fund projects for up to 3 years in 2008. DEWR also offer tenders for threatened species projects. The Australian Sea Lion Recovery Plan is scheduled to be released in late 2007, and this may result in additional Australian Government funds being made available for sea lion research. Seal Bay is only one of over 75 known breeding sites for the species, and Recovery Plan funding will have to be spread in such a way to manage/mitigate threats and assess/monitor population status across the range of the species.

Non-Government grants

There are a number of non-Government granting agencies that have provided funding for sea lion research at Seal Bay. These include the Nature Foundation of SA and the Sea World Research and Rescue Foundation, which fund period defined research, usually 1-3 year projects at <$20,000 per year.

Donations and sponsorship

Presently none of the revenue collected at Seal Bay is specifically returned to meet the costs of monitoring the status and health of the population, or to manage threats to it. However, revenue raised at Seal Bay broadly contributes to covering the salaries of DEH staff in SA, including the Senior Guide (Seal Bay) and the Conservation Program Manager (Kangaroo Island). Visitors can contribute to monitoring and research of the Seal Bay population by donation. A donation box has been placed in the Seal Bay visitor centre. The Nature Foundation of SA established an Australian sea lion Research Fund, and placed a ‘money-spinner’ and brochures in the Seal Bay visitor centre and at the Adelaide Zoo, to encourage donations. The money will be directed towards research that assists with the management of Australian sea lion populations.

Sponsorship for monitoring and research from major businesses and corporations should be investigated. For example, the Phillip Island Nature Park in Victoria has significant corporate

sponsorship from BHP Billiton, Esso/Mobil and the Southcorp Wines/Foster's Group. Corporations such as SeaLink Kangaroo Island would be an obvious business to target for sponsorship, because they are a major beneficiary of the sea lion population at Seal Bay. Based on information on their web site (http://www.sealink.com.au/Sponsorship.html) they currently do not provide cash support, but provide SeaLink Travel Group products and services.

Cost recovery

Proposed amendments to the National Parks and Wildlife (Protected Animals – Marine Mammals) Regulations 2007 aim to provide an appropriate level of protection for marine mammals by:

- establishing caution zones and approach limits around marine mammals, and restricting certain activities (eg. vessel speed, approach direction) within the caution zone;
- ensuring consistency between the Regulations and the National Guidelines;
- mandating permits for commercial operators that utilise marine mammals; and
- enabling DEH to charge fees for permits, consistent with other commercial tour operator licences issued under the Act.

The last two points imply that DEH seeks to recover some of the costs associated with enforcing the regulations, and ensuring that interactions between people and marine mammals are managed, and do not impact marine mammal populations. The draft 'Regulatory Impact Statement' of the National Parks and Wildlife (Protected Animals – Marine Mammals) Regulations 2007 also indicates that "A permitting process is considered to be in the public interest, as it will help ensure the ecologically sustainable development of the industry, improve the quality of product for consumers and increase safety of the public and marine mammals. It is anticipated operators will also receive direct benefits through minimising threats to the marine mammal populations on which they rely, and increasing their professional credibility and ability to provide higher quality tourist experiences."

The draft 'Regulatory Impact Statement' indicates that there are about 15 businesses across South Australia that specialise in marine mammal interaction tours. With proposed permit fees ranging from between $350-550 (Draft National Parks and Wildlife (Protected Animals – Marine Mammals) Regulations 2007), the maximum revenue that could be generated from fees would be just over $8,000. It is not clear if these are one-off permits or annual fees.

There is precedence within DEH for the use of fees to fund research relating to the conservation and management of wildlife. The SA DEH Wildlife Conservation Fund Research

Grants Program is funded through revenue obtained from South Australian Hunting permits. This funding program has supported applications to assist the monitoring of Australian sea lion populations, including at Seal Bay. These are typically small grants of <$10,000 per year.

A cost-recovery approach would ensure that a portion of visitor entry fees to Seal Bay were allocated to cover the costs of managing the sea lion population. A survey of Seal Bay visitors would likely demonstrate an expectation that part of the admission fees is used for conservation and management of the sea lion population, to ensure that Seal Bay tourism is sustainable into the future. The current entry fees charged for visitors at Seal Bay are $13.50 adult, $10.75 concession, $8.00 child and $36.50 for families. Given that Seal Bay receives over 100,000 visitors per year, $1 collected from each visitor for conservation and management of the sea lion population would cover all of the projected costs for maintaining an annual monitoring program at Seal Bay (scenario 1 – previous chapter) and most of the costs for monitoirng other sea lion populations in the Kangaroo Island region (The Pages and Seal Slide, scenario 2). Such an approach could be extended to include a portion of the non-tour sales at the Seal Bay information centre (eg. books and t-shirts) and additional levies on tour group operators that utilise the Seal Bay population.

Such an approach is used at many iconic Australian tourism destinations. For example, the Phillip Island Nature Park in Victoria, directs a portion of revenue raised from entry fees and sales at the Penguin Parade and other sites (eg. Koala Conservation Park, The Nobbies and Churchill Island) to cover the costs of managing the natural resources that underpin the economic sustainability of the Park (Phillip Island Nature Parks Annual Report 2005-2006). This includes research staff and technicians that monitor the status, health and ecology of the little penguin population and research, monitor and mitigate potential threats to its sustainability. This also includes fox control, habitat management and assessing at-sea management issues of maintaining a viable little penguin population (eg. investigating the effects of commercial fisheries, channel deepening in Port Phillip Bay). Research is also undertaken on others species including Australian fur seals, and hooded plovers. Importantly, research and monitoring are integrated into the visitor experience at the Penguin Parade Visitor Centre, and are managed by a Scientific Research Advisory Committee (Phillip Island Nature Parks Annual Report 2005-2006).

The Great Barrier Reef Marine Park Authority (GBRMPA) requires that an Environmental Management Charge (EMC), often referred to as the ‘Reef Tax’, is paid by most commercial operators, which are granted permits by the Great Barrier Reef Marine Park Authority (GBRMPA). This includes operators that conduct tourism programs, non-tourism commercial

charters and those businesses operating facilities in the Great Barrier Reef Marine Park. Visitors to the Reef who participate in a tourism activity pay the charge to the permit holder. The role of the operator in relation to the charge is to collect and remit the charge to the GBRMPA. All funds received as EMC payments are applied directly to management of the Great Barrier Reef Marine Park including education, research (eg. CRC Reef Research Centre), ranger patrols and policy development. The majority of visitors pay the standard tourist program charge of $4.50 per day, subject to concessions and exemptions. A different scale of charges applies to other commercial operations (eg. pontoons, marinas, floating hotels, underwater observatories).

During the 2005/2006 Visitor Exit Surveys, which were undertaken by the KI Tourism Optimisation Management Model (TOMM), the attitudes and perceptions of visitors were evaluated with respect to a potential levy (similar to the GBRMPA EMC) to assist sustainable environmental management on Kangaroo Island. The survey indicated that almost two-thirds (65%) of visitors to Kangaroo Island indicated that they would be prepared to contribute to sustainable environmental management through a levy system, with similar responses from intrastate, interstate and international visitors (KI TOMM Visitor Exit Survey 2005/2006, http://tomm.info/media/contentresources/docs/TOMM_VES_2005-2006_FinalReport.pdf). For those who were willing to contribute to such a levy, the $3-5 range was most commonly supported. Results from these surveys indicate that there is broad public support for the concept of a fee or levy based system to ensure that the use of our natural resources is sustainably managed. Clearly, if such a levy were introduced for Kangaroo Island, part of the revenue collected could be directed to support management of seal populations on the island.

7.2 Best approaches to funding

The aim of this section of the report is to identify a range of funding sources that could be targeted to fund a population monitoring and management program at Seal Bay. We conclude that State funding is unlikely to be able to meet the costs of maintaining a monitoring and research program unless dedicated recurrent funds can be sourced. Similarly, funding through competitive grant programs from State Government (eg. WCF), Australian Government (eg. NHT-MSRP and ACAMMS) or non-Government (eg. SWRRF, NFSA) sources cannot be guaranteed, and these agencies generally only fund period-defined projects (usually 1-3 years). Revenue generated from donations and sponsorship has the potential to provide some recurrent funding, which could be used to offset the costs of monitoing and research programs, but current donation levels are inadequate. The Seal Bay sea lion population currently has no corporate sponsorship.

Cost-recovery approaches (eg. revenue from visitor fees, tourism operator licence fees or environmental management levies) would appear consistent with broad DEH policy and are used elsewhere in Australia to support the costs of managing natural assets (eg. tourism, mining, forestry and fisheries). These approaches ensure that the maximum socioeconomic benefits are returned to the community, and that natural assets are managed in accord with the principles of ecologically sustainable development. If developed and implemented appropriately, cost-recovery approaches have the benefit of being able to fund the ongoing population management program of the sea lion population at Seal Bay, and possibly all seal monitoring and management needs for the Kangaroo Island region. As previously indicated, revenue from grants, donations and sponsors is better directed at targeted research programs, or to supplement operating or equipment costs (eg. scanners) associated with long-term monitoring.

Additional benefits from the cost-recovery approach would be that the costs incurred by the State Government for seal conservation and management would be largely offset, freeing up resources for other programs. Investment by industry and the public into management of the sea lion population at Seal Bay would instil a sense of proprietary in the Kangaroo Island, Australian and international communities that utilise the region's natural assets. If the public and industry feel a greater sense of ownership and shared responsibility for the future sustainability of the sea lion population, they will expect that populations are managed appropriately. Because the conservation and management of these seal populations would be funded by the community this would promote greater accountability and reporting on the sea lion population status performance indicators. Adequate funding would ensure a greater capacity to integrate research and monitoring into the visitor experience, producing positive educational spin-offs.

8. CONCLUSIONS AND RECOMMENDATIONS

In order to meet the long-term management needs of Seal Bay to ensure that the sea lion population remains viable and economically sustainable as a tourism destination into the future, a population monitoring and research program needs to be established in order to monitor changes in the status, health and trends of the population, and to identify, measure and mitigate threats. Such a program would provide critical performance measures to assess whether or not the population is being appropriately managed, and provide an effective insurance policy for the regional tourism industry.

A population monitoring and research program should include both long-term monitoring and targeted research. Long-term monitoring should focus on the assessment of pup production and mortality each breeding season, and the monitoring of age-specific and cohort specific fecundity and survival rates. Targeted research should focus on specific management needs. The most critical of these will be those that identify the cause(s) of decline in the population, and those that more broadly target the monitoring and mitigation of threatening processes.

Several scenarios of monitoring programs have been proposed, all of which fall well outside the funding presently available to monitor the Seal Bay sea lion population. Cost-recovery from visitor fees and levies and tourism operator licence fees would provide a significant level of revenue to fund seal population management programs. Such an approach is consistent with DEH policy, and is used elsewhere in Australia to support the costs of managing publicly owned natural assets (eg. tourism, mining, forestry and fisheries) to ensure maximum socio-economic benefits are returned to the community, and that resources are managed in accord with the principals of ecologically sustainable development. Cost-recovery approaches have the benefit of being able to fund the conservation and management of the Seal Bay population, and being able to secure long-term funding for population management.

We make the following recommendations:

- A population monitoring and research plan needs to be developed and implemented. This would aim to ensure that the status and health of the population are adequately monitored; that the population decline is arrested; and that threatening processes are identified, monitored and managed;

- A population monitoring and research program should include both a long-term monitoring program (monitoring of pup production and mortality and vital demographic rates) and targeted projects that address specific data gaps and management needs;

- The population monitoring and research program will require strong scientific leadership and management, and results and methodologies should be reported regularly upon and reviewed;

- Access restrictions that presently impede monitoring and research activities at Seal Bay, both spatially (EPA) and temporally (9am-5pm daily) should be reviewed;

- Options for cost-recovery from visitor fees and tourism operator licence fees to fund critically important population management programs need to be investigated.

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10. REFERENCES

Anonymous (1977). Management plan; Seal Bay and Cape Gantheaume Conservation Parks, Kangaroo Island, South Australia. National Parks and Wildlife Division of the Department for the Environment, [Adelaide, SA], 35 pp.

Arianna-Lovasz, T., Croft, D. and Moss, G. (2005). Establishing tourist approach distance guidelines at Seal Bay Conservation Park, South Australia. Australasian Wildlife Management Society, 18th Conference, Hobart, Tasmania, November 2005, p. 66, Abstract.

Bruce, B. D. (1992). Preliminary observations on the biology of the white shark, *Carcharodon carcharias*, in South Australian waters. *Australian Journal of Marine and Freshwater Research* 43: 1-11.

Campbell, R. (2003). Demographic and population structure of the Australian sea lion, *Neophoca cinerea*. PhD thesis, University of Western Australia, Perth, Western Australia.

Charrier, I. and Harcourt, R. G. (2006). Individual vocal identity in mother and pup Australian sea lions (*Neophoca cinerea*). *Journal of Mammalogy* 87: 929-938.

Costa, D. P. and Gales, N. J. (2003). Energetics of a benthic diver: seasonal foraging ecology of the Australian sea lion, *Neophoca cinerea*. *Ecological Monographs* 73: 27-43.

Dennis, T.E. (2005). Australian sea lion survey (and historical) records for South Australia. Report to the Wildlife Conservation Fund, Department for Environment and Heritage, South Australia.

Fowler, S.L., Costa, D. P., Arnould, J. P. Y., Gales, N. J. and Kuhn, C. E. (2006). Ontogeny of diving behaviour in the Australian sea lion: trials of adolescence in a late bloomer. *Journal of Animal Ecology* 75: 358-367.

Fowler, S. L., Costa, D. P. & Gales , N. (2007). Ontogeny of movements and foraging ranges in the Australian sea lion. *Marine Mammal Science* 23**:** 598-614.

Fowler, S. L., Costa, D. P., Arnould, J. P. Y., Gales , N. J. & Burns, J. (*in press*). Ontogeny of oxygen stores and physiological diving capability in Australian sea lions. *Functional Ecology*.

Gales, N. J. & Cheal, A. J. (1992) Estimating diet composition of the Australian sea-lion *(Neophoca cinerea)* from scat analysis: An unreliable technique. *Wildlife Research* 19**:** 447-456.

Gales, N. J., Costa, D. P. and Kretzmann, M. (1996). Proximate composition of Australian sea lion milk throughout the entire supra-annual lactation period. *Australian Journal of Zoology* 44: 651-657.

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

Goldsworthy, S. D. and Page, B. (2007). A risk-assessment approach to evaluating the significance of seal bycatch in two Australian fisheries. *Biological Conservation* 139: 269-285.

Goldsworthy SD, Hamer D, Page B (2007a). Assessment of the implications of interactions between fur seals and sea lions and the southern rock lobster and gillnet sector of the Southern and Eastern Scalefish and Shark Fishery (SESSF) in South Australia. SARDI Aquatic Sciences Publication Number F2007/000711-1. SARDI Research Report Series Number 225, pp 164.

Goldsworthy SD, Shaughnessy PD, Page B, Dennis TE, McIntosh RR, Hamer D, Peters KJ, Baylis AMM, Lowther A, Bradshaw (2007b) Developing population monitoring protocols for Australian sea lions. Report for the Department of the Environment and Water Resources. SARDI Aquatic Sciences Publication Number F2007/000554, SARDI Research Report Series No. 219, pp 75.

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: 270-274.

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: 2047-2055.

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: 617-619.

Kretzmann, M. B., Costa, D. P., Higgins, L. V. and Needham, D. J. (1991). Milk composition of Australian sea lions, *Neophoca cinerea*: variability in lipid content*. Canadian Journal Zoology* 69: 2556-2561.

Ling, J. K. and Walker, G. E. (1976). Seal studies in South Australia: progress report for the year 1975. *South Australian Naturalist* 50: 59-68, 72.

Ling, J. K. and Walker, G. E. (1977). Seal studies in South Australia: progress report for the period January 1976 to March 1977. *South Australian Naturalist* 52: 18, 20-27, 30.

Ling, J. K. and Walker, G. E. (1978). An 18-month breeding cycle in the Australian sea lion? *Search* 9: 464-465.

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 Natur*alist 54: 68-78.

McIntosh, R. R. (2007). The life history and population demographics of the Australian sea lion, *Neophoca cinerea.* PhD thesis, La Trobe University, Bundoora, Victoria.

McIntosh, R. R., Shaughnessy, P. D. and Goldsworthy, S. D. (2006a) Mark-recapture estimates of pup production for the Australian sea lion, *Neophoca cinerea,* at Seal Bay Conservation Park, South Australia. In 'Sea Lions of the World'. (Eds A. W. Trites, S. K. Atkinson, D. P. DeMaster, L. W. Fritz, T. S. Gelatt, L. D. Rea and K. M. Wynne). pp 353-367. (Alaska Sea Grant College Program, University of Alaska: Fairbanks, Alaska).

McIntosh, R. R., Page, B. & Goldsworthy, S. D. (2006b) Dietary analysis of regurgitates and stomach samples from free-living Australian sea lions. *Wildlife Research* 33**:** 661-669.

McKenzie, J. and Moss, G. (2005). Monitoring pinniped populations on Kangaroo Island and The Pages Islands. A review of pinniped monitoring activities undertaken by the Department for Environment and Heritage; sampling protocols, data management and integration. Draft report to South Australia, Department for Environment and Heritage, Kangaroo Island. 97 pp.

McKenzie, J., Goldsworthy, S. D., Shaughnessy, P. D., and McIntosh, R. (2005). Understanding the impediments to the growth of Australian sea lion populations. Final report to Department of the Environment and Heritage, Migratory and Marine Species Section. South Australian Research and Development Institute (Aquatic Sciences), Adelaide, 107 pp. SARDI Publication number RD4/0171.

Page, B., McKenzie, J., McIntosh, R., Baylis, A., Morrissey, A., Calvert, N., Haase, T., Berris, M., Dowie, D., Shaughnessy, P. D. and Goldsworthy, S. D. (2004). Entanglement of Australian sea lions and New Zealand fur seals in lost fishing gear and other marine debris before and after Government and industry attempts to reduce the problem. *Marine Pollution Bulletin* 49: 33-42.

Shaughnessy, P.D., and Goldsworthy, S.D. (2007). Population assessment of fur seals and sea lions at some colonies in South Australia, 2006-07. SARDI Aquatic Sciences Publication Number F2007/000750-1, SARDI Research Report Series No. 236, pp 43.

Shaughnessy, P. D., Dennis, T. E. and Berris, M. (2007). Predation on Australian sea lions *Neophoca cinerea* by white sharks *Carcharodon carcharias* in South Australia. *Australian Mammalogy* 29:

Shaughnessy, P. D., McIntosh, R. R., Goldsworthy, S. D., Dennis, T. E. and Berris, M. (2006). Trends in abundance of Australian sea lions, *Neophoca cinerea,* at Seal Bay, Kangaroo Island, South Australia. In ‘Sea Lions of the World’. (Eds A. W. Trites, S. K. Atkinson, D. P. DeMaster, L. W. Fritz, T. S. Gelatt, L. D. Rea and K. M. Wynne). pp 325-351. (Alaska Sea Grant College Program, University of Alaska: Fairbanks, Alaska).

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'. (Eds S. H. Ridgway and R. J. Harrison.) Volume 1, pp. 99-118. (Academic Press, London.)