Population assessment of fur seals and sea lions at some colonies in South Australia, 2006-07

Final Report to the Department for Environment and Heritage, South Australia and the South Australian Wildlife Conservation Fund

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SUMMARY

At Kangaroo Island in late January and early February 2007, the abundance of New Zealand fur seal pups was determined at Cape Gantheaume and Cape du Couedic using a mark-recapture technique in large colonies, and by direct counting in several small colonies.

The number of fur seal pups for the whole of Kangaroo Island was estimated to be 6827. At the eastern end of the island, the estimated number of pups at Berris Point, Cape Gantheaume and sites nearby was 3831, exactly the same as in the previous summer. The Berris Point colony increased by 150 pups and the Cape Gantheaume colony decreased by a similar amount. At Cape du Couedic, pup numbers increased slightly, from 2586 to 2665. The greatest increases were at the recently formed colonies which are on the periphery of the Cape du Couedic area: at Knife and Steel Point and at Spooks North.

The average rate of increase in the fur seal colonies on Kangaroo Island in the 19 years since this study began in January 1989 is 12.3% per annum for the combination of Cape Gantheaume and Berris Point colonies at the eastern end of the Island, and for the Cape du Couedic colonies at the western end it is 12.5% per annum over 18 years.

North Casuarina Island was visited this summer for the first time since February 1996. The estimate of abundance for New Zealand fur seal pups was 299, 40% lower than the estimate made 11 years ago. In addition, 11 Australian fur seal pups were found, ten of them mixed with New Zealand fur seal pups in the cave and nearby on rock platforms at the eastern end of the island, and one pup at the north-western end of the island. This is the first evidence of Australian fur seals breeding in South Australia.

Summation of all the estimates for Kangaroo Island leads to 6,847 New Zealand fur seal pups for the 2006-07 pupping season, which is 1.0% larger than the estimate for the previous year.

New Zealand fur seal pups were heavier at Cape Gantheaume colony (males averaged 7.3 kg and females 6.7 kg) than at Nautilus Rock colony (males 6.8 kg and females 6.2 kg) this season, which has been the case in many previous seasons on Kangaroo Island. Likewise, male pups were heavier than female pups. Pup weights were lower than the long term averages at both colonies, by a quarter to half a kilogram.

Australian fur seals were seen at several New Zealand fur seal colonies on Kangaroo Island in late January and early February 2006: at Berris Point, Cape Gantheaume, at several sites on Cape du Couedic, as well as at North Casuarina Island. The largest counts were 328 at North Casuarina Island, 33 at Cape Gantheaume and 41 at Admirals Arch, Cape du Couedic.

At The Pages Islands, the maximum count of Australian sea lion pups for the 2006-07 season (403 pups) was 30% lower than that for the previous season, of 577 pups, and lower than the long term average, of 474 pups (n=12 seasons).

1. INTRODUCTION

Two species of eared seal are reported to breed in South Australia, the New Zealand fur seal *Arctocephalus forsteri* and the Australian sea lion *Neophoca cinerea* (Goldsworthy and Crawley 1995, Marlow 1995). For each species, much of the population is in the area between the southern tip of Eyre Peninsula and Kangaroo Island (Gales et al. 1994, Shaughnessy et al. 1994). This report provides information on long-term projects aimed primarily at determining trends in abundance of New Zealand fur seals on Kangaroo Island (Figure 1) and of Australian sea lion pups at The Pages Islands (Figure 2).

The abundance estimates are directed at pups because they form the only age-class that is easily recognisable and all of them (in the fur seal) or most (in the sea lion) are ashore together. Although the relationship between the number of pups and the total population size is variable, depending on the status of the population, pup numbers form a useful index of population size (Berkson and DeMaster 1985).

The fur seal projects described here were conducted on Kangaroo Island during late January and early February 2007 with assistance from local staff of the Department for Environment and Heritage (DEH). Timing for the fur seal projects was chosen to minimise interactions between seals and people, and began in late January, when pups averaged 5 weeks of age based on timing of the pupping season reported by Goldsworthy and Shaughnessy (1994). Territorial structure of the colonies has broken down by then and most adults move away when confronted by people. This makes it safer for workers to enter colonies and less stressful for animals than if work began earlier.

This report includes visits to North Casuarina Island in late January and early February to estimate the abundance of New Zealand fur seal pups. This island had not been visited as part of this project since February 1996. The presence of Australian fur seals on the island is noted, including a small number of pups.

This report also covers visits to The Pages Islands to estimate the abundance of Australian sea lions in the 2006-07 pupping seasons. In addition, trends in the abundance of pups over 13 seasons from 1986-87 are analysed.

In brief, aims of the projects reported here were:

- to repeat the abundance estimates in New Zealand fur seal colonies at Cape Gantheaume and Cape du Couedic on Kangaroo Island,
- to continue the comparison of pup weights at Nautilus Rock (Cape du Couedic) and Cape Gantheaume colonies
- to estimate the abundance of Australian sea lions at The Pages Islands in the 2006-07 pupping seasons and to analyse trends.

Incidental data included here are counts of Australian fur seals hauled-out at several sites on Kangaroo Island, and counts of New Zealand fur seals at some small colonies. The period covered by this report is from December 2006 to June 2007. This is the 19th report in a series.

2. NEW ZEALAND FUR SEALS

2.1 Methods

2.1.1 Direct counting

Numbers of New Zealand fur seal pups in small colonies were estimated by counting; these are referred to as 'direct counts' to distinguish them from the mark-recapture estimates.

2.1.2 Mark-recapture estimation - marking

Pups were marked by clipping the black natal hair (lanugo) on the top of their heads between the eyes and down toward the nose, with curved surgical scissors to reveal light grey underfur. This is a temporary mark, in that the natal hair is shed in about March - April, when the adult type-pelage emerges. Care was taken to distribute the marking effort uniformly throughout each colony: pups were marked by teams of six to eight people with a recorder while they moved through each breeding colony catching all pups that were readily available. We aimed this summer to mark about 45 per cent of pups in most colonies.

2.1.3 Mark-recapture estimation - recapturing

Recaptures were conducted visually without handling the pups. Two (or three) people worked together while they walked through the length of each colony, one recorded data, and the other(s) observed pups. The recaptures are considered as ‘resightings’ because the pups were not handled. The observer(s) scanned pups' heads for signs of the clip mark and, for each pup sighted, informed the recorder whether it was marked or clear (unmarked). At most colonies, there were six recapture sessions, two per day, at least half an hour apart. Recapture sessions began a day or more after pups had been marked. At most colonies, the recapture sessions were conducted by two pairs of people on each day. Thus recaptures were done at each colony over three days. At both Berris Point and Weirs Cove two people conducted two recapture sessions on each of three days, with at least 1 ½ hours between each session.

By distributing marks and performing resights uniformly throughout the entirety of each breeding colony, the sampling process at resighting should be random with respect to the marking process, which is an important assumption of the mark-recapture process. The sampling was done without replacement, in other words, care was taken to avoid recording pups more than once in each recapture session.

2.1.4 Dead pups

In each colony, dead pups were recorded when pups were marked (Table 1) and were either moved to the back of the colony, covered with rocks or marked with road-marking paint. Dead pups were also counted at recapture sessions, and were recorded as being in one of several categories. In the first instance it was noted whether they were ‘marked’ or ‘unmarked’. They were also recorded as having been dead for several days and hence considered to have been overlooked when pups were marked (and recorded as such in Table 1), or as having died since the previous day. The last were added to the recapture estimate on the day they were recorded.

2.1.5 Calculation of mark-recapture estimates

The estimate of pup numbers (N) was calculated using a variation of the Petersen method (Seber 1982), with the formulae

$$\hat{N} = \frac{(M+1)(n+1)}{(m+1)} - 1,$$

where:
M is the number of marked pups at risk of being sampled during recapture operations
n is the number of pups examined in the recapture sample, and
m is the number of marked pups in the recapture sample.

The variance of this estimate was calculated from

$$V = \frac{(M+1)\,(n+1)\,(M-m)\,(n-m)}{(m+1)^2\,(m+2)}$$

and the 95% confidence limits were calculated from

$$\hat{N} = +/- (1.96 * V^{0.5}).$$

Since there were several mark-recapture estimates (N_j) for each colony, one from each recapture session, they were combined by taking the mean (N) for each colony using formulae from White and Garrott (1990, pp. 257 & 268):

$$\hat{N} = \sum_{j=1}^{q} \hat{N}_j / q,$$

where q was the number of estimates for the individual colony (i.e., the number of recapture sessions). The variance of this estimate was calculated from

$$\text{Var}\,\hat{N} = \frac{1}{q^2} \sum_{j=1}^{q} \text{Var}\,(\hat{N}_j)$$

and its standard deviation was calculated from

$$[\text{Var}\,(\hat{N})]^{½}.$$

For the Cape Gantheaume colony and other colonies that were divided into several sectors, pup numbers were calculated for each sector by the above methods. An estimate for the whole colony was then obtained by summing the estimates for each sector. The variance of that combined estimate was obtained by summing the variances of each sector, and the standard deviation was calculated by taking the square root of that variance.

For each colony, the number of dead pups was added to the estimate of the number of live pups to give the overall estimate of pup numbers in a colony.

The rate of change in pup numbers was calculated using linear regression of the natural logarithm of the mean estimate of pup numbers against year. An exponential rate of increase has been demonstrated for the New Zealand fur seal on Kangaroo Island (Shaughnessy et al.

1995) and for other species. The exponential rate of increase (r) is the slope of the regression line. It is also expressed as a percentage increase using the following formula

$$(e^r-1) * 100$$

Means are presented as ± standard deviation (SD) and all statistical tests are two-tailed, unless stated, with the α level of statistical significance set at 0.05.

2.1.6 Pup weighing

On 27 January 2007, 110 pups were weighed and sexed at the Cape Gantheaume colony and 85 were weighed and sexed at the Nautilus Rock colony. At Nautilus Rock, we were unable to locate and catch the target sample size of 110 pups.

2.2 Results and Discussion

2.2.1 Pup marking

At the Berris Point colony in Cape Gantheaume Conservation Park, 387 pups were marked on 23 January (Table 1) by a team from DEH along with Adam McKeown and Graham Harrington from CSIRO Sustainable Ecosystems, Dani Ayers from NSW Department of Environment and Climate Change, and Peter Shaughnessy from the South Australian Museum. For the first time, the Berris Point colony was divided into three areas for the mark-recapture project, which are referred to as North, Middle and South. They were separated by deep channels that extend through the schist to the base of the limestone slopes. This summer the colony had extended several tens of metres at its northern end compared with its extent the previous season.

At the Cape Gantheaume colony, pups were marked on 23 and 24 January by the same team. A description of the colony was included in previous reports (e.g., Shaughnessy 2000). The mark-recapture estimation procedure was used through the whole colony except in the cave west of sector A and 1,461 pups were clipped (Table 1).

At the Cape du Couedic colonies of Weirs Cove North, Weirs Cove South, Nautilus Rock, Nautilus North, Libke and Spooks North, pups were marked on 27, 28 and 29 January with a team from DEH plus Adam McKeown, Graham Harrington, Dani Ayers and Peter Shaughnessy. The numbers of pups marked in these colonies were 110, 48, 85, 225, 400 and 206, respectively. For the first time, the Libke Point colony was divided into two areas for the mark-recapture project, which are referred to as South and North. They were separated by an area where there were no fur seals which is near the base of the steep climb out of the colony. As in the previous summer, the Libke colony was considered to extend north almost to the indentation known locally as Spooks Bay.

On North Casuarina Island, 174 pups were marked on 29 January. Access to the island was by helicopter chartered from Andrew Geering of Kingscote. Overall on Kangaroo Island, 3,270 pups were marked for this study.

2.2.2 Berris Point colony

The mark-recapture procedure was based on 387 marked pups. Overall, the mean proportion of marked pups in six recapture sessions was 0.46. The estimated pup production for the three sectors is: North, 280, Middle, 417 and South, 153 (Table 2). From the sum of these sectors, the estimate for the whole colony was 850 ± 15.3; this includes five dead pups considered to have been dead at marking.

2.2.3 Cape Gantheaume colony

The mark-recapture procedure was based on 1,460 marked pups, one less than the number marked because a dead, marked pup was found at the first recapture session. The mean proportion of marked pups in six recapture sessions was 0.505. The estimated number of pups (live + dead) was 2,909 ± 23.8 (Table 3). This includes the 11 pups listed as dead at marking. Another 41 pups were recorded in the cave between the Beach sector and sector A. With their addition, the estimate for the Cape Gantheaume colony is 2,950 pups.

Mean estimates of pup numbers (live plus dead pups) in sectors of the colony were (Table 4):
* Beach sector, 690
* cave between the Beach sector and sector A, 41
* sectors A + B, 100
* sectors C + D + E, 314
* sectors F + G + H, 254
* sectors I + J, 927
* sectors K + L, 636.

The total of these mean sector estimates is 2,962 ± 24.7; the estimate for the colony calculated as a whole is 2,950 (above). The difference is 38 pups. The estimate for the colony calculated as a whole is likely to be less accurate than that for the sum of sectors because the mark-recapture procedure assumes that the marking effort and the recapture effort are uniform throughout the area under consideration, and this is more likely for a series of small areas than for one large area.

2.2.4 Cape du Couedic, Weirs Cove colonies

At Weirs Cove, there are two disjunct groups of fur seals, one north of the jetty (Weirs Cove North) and one south of the jetty (Weirs Cove South).

At Weirs Cove North, the mark-recapture procedure was based on 110 marked pups. The mean proportion of marked pups in six recapture sessions was 0.42. The estimated number of live plus dead pups was 267 ± 8.5 (Table 5); this includes two pups found dead during marking.

At Weirs Cove South, the mark-recapture procedure was based on 48 marked pups. The mean proportion of marked pups in six recapture sessions was 0.43. The estimated number of pups was 112 ± 4.6 (Table 5); no dead pups were seen.

2.2.5 Cape du Couedic, North Casuarina colony

One hundred and seventy four pups were marked at this colony but the mark-recapture estimate was based on 173 pups because a marked pup was found dead during a recapture session. The mean proportion of marked pups in five recapture sessions was 0.61. The estimated number of live pups and dead pups was 309 ± 6.2 (Table 6); this includes 15 pups found dead during marking plus one marked and six unmarked pups seen during recapture sessions that were considered to have been dead at marking.

At least two of the pups that were caught and marked were Australian fur seals. They were in the east-facing cave and near the waters edge, east of the cave's entrance. We estimated there were another eight Australian fur seal pups in the mark-recapture area, and one more running with adults and subadults on the northern side of the island (see section 3.2). This makes a total of 11 Australian fur seal pups on North Casuarina Island, ten of which are included in the estimate of 309 pups on the island. Therefore the estimated number of New Zealand fur seal pups at North Casuarina Island is 299. This is 40% lower than the previous mark-

recapture estimate of New Zealand fur seal pups on the island, of 499 in February 1996 (Shaughnessy 1997a). The exponential rate of decrease of the pup numbers over 11 years is r = 0.0466, equivalent to 4.8% per annum.

Australian fur seals were less prevalent on the island in early 1996; 35 adult males were recorded and no animals of other age classes. It is likely that the number of Australian fur seals have gradually increased on North Casuarina Island since 1996, as they have been increasing at breeding colonies in Victoria (Kirkwood et al. 2005) and on Kangaroo Island. At the same time, it is likely that number of New Zealand fur seals occupying North Casuarina Island has decreased. Consequently, the estimated number of New Zealand fur seal pups at the island for January 2005 in Table 11, has been adjusted to 313 by exponential interpolation from 499 (which is the estimate from February 1996).

2.2.6 Cape du Couedic, Nautilus Rock colony

Eighty five pups were marked (and weighed) in this colony, which included the narrow portion of the colony that extends north at the base of the cliffs as far as the wave-washed rocks that separate this colony from Nautilus North colony. The mean proportion of marked pups in six recapture sessions was 0.79. The estimated number of live pups and dead pups was 109 ± 2.1 (Table 7); this includes one pup found dead at marking.

2.2.7 Cape du Couedic, Nautilus North colony

Two hundred and twenty five pups were marked at this colony. The proportion of marked pups in six recapture sessions averaged 0.51. The estimated number of live pups and dead pups was 442 ± 7.7 (Table 7); this includes four pups listed as dead at marking and one seen during a recapture session that was considered to have been dead at marking.

2.2.8 Cape du Couedic, Libke colony

In the North part of the Libke colony, 151 pups were marked. The proportion of marked pups in six recapture sessions averaged 0.39. The estimated number of live pups and dead pups in was 387 (Table 8), which includes one pup found dead at marking.

In the South part of the Libke colony, 249 pups were marked but the mark-recapture estimate was based on 248 pups because a marked pup was found dead during the first recapture session. The proportion of marked pups in six recapture sessions averaged 0.46. The estimated number of live pups and dead pups was 546 (Table 8) which includes two pups found dead at marking, five seen during recapture sessions that were considered to have been dead at marking and a marked pup found dead during the first recapture session (noted above).

The sum of these mean sector estimates for Libke colony is 933 ± 16.8.

2.2.9 Cape du Couedic, Spooks North colony

The mark-recapture procedure was based on 206 clipped pups and the mean proportion of marked pups in six recapture sessions was 0.58. The estimated number of live pups and dead pups was 364 ± 7.0 (Table 9); this included four pups found dead during marking and two seen during a recapture session that were considered to have been dead at marking.

2.2.10 Small breeding colonies and haul-out sites on Kangaroo Island

Counts of fur seals in small colonies on Kangaroo Island are discussed below and summarised in Tables 10 and 11.

2.2.10 (i) Near Cape Gantheaume

At Little Weirs Cove a few km north-east of Cape Gantheaume, there were two counts of New Zealand fur seal pups. On 7 January, Jane McKenzie counted 6 pups and on 27 January

Dave Dowie counted 7 pups. At the western end of the beach at Cape Gantheaume beyond the limestone headland, eleven fur seal pups were counted in caves at the base of the cliffs by Jane McKenzie on 7 January.

2.2.10 (ii) South coast, Stunsail Boom River to Cave Point
On 2 January, Jane McKenzie walked on the south coast west from the mouth of the Stunsail Boom River and saw a single pup with an adult female and adult male at 'Xenolith Point'. A pup was seen at the same site in February 2006. At Cave Point, 30 pups were counted on 1 February. These sites are in Cape Bouguer Wilderness Area. Cape Bouguer itself was not visited in the 2006-07 summer.

2.2.10 (iii) Cape du Couedic, Knife and Steel Point
This rocky point is between Remarkable Rocks and the beach in Weirs Cove. We planned to mark pups at the Knife and Steel Point colony on 29 January 2007 but it was decided that access along the coast from Weirs Cove was too difficult for the three or four visits that would be required to make a mark-recapture estimate. Instead, D. Snowball and D. Kerry walked to the colony and counted 147 pups. Pup numbers at this site have increased rapidly since January 2003 when A. McKeown found a single fur seal pup there. There were 14 pups there in January 2004 and 98 in January 2006 (there was no count in January 2005).

2.2.10 (iv) Cape du Couedic, Admirals Arch
At Admirals Arch on 26 January 2007, P. Arthur and P. Shaughnessy counted 13 pups in the whole area, one of which was dead. This is similar to the number there last summer (14 pups), but fewer than in January 2005 (19). Other New Zealand fur seals ashore were not counted.

2.2.11 Overall abundance on Kangaroo Island

Estimates of pup abundance at the nine colonies where the mark-recapture procedure was used in this project total 6,338 (Berris Point, Cape Gantheaume, Weirs Cove North, Weirs Cove South, North Casuarina Island, Nautilus Rock, Nautilus North, Libke and Spooks North; Table 11). Another 231 pups were counted at nine small colonies and sites in January or early February 2007, or in the previous summer: Cape Linois, Little Weirs Cove, west of Cape Gantheaume beach, four sites on the south coast (including Cave Point and Cape Bouguer), Knife and Steel Point, and Admirals Arch. In addition, there are another two colonies where pup abundance was not estimated in early 2007; the most recent estimates for these colonies are 257 at Ladders North and 21 at Ladders South in January 1998.

Summation of these mean estimates for Kangaroo Island gives a total of 6,847 pups for the 2006-07 pupping season. This is 1.0% greater than the estimate for the previous year, 6778 (following revision of the estimate for North Casuarina in 2005-06; section 2.2.5).

Mark-recapture results in breeding colonies of the New Zealand fur seal at Cape Gantheaume and Cape du Couedic since January 1989 are summarised in Table 12 and Figure 3 (which includes the direct counts at small colonies near Cape Gantheaume and at Knife and Steel Point, but does not include North Casuarina Island). In general, pup numbers increased over the first 12 summers, from January 1989 to January 2000, decreased markedly in January 2001, and recovered in January 2002 to levels slightly larger than recorded previously. Results in January 2003 were similar to those for January 2000 and 2002, and then there was a marked increase in the next four summers (2003 to 2006). In January 2007, numbers at these colonies (6184 pups) were slightly larger those for January 2006 (6137 pups; Shaughnessy 2006), differing by only 0.7%.

At the eastern end of the island, at the colonies where mark-recapture estimates were made (Berris Point and Cape Gantheaume), plus counts of the small number of pups nearby, pup numbers were almost unaltered at 3831 in January 2006 and 3830 in January 2007, although they decreased at Cape Gantheaume and increased at Berris Point. For all these colonies, pup numbers have increased exponentially since January 1989 at an average of r = 0.116, equivalent to 12.3% per annum (n = 19 seasons, $R^2 = 0.96$).

For each sector at Cape Gantheaume in January 2007, pup numbers were lower than those in the previous summer, even in Sectors F to L which decreased from 1883 to 1817 pups (Table 13, Figure 4) despite there appearing to be being more animals sector K than previously. The largest part of the Cape Gantheaume colony is in the second bay north-east from the Cape together with the adjacent headlands, in sectors F to L (with 1817 pups in January 2007), followed by Beach sector which is west of the Cape (690 pups in January 2007). The headland at Cape Gantheaume and the first bay to its north-east (sectors A to E) form the smallest part of the colony, with 414 pups in January 2007. When the study began in January 1989 and the whole of the Cape Gantheaume colony produced 457 pups, nearly all of them were in this area.

At Cape du Couedic, for the six colonies where mark-recapture estimates were made in both January 2006 and January 2007 (Weirs Cove North, Weirs Cove South, Nautilus Rock, Nautilus North, Libke and Spooks North) together with direct counts at the new colony of Knife and Steel Point, pup numbers increased by 1.0% from 2897 to 2925. This was lower than the increase from January 2005 to January 2006, of 5.3%. There have been substantial increases at the two new sites on the periphery of Cape du Couedic in recent years: at Knife and Steel Point, from 14 pups in January 2004 to 147 pups in January 2007; and at Spooks North, from 19 pups in January 2004 to 364 pups in January 2007 (Table 12). At the same time, some of the established colonies have been decreasing: Nautilus Rock and Nautilus North (Table 12, Figure 5) and North Casuarina Island (section 2.2.5). For the colonies at Cape du Couedic (excluding North Casuarina) since January 1989, pup numbers have increased exponentially at an average of r = 0.088, equivalent to 9.2% per annum (n = 18 seasons, $R^2 = 0.96$). This is lower than the overall rate of increase at the eastern end of the island (of 12.3%).

The small changes in pup numbers from 2005-06 to 2006-07 at the western and eastern ends of Kangaroo Island contrast with the much larger increases in previous years. One of the cohorts that produced pups in 2006-07 was that of 2000-01, the season when pup production was greatly diminished on Kangaroo Island compared with previous seasons. Females of the 2000-01 cohort were six years of age in the 2006-07 pupping season and are now part of the reproductive group (McKenzie 2006). The small size of that cohort must be partly responsible for the relatively low rate of increase in pup numbers for 2006-07.

2.3 Weight of New Zealand fur seal pups, January 2007

Pups were weighed at Cape Gantheaume and Nautilus Rock colonies on 27 January 2007 (Table 14). At Cape Gantheaume, males averaged 7.3 kg and females 6.7 kg, and at Nautilus Rock, males averaged 6.8 kg and females 6.2 kg. These mean weights were lighter than the long-term averages, at Cape Gantheaume by 0.54 and 0.27 kg for males and females, respectively, and at Nautilus Rock they were lighter by 0.34 and 0.40 kg.

These data for January 2007 have been analysed by a two factor analysis of variance with unequal number of replications and with both factors (sex and colony) considered fixed.

Results (Tables 14 and 15) indicate that there was a significant difference in weights between the sexes (males heavier than females) and between colonies (Cape Gantheaume pups heavier than Nautilus Rock pups). There was no significant interaction between these two factors.

Pups have been weighed in these colonies in 19 consecutive summers: in early February (1989, 1990) or the latter half of January (1991 to 2007). Pups have generally been heavier at Cape Gantheaume than at Nautilus Rock; the difference has been statistically significant in eight summers previously (February 1990, and January of 1993, 1998 to 2003). The reason for the difference between colonies could be earlier commencement to the pupping season at Cape Gantheaume than at Nautilus Rock in most seasons, or easier access to feeding sources for pregnant females from the Cape Gantheaume colony than from the Nautilus Rock colony.

2.4 Counts of New Zealand fur seal at other sites in SA

On 30 January 2007, Terry Dennis (in litt.) surveyed the base of the cliffs east of Newland Head (between Encounter Bay and Cape Jervis) and sighted a small number (<10) subadult males scattered over several sites. During winter and spring of 2006, he saw about 50 fur seals there.

At The Pages Islands, small numbers of New Zealand fur seals were seen on three of the four visits to count sea lions, with a maximum of 33 fur seals on 10 February 2007.

On the west coast of Eyre Peninsula, 30 fur seals were seen on Nicolas Baudin Island on 18 June 2007, most of them at the western end of the island. Two pups were at a rock pool in the centre of the island.

3. AUSTRALIAN FUR SEALS ON KANGAROO ISLAND

3.1 Introduction

Most Australian fur seals breed on islands of Victoria and Tasmania in Bass Strait, with the closest breeding colony to Kangaroo Island at Lady Julia Island near Portland. The most recent estimate of pup numbers there was 5,899 in the 2002-03 summer (Kirkwood et al. 2005).

During this long-term study of trends in abundance of New Zealand fur seal pups on Kangaroo Island, Australian fur seals *A. pusillus doriferus* have been sighted at several breeding colonies of the New Zealand species, including Cape Gantheaume, Berris Point and Cape du Couedic (at several sites). The first record in this series of reports is from January 1989 (Shaughnessy 1989), when they were sighted at North Casuarina and South Casuarina Islands. None was recorded at the Cape Gantheaume fur seal colony that summer, although they have been sighted there frequently since then. Australian fur seals have also been recorded on Main Beach at Seal Bay, at Cape Bouguer and on Young Rocks, south of Kangaroo Island at 36 23 S, 137 12 E (Shaughnessy and Dennis 1999).

3.2 Methods

Australian fur seals were counted at Cape Gantheaume, Berris Point and Cape du Couedic in January and early February 2007 when estimates of abundance were being made of New Zealand fur seals in their breeding colonies by mark-recapture. In addition, three visits were made for this purpose to North Casuarina Island in late January and early February, when the opportunity was taken to count numbers of Australian fur seals. At South Casuarina, animals were counted from a helicopter on two circuits of the Island on 31 January.

3.3 Results

Australian fur seals were seen at Cape Gantheaume and Cape du Couedic on Kangaroo Island, and on the nearby Casuarina Islands (Table 16). At Cape Gantheaume, the maximum count was 36 on 23 January 2007 in sectors A and B of the New Zealand fur seal colony. At Cape du Couedic, 41 were counted on the eastern side of Admirals Arch from a visitors' lookout. New Zealand fur seals and Australian sea lions also occupied that site. At South Casuarina there were 69 animals.

At North Casuarina Island, 328 adult and subadult Australian fur seals were counted on 29 January, of which 158 were on the northern side (most of which would have been visible from Cape du Couedic), 95 were on the south-eastern side, and 75 were in the cave and on the flat rock platforms at the cave's entrance on the eastern side of the island. On 1 February, 313 adults and subadults were counted.

On 29 January 2007 on North Casuarina Island, Australian fur seal pups were noticed among the New Zealand fur seal pups in the cave while pup-marking was underway. The Australian fur seal pups were recognised because of their larger size (length and bulkiness) and their browner coloured pelage. We estimated there were ten Australian fur seal pups among the New Zealand fur seal pups in the cave, and between the cave entrance and the sea on the eastern side of the island on rock platforms and in pools. We estimated that five of these were marked. One other Australian fur seal pup was seen on the north-western side of the island among adults and subadults that scampered to the sea as we approached them on the island's north coast. Thus we estimate there were 11 Australian fur seal pups on North Casuarina Island.

3.4 Discussion

Australian fur seals were first recorded on North Casuarina Island on 25 January 1989, when 33 were seen on a rock platform on the eastern side of the island (Shaughnessy 1989, p. 21-22). They were also seen on South Casuarina Island on the same day (22 animals). The next visit to the Island was on 6 February 1990 when 98 Australian fur seals were seen. These included adult males, subadult males and at least four adult females. Three of the adult males were dead. Two of the dead ones were lying nose-to-nose; their skulls were collected and deposited in the South Australian Museum.

The first record of Australian fur seals on Kangaroo Island dates from 13 and 14 February 1988, when Terry Dennis (in litt.) made notes and a sketch of a large fur seal hauled out near the headland at Cape Gantheaume. It had a relatively small head and bulbous forehead in comparison with the New Zealand fur seals nearby, and its coat colour was chestnut brown (and paler than the New Zealand fur seals). When it moved over the rocks, its gait differed from that of the New Zealand fur seals in that it was slower and it swayed from side to side. In addition, he photographed a group of animals and sent the photographs to Bob Warneke, then of the Victorian Department of Conservation, Forests and Lands in Melbourne. Warneke responded on 25 March 1988 advising that all the animals were Australian fur seals and that most of them were bachelor males and juveniles.

A hybrid pup from the New Zealand fur seal colony at Cape Gantheaume was identified on the basis of a blood sample collected in mid-June 1995 by Terry Dennis. The pup was then aged about 6 months. When it was tagged (Blue 1392) in January 1995 at about 6 weeks of age, it was recorded as having an unusual appearance. In June it was sucking from an adult female that was identified as a New Zealand fur seal based on its external appearance.

Isozyme analysis of the blood sample by Mark Adams of the South Australian Museum indicated that the pup was a hybrid of an Australian fur seal male and a New Zealand fur seal female (Shaughnessy 1997a).

The South Australian Museum has several specimens of the Australian fur seal that pre-date the first observation of live animals on the Casuarina Islands in January 1989. The earliest is from a juvenile collected 3.5 miles (6 km) inland near Dublin, 55 km north-west of Adelaide in 1885. Other early specimens are from Cape Banks in 1934, South Neptune Island in 1967, the south coast of Kangaroo Island in 1972, Victor Harbor in 1976, Salt Creek in 1978. Another seven specimens were collected between 1979 and 1990 from the south-east of South Australia. Thus it is apparent that Australian fur seals have been in South Australian waters for many years.

This report of Australian fur seals breeding at North Casuarina Island is the first for South Australia. The pups were far too small to have swum there from any of the breeding colonies of this species in Victoria or Tasmania and must have been born on the Island.

4. AUSTRALIAN SEA LIONS

4.1 Introduction

Breeding seasons of the Australian sea lion are non-annual, being separated by intervals of 17.5 to 18 months (Ling and Walker 1978, Higgins 1990), and the seasons are asynchronous across the species' range (Gales et al. 1994). Consequently estimates of abundance for individual colonies are not reported on an annual basis.

During this reporting period, Australian sea lion pup numbers were estimated at two large colonies during their 2006-07 pupping seasons, at The Pages Islands and at Dangerous Reef (Figure 2). Counts at The Pages were done by DEH staff from Kangaroo Island led by Clarence Kennedy from December 2006 to March 2007. This section of the report includes these counts and an analysis of trends in pup abundance at The Pages Islands.

At Dangerous Reef, sea lions were counted between July 2006 and February 2007, mostly by Andy Lowther, a post-graduate student at La Trobe University, Melbourne. The final count and a one-off mark-recapture estimate were done by PDS and Bec McIntosh of La Trobe University, along with DEH staff from Port Lincoln. Information on the 2006-07 pupping season at Dangerous Reef is contained in a report to Sea World Research and Rescue Foundation by R. McIntosh and P. Shaughnessy.

Finally, a single count of sea lions was made at Nicolas Baudin Island in June 2007 in order to determine the timing of the beginning of the colony's pupping season.

4.2 Methods

As outlined in previous reports (e.g., Shaughnessy and Dennis 2001), the usual method for monitoring abundance of sea lions is for two or three observers to walk through a colony searching for and counting pups and, in some instances, other sea lions ashore. Numbers of the latter were recorded in various age-sex classes or simply recorded as 'unclassed'. Pups were recorded in four categories based on those used by Gales et al. (1994):

- *brown pups*, live pups in natal pelage or still moulting it,
- *moulted pups*, live pups that have completely moulted their natal pelage; in most pups that occurs at about 5 months of age (T. Dennis and M. Berris, unpublished observations),

- *unclassed pups*, when the counter did not distinguish between live brown pups and live moulted pups, and
- *dead pups*.

The distinction between 'brown pups' and 'moulted pups' is useful in estimating the temporal progression of the breeding season at a site when only one or two surveys are possible. Numbers in these two categories are amalgamated here for counts at The Pages Islands and form the category 'live pups'.

Pup numbers are chosen as the index of abundance because pups are easily recognisable and are manageable (if the estimating technique requires handling). In addition, most of the pups are ashore at one time, unlike the other age classes in which a highly variable proportion is ashore at any one time. But in the Australian sea lion, the pupping season is extended and it is difficult to schedule counts to coincide with pup numbers reaching their maximum when estimates are made by direct counting. In addition, some of the pups born early in the pupping season leave with their mothers before the last pups have been born. For example, tagged pups from Seal Bay have been reported at the Seal Slide and at Cape Bouguer on Kangaroo Island, aged less than 6 months (Ling and Walker 1976, 1979). Consequently each count of pups is likely to underestimate the number of pups born and, unless several counts are made during the pupping season, pup production will be underestimated seriously. In an effort to minimise the problem in the 2006-07 pupping seasons, there were four counts at The Pages Islands and 11 at Dangerous Reef.

At both colonies, care was taken to record the number of pups that had died since the previous visit so that the number of pups that died during the whole pupping season could be estimated. A record of pups that died through the pupping season allowed the pup production for the season to be determined more accurately than if dead pups were not recorded or if they were only recorded on one or two occasions. To avoid recounting, dead pups were marked with spray-paint or covered with rocks when they were counted.

The number of dead pups recorded at each visit was added to the number recorded at previous visits to give the number of 'Accumulated dead pups'. When that number was added to the numbers of moulted pups and brown pups recorded on that visit, it gave the best available estimate of pup production to that date.

For The Pages Islands, pup mortality was estimated from the number of accumulated dead pups to when the sum of live plus dead pups reached its maximum. The incidence of pup mortality was then expressed as a percentage and calculated from:

(Dead pups * 100) / (Dead pups + Live pups),

where 'Dead pups' is the accumulated number of dead pups when the sum of it and the number of live pups reached its maximum for the season. The mean pup mortality over several seasons at The Pages was taken as the unweighted average, that is, the average of the estimates of pup mortality for each season.

The single visit to Nicolas Baudin Island on 18 June 2007 was to determine the date of the commencement of its pupping season, which was predicted to be in June by Terry Dennis in Goldsworthy et al. (2007). The visit involved a circuit of the island by two observers counting sea lion pups, bulls and other age classes.

4.3 Results and Discussion

4.3.1 Pup abundance and mortality at The Pages Islands in 2006-07

For The Pages Islands in the pupping season of 2006-07, the largest estimate of live pups and accumulated dead pups was 403 made on the third of four visits, on 10 February 2007 (Table 17, Figure 6). The count was 30% lower than that for the previous season, of 577 pups, and lower than the long term average, of 474 pups over 12 seasons (Table 18). The extent of pup mortality recorded for the 2006-07 pupping season was relatively low, at 10.4% compared with 33.4% in 2005 and 17.4% for the long term average over 12 seasons.

On North Page Island, there were 199 pups, of which 14 (7.0%) were recorded dead, compared with 267 in the previous season, with 30.3% dead (Shaughnessy 2005b). On South Page Island, there were 204 pups, of which 28 (13.7%) were recorded dead, compared with 310 in the previous season, with 36.1% dead.

4.3.2 Trends in pup abundance at The Pages Islands

For the sea lion colony at The Pages Islands, maximum pup counts are now available from Dennis (2005) and from previous reports in this series for 13 pupping seasons, from 1986-87 to 2006-07 (Table 18). The only seasons missing in this series are 1988 and 1994 when no visits were made to the colony. In the first season in the series (1986-87), only live pups were counted.

Data are analysed here for The Pages Islands group as a whole, because Campbell (2003) did not include the site in his study of philopatry in Australian sea lion colonies, contrary to an assumption in the previous report on The Pages Islands (Shaughnessy 2005b, section 4.3.4). Therefore it is appropriate at this stage to consider sea lions on the two islands as a single breeding colony. The data set is analysed in three ways. First the maximum counts of live pups are analysed for the 13 seasons: this is similar to the manner in which trends in the data set for the sea lion colony at Seal Bay, Kangaroo Island were analysed by Shaughnessy et al. (2006). Second, the data set of live pup counts is considered with the data for 1995-96 omitted because of the extremely high level of pup mortality in that season (55.6%, Table 18). Third, the data set for pup production (live plus dead pups) is analysed.

4.3.2 (i) Trends in counts of live pups 1986-87 to 2006-07, 13 seasons

Pup numbers ranged from 195 to 523 and averaged 396 ± 81.6 (Table 18). There was considerable variation in the number of pups born in these 13 pupping seasons (Figure 7). There was no significant trend in the data which showed a slight decline with regression slope –0.0066, equivalent to -0.65% per breeding cycle (R^2=0.014, P = 0.70).

4.3.2 (ii) Trends in counts of live pups 1986-87 to 2006-07 omitting1995-96, 12 seasons

As noted above, data from 1995-96 are omitted in this analysis because of the extremely high level of pup mortality then. Pup numbers ranged from 348 to 523 and averaged 413 ± 57.2. There was considerable variation in the number of pups born in these 12 pupping seasons. The data showed a slight decrease with regression slope -0.0118, equivalent to -1.17% per breeding cycle, although not significant (R^2=0.17, P = 0.19)

4.3.2 (iii) Trends in counts of live plus dead pups, 1989-90 to 2006-07, 12 seasons

Pup numbers ranged from 381 to 607 and averaged 474 ± 67.1 (Table 18). There was considerable variation in the number of pups born in these 12 pupping seasons (Figure 8). There was no significant trend in the data which showed a slight increase with regression slope 0.0078, equivalent to 0.78% per breeding cycle (R^2=0.051, P = 0.48).

4.3.3 Trends in pup mortality at The Pages Islands

For the 12 seasons when dead pups were recorded, the incidence of pup mortality ranged from 3.1% to 55.6% and averaged 17.4 ± 14.5%. The lowest estimates of pup mortality, of 3.1% and 6.0%, were made in the first two seasons that dead pups were counted (1989-90 and 1991), when it is likely that pup mortality was underestimated, because the counters were not fully aware of its significance. In the absence of data from those two seasons, the incidence of pup mortality averaged 20.0 ± 14.6%.

From 1995-96 to 2006-07, when mortality data were collected every season (n = 9), there appears to be a regular variability in the incidence of pup mortality between pupping seasons with alternating high and low incidences of mortality (Figure 9). This variability pattern seems to be less apparent than that displayed at Dangerous Reef colony (e.g., Shaughnessy 2005a, section 5.3).

4.3.4 Trends at The Pages Islands

Some caution is necessary when interpreting these data because it is not clear that visits to the colony coincided with the peak in numbers in pup production or even with the peak in numbers of pups ashore for each season. Until the 1998 pupping season, only one to three counts were made in the colony each season, whereas from 1999-2000 onwards there were four to eight counts each season. Hence the chances of visits coinciding with the maximum in pup numbers were smaller until 1998 than from 1999-2000 onwards, as were opportunities for counting dead pups.

It is interesting to compare trend data for The Pages Islands with those for Seal Bay on Kangaroo Island, where maximum counts of live pups showed a strong divergence between pupping seasons, with high counts interspersed with low counts in most instances (Shaughnessy et al. 2006). That pattern is not apparent for the maximum counts each pupping season at The Pages Islands.

The decline in maximum counts of live pups at Seal Bay over 13 seasons was equivalent to 1.14% per breeding cycle, with $R^2 = 0.216$. At The Pages Islands, the data for live pups (with the aberrant 1995-96 season omitted) showed a decline of 1.17% per breeding cycle, which is similar to that at Seal Bay. But if the analysis for The Pages Islands includes both live plus dead pups, the population size increased at 0.78% per breeding cycle. Further counts are required to determine the population status of Australian sea lions at The Pages Islands.

4.3.5 Nicolas Baudin Island

On 18 June 2007, 12 pups were seen on Nicolas Baudin Island, one of which was dead. One pup had been born in recent days, as indicated by the large amount of blood on the pup and its mother. The 16 adult males seen were active and several of them were mate-guarding. In addition, another 86 animals were ashore. Judging by the size of the largest pups, the pupping season must have begun about two weeks previously, i.e., in the first week of June.

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Australian sea lions on The Pages Islands were counted by Clarence Kennedy, Mike Penhall, Derek Snowball, and Albert Zepf. David Stemmer provided information on Australian fur seal specimens held in the South Australian Museum.

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TABLES

Table 1. Numbers of New Zealand fur seal pups marked at breeding colonies on Kangaroo Island in January 2007. Pups were marked by clipping hair on the head.

Colony	**Date**	**No. marked**	**Dead** (found at marking)	**Dead** (found at recapture, missed at marking)
Berris Point				
North	23 Jan	150	1	0
Middle	23 Jan	172	2	1
South	23 Jan	65	1	0
Cape Gantheaume				
Sector Beach	23 Jan	324	2	0
Sector A, B	24 Jan	48	1	0
Sector C, D, E	24 Jan	181	0	0
Sector F, G, H	24 Jan	128	2	0
Sector I, J	24 Jan	470	3	0
Sector K, L	24 Jan	310	3	0
Sub-total, Berris & Cape Ganth		**1848**	**15**	**1**
Cape du Couedic Area				
Weirs Cove, north	29 Jan	110	2	0
Weirs Cove, south	28 Jan	48	0	0
Nautilus Rock	27 Jan	85	1	0
Nautilus North	27 Jan	225	4	1
Libke, south	28 Jan	249	2	5
Libke, north	28 Jan	151	1	0
Spooks North	28 Jan	206	4	2
Sub-total, Cape du Couedic area		**1248**	**14**	**8**
North Casuarina Island	29 Jan	**174**	**15**	**7**
Total for Kangaroo Island		**3270**	**44**	**16**

Table 2. Mark-recapture estimates of New Zealand fur seal pups at Berris Point colony, Cape Gantheaume Conservation Park, Kangaroo Island, in January 2007.

Date	Caller [a]	No. marked pups (M)	No. pups examined (n)	No. marked pups recaptured (m)	Pup population estimate (N)	Dead [b]	Total	Standard deviation
North section								
25-Jan	PS	150	160	100	239.7	1	240.7	8.4
25-Jan	AM	150	147	85	258.9	1	259.9	11.8
26-Jan	CK	150	87	39	331.2	1	332.2	32.9
26-Jan	CK	150	130	73	266.3	1	267.3	14.5
27-Jan	CK	150	96	49	291.9	1	292.9	23.4
27-Jan	CK	150	105	55	284.8	1	285.8	20.6
Mean estimate					279		280	8.3
Middle section								
25-Jan	PS	172	190	70	464.4	3	467.4	33.4
25-Jan	AM	172	197	79	427.2	3	430.2	26.9
26-Jan	CK	171	195	88	377.8	3+1u+1m	382.8	20.5
26-Jan	CK	171	179	77	395.9	3+1u+1m	400.9	24.9
27-Jan	CK	171	156	68	390.4	3+1u+1m	395.4	27.1
27-Jan	CK	171	185	75	419.9	3+2u+1m	425.9	27.6
Mean estimate					413		417	11.0
South section								
25-Jan	PS	65	93	35	171.3	1	172.3	15.0
25-Jan	AM	65	82	37	143.2	1	144.2	11.1
26-Jan	CK	65	75	33	146.5	1	147.5	12.9
26-Jan	CK	65	42	24	112.5	1	113.5	11.4
27-Jan	CK	65	61	27	145.1	1	146.1	15.2
27-Jan	CK	65	67	22	194.1	1	195.1	26.2
Mean estimate					152	1	153	6.6
Total, Berris Point (sum of sections)								
Mean estimate					844	6	850	15.3

[a] Recapturers (callers) were: Clarence Kennedy, Adam McKeown and Peter Shaughnessy.

[b] 4 dead pups were found during pup marking, 1 in North section, 2 in Mid and 1 in South. During recapture sessions, no dead pups were found in North or South sections; in Middle section, 1 dead pup was found that was considered to have been dead when pups were marked
'u' and 'm' indicate unmarked and marked dead pups found during recapture sessions.

Table 3. Mark-recapture estimates of New Zealand fur seal pups at Cape Gantheaume colony, Kangaroo Island in January 2007.

Date	Caller [a]	No. marked pups (M)	No. pups examined (n)	No. marked pups recaptured (m)	Pup population estimate (N)	Dead	Total	Standard deviation
26-Jan	DD	1460	1450	725	2919.0	11+2u+1m	2933.0	54.3
26-Jan	DW	1460	1039	529	2865.9	11+3u+1m	2880.9	69.5
27-Jan	DD	1460	1479	737	2928.9	11+4u+1m	2944.9	53.7
27-Jan	DW	1460	1145	588	2841.6	11+5u+1m	2858.6	63.0
28-Jan	DD	1460	1518	790	2804.6	11+6u+1m	2822.6	46.7
28-Jan	DW	1460	1405	685	2993.4	11+8u+1m	3013.4	59.5
Mean estimate					2892		2909	23.8
Cave between Beach & sector A					41	0	41	
Total pups					2933		2950	

[a] Recapturers (callers) were: Dave Dowie, Desley Whisson.

[b] 11 dead pups were found when pups were marked on 23 and 24 January; none was found during recapture sessions that were considered to have been dead when pups were marked
'u' indicates unmarked dead pups found during recapture sessions
'm' indicates marked dead pups found during recapture sessions.

Table 4. Mark-recapture estimates of New Zealand fur seal pups in sectors at Cape Gantheaume colony, Kangaroo Island in January 2007.

Date	Caller [a]	No. marked pups (M)	No. pups examined (n)	No. marked pups recaptured (m)	Pup population estimate (N)	Dead [b]	Total	Standard deviation
BEACH sector								
26-Jan	DD	323	299	132	729.8	2+1m	732.8	36.2
26-Jan	DW	323	205	105	628.7	2+1m	631.7	34.8
27-Jan	DD	323	308	156	636.7	2+1m	639.7	25.5
27-Jan	DW	323	262	121	697.5	2+1u+1m	701.5	36.4
28-Jan	DD	323	318	150	683.5	2+1u+1m	687.5	29.4
28-Jan	DW	323	284	123	743.7	2+1u+1m	747.7	39.3
Mean, Beach sector					687		690	13.9
SECTOR A B								
26-Jan	DD	48	57	24	112.7	1	113.7	11.8
26-Jan	DW	48	39	19	97.0	1	98.0	11.6
27-Jan	DD	48	46	21	103.7	1	104.7	11.8
27-Jan	DW	48	54	28	91.9	1	92.9	7.5
28-Jan	DD	48	52	30	82.8	1	83.8	5.8
28-Jan	DW	48	51	23	105.2	1	106.2	11.1
Mean, Sector AB					99		100	4.2
SECTOR C D E								
26-Jan	DD	181	195	112	314.7	0	314.7	11.8
26-Jan	DW	181	161	85	341.8	0	341.8	18.3
27-Jan	DD	181	178	104	309.3	0	309.3	12.6
27-Jan	DW	181	155	92	304.3	0	304.3	14.0
28-Jan	DD	181	175	104	304.1	0	304.1	12.2
28-Jan	DW	181	180	104	312.7	0	312.7	12.8
Mean, Sector CDE					314		314	5.6
SECTOR F G H								
26-Jan	DD	128	146	75	248.5	2+1u	251.5	12.7
26-Jan	DW	128	95	53	228.3	2+1u	231.3	15.6
27-Jan	DD	128	146	66	282.0	2+1u	285.0	17.6
27-Jan	DW	128	124	61	259.1	2+1u	262.1	16.8
28-Jan	DD	128	140	72	248.2	2+2u	252.2	13.3
28-Jan	DW	128	134	71	240.9	2+2u	244.9	12.9
Mean, Sector FGH					251		254	6.1

Table 4 (continued)

Date	Caller [a]	No. marked pups (M)	No. pups examined (n)	No. marked pups recaptured (m)	Pup population estimate (N)	Dead [b]	Total	Standard deviation
SECTOR I J								
26-Jan	DD	470	429	221	911.3	3	914.3	30.9
26-Jan	DW	470	363	180	946.2	3	949.2	39.1
27-Jan	DD	470	497	252	926.1	3+1u	930.1	27.8
27-Jan	DW	470	379	198	898.4	3+1u	902.4	33.4
28-Jan	DD	470	516	272	891.0	3+1u	895.0	24.0
28-Jan	DW	470	463	225	966.0	3+2u	971.0	33.2
Mean, Sector IJ					923		927	13.0
SECTOR K L								
26-Jan	DD	310	324	161	622.9	3+1u	626.9	24.0
26-Jan	DW	310	176	87	624.5	3+2u	629.5	39.8
27-Jan	DD	310	304	138	681.4	3+2u	686.4	31.6
27-Jan	DW	310	171	88	600.0	3+2u	605.0	37.2
28-Jan	DD	310	317	162	605.7	3+2u	610.7	22.8
28-Jan	DW	310	293	139	652.1	3+3u	658.1	29.5
Mean, Sector KL					631		636	12.8
Total of sector means					2905		2921	24.7
Cave between Beach & sector A					41		41	
Overall total [c]					2946		2962	

[a] Recapturers (callers) were: Dave Dowie, Desley Whisson.

[b] 11 dead pups were found when pups were marked on 23 and 24 January; none was found during recapture sessions that were considered to have been dead when pups were marked
'u' indicates unmarked dead pups found during recapture sessions
'm' indicates marked dead pups found during recapture sessions.

Table 5. Mark-recapture estimates of New Zealand fur seal pups at Weirs Cove colonies, Cape du Couedic, Kangaroo Island, in January and February 2007.

Date	Caller [a]	No. marked pups (M)	No. pups examined (n)	No. marked pups recaptured (m)	Pup population estimate (N)	Dead [b]	Total	Standard deviation
Weirs	**Cove**	**North**						
31-Jan	GH	110	136	49	303.1	2 + 1u	306.1	25.2
31-Jan	GH	110	103	45	250.0	2 + 1u	253.0	20.9
2-Feb	AW	110	118	52	248.2	2 + 2u	252.2	18.3
2-Feb	AW	110	129	57	247.8	2 + 2u	251.8	16.7
3-Feb	GH	110	129	58	243.6	2 + 2u	247.6	16.0
3-Feb	GH	110	115	44	285.1	2 + 2u	289.1	25.5
Mean estimate					263		267	8.5
Weirs	**Cove**	**South**						
31-Jan	GH	48	76	35	103.8	0	103.8	6.5
31-Jan	GH	48	53	27	93.5	0	93.5	8.0
2-Feb	AW	48	73	26	133.3	0	133.3	13.6
2-Feb	AW	48	56	22	120.4	0	120.4	13.9
3-Feb	GH	48	56	21	126.0	0	126.0	15.4
3-Feb	GH	48	65	32	97.0	0	97.0	6.8
Mean estimate					112		112	4.6

[a] Recapturers (callers) were: Graham Harrington, Ann Warner.

[b] At Weirs Cove North, 2 dead pups were found during pup marking on 29 January and 2 unmarked pups were found during recapture sessions.
'u' indicates unmarked dead pups.

At Weirs Cove South, no dead pups were found
No marked pups were found dead during recaptures in either colony.

Table 6. Mark-recapture estimates of New Zealand fur seal pups at North Casuarina colony, Kangaroo Island, in January and February 2007.

Date	Caller [a]	No. marked pups (M)	No. pups examined (n)	No. marked pups recaptured (m)	Pup population estimate (N)	Dead [b]	Total	Standard deviation
31-Jan	DS	173	137	81	291.8	15+6u+1m	313.8	14.9
31-Jan	DS	173	136	71	330.1	15+6u+1m	352.1	20.4
31-Jan	DS	173	168	100	290.1	15+6u+1m	312.1	11.8
1-Feb	CJ, AB	173	158	110	248.2	15+6u+1m	270.2	7.8
1-Feb	CJ, AB	173	137	81	291.8	15+6u+1m	313.8	10.7
Mean estimate					287	22	309	6.2
Of these, 10 were Australian fur seal pups							less 10	
Mean estimate of New Zealand fur seal pups							299	

[a] Recapturers (callers) were: Alison Buck, Chris Jones, Derek Snowball.

[b] 15 dead pups were found during pup marking on 29 January.
During recapture sessions, 6 unmarked pups and 1 marked pup were found. It is assumed that they were all dead when recaptures began.
'u' indicates unmarked dead pups and 'm' indicates a marked dead pup.

Table 7. Mark-recapture estimates of New Zealand fur seal pups at Nautilus Rock and Nautilus North colonies, Cape du Couedic, Kangaroo Island, in January and February 2007.

Date	Caller [a]	No. marked pups (M)	No. pups examined (n)	No. marked pups recaptured (m)	Pup population estimate (N)	Dead [b]	Total	Standard deviation
Nautilus Rock								
31-Jan	DA	85	58	47	104.7	1	105.7	4.3
2-Feb	DS	85	81	64	107.5	1	108.5	3.0
2-Feb	DS	85	69	53	110.5	1	111.5	4.4
3-Feb	DA	85	63	47	113.7	1	114.7	5.4
3-Feb	FM	85	38	31	103.8	1	104.8	6.1
Mean estimate, Nautilus Rock					108		109	2.1
Nautilus North								
31-Jan	DA	225	214	110	436.7	4+1u	441.7	20.5
31-Jan	DA	225	268	132	456.1	4+1u	461.1	18.0
2-Feb	DS	225	281	151	418.3	4+1u	423.3	13.2
2-Feb	DS	225	237	122	436.3	4+1u	441.3	18.4
3-Feb	DA	225	227	112	455.0	4+1u	460.0	21.4
3-Feb	EC	225	190	102	418.1	4+1u	423.1	20.6
Mean estimate, Nautilus North					437		442	7.7

[a] Recapturers (callers) were: Dani Ayers, Evelyn Chia, Frances Marsh, Derek Snowball.

[b] At Nautilus Rock, 1 dead pup was found during pup marking on 27 January.
At Nautilus North, 4 dead pups were found during pup marking on 27 January and another 1 pup that was considered to have been dead when pups were marked was found during a recapture session.
'u' indicates an unmarked dead pup.
No marked pups were found dead during recaptures at either colony.

Table 8. Mark-recapture estimates of New Zealand fur seal pups at Libke colony, Cape du Couedic, Kangaroo Island, in January and February 2007.

Date	Caller [a]	No. marked pups (M)	No. pups examined (n)	No. marked pups recaptured (m)	Pup population estimate (N)	Dead [b]	Total	Standard deviation
North Libke								
31-Jan	PS	151	123	51	361.5	1	362.5	30.8
31-Jan	PS	151	124	50	371.5	1	372.5	32.4
2-Feb	DA	151	176	74	357.7	1	358.7	22.2
2-Feb	DA	151	179	66	407.4	1	408.4	29.3
3-Feb	DA	151	187	65	432.0	1	433.0	32.1
3-Feb	DA	151	179	70	384.4	1	385.4	25.8
Mean estimate, North Libke					386		387	11.8
South Libke								
31-Jan	PS	248	205	90	562.7	2+5u+1m	570.7	35.0
31-Jan	PS	248	227	118	476.1	2+5u+1m	484.1	21.8
2-Feb	DA	248	216	109	490.2	2+5u+1m	498.2	24.5
2-Feb	DA	248	249	100	615.3	2+5u+1m	623.3	36.3
3-Feb	DA	248	247	118	517.9	2+5u+1m	525.9	24.7
3-Feb	DA	248	257	112	567.5	2+5u+1m	575.5	29.5
Mean estimate, South Libke					538		546	11.9
Total, Libke colony (sum of sectors)								
Mean estimate					924		933	16.8

[a] Recapturers (callers) were: Dani Ayers, Peter Shaughnessy.

[b] At North Libke, 1 dead pup was found during pup marking on 28 January; no dead pups during recapture sessions.
At South Libke, 2 dead pups were found during pup marking on 28 January and 5 were found during recapture sessions that were considered to have been dead when pups were marked.
A marked dead pup was found during the first recapture session.
'u' indicates unmarked dead pups and 'm' indicates a marked dead pup.

Table 9. Mark-recapture estimates of New Zealand fur seal pups at Spooks North colony, Cape du Couedic, Kangaroo Island, in January and February 2007.

Date	Caller [a]	No. marked pups (M)	No. pups examined (n)	No. marked pups recaptured (m)	Pup population estimate (N)	Dead [b]	Total	Standard deviation
31-Jan	PS	206	127	80	326.1	6	332.1	17.1
31-Jan	PS	206	143	83	353.9	6	359.9	19.2
2-Feb	DA	206	153	92	341.8	6	347.8	16.5
2-Feb	DA	206	185	95	400.1	6	406.1	20.7
3-Feb	DA	206	231	131	362.8	6	368.8	12.5
3-Feb	DA	206	191	108	363.6	6	369.6	15.7
Mean estimate					358		364	7.0

[a] Recapturers (callers) were: Dani Ayers, Peter Shaughnessy.

[b] 4 dead pups were found during pup marking on 28 January and 2 found during recapture sessions were considered to have been dead when pups were marked
No marked dead pups were found during recapture sessions.

Table 10. Counts of New Zealand fur seals at small sites on Kangaroo Island and elsewhere in South Australia during 2007.

Colony	Position	Date	Unclassed animals	Black pups	Observers
Newland Head & several sites nearby	36.642 S, 138.522 E	30 Jan 07	<10	0	T. Dennis
North Pages Island	35.770 S, 138.290 E	10 Feb 07	15	-	C. Kennedy
South Pages Island	ditto	10 Feb 07	15	-	C. Kennedy
South West Reef, Pages Is	ditto	10 Feb 07	3	-	C. Kennedy
Cape Hart	35.900 S, 138.033E	5 Aug 07	ca 300	-	A. Zepf
Cape Gantheaume, near Little Weirs Cove	Near 36.083 S, 137.467 E	27 Jan 07	-	7	D. Dowie
Cape Gantheaume, caves west of beach	Near 36.083 S, 137.467 E	7 Jan 07	17	11	J. McKenzie
Xenolith Point	36.024 S, 136.977 E	6 Jan 07	2	1	J. McKenzie
Cave Point	36.026 S 136.965 E	1 Feb 07	-	30	D. Ayers, P. Shaughnessy
Knife and Steel Point	Between Remarkable Rocks & Cape du Couedic	29 Jan 07	-	147	D. Snowball, D. Kerry
Nicolas Baudin Is	33.016S, 134.133E	18 Jun 07	28	2	P Shaughnessy D. Armstrong

Table 11. Summary of abundance estimates of New Zealand fur seal pups in breeding colonies on Kangaroo Island in January and February 2007 (with estimates from previous seasons in *italics* for colonies not visited in 2007).
They are compared with estimates from the previous summer (January – February 2006). Colonies are listed in a clockwise direction from east to west.

Breeding colony or haul-out site	Method of estimation	Pup numbers, Jan 2007 Live	Dead [a]	Total	Pup Numbers early 2006 [b]
EASTERN END					
Cape Linois	Direct counting	-	-	*2* [b]	2
Berris Point	Mark-recapture	844	6	850	697
Little Weirs & nearby	Direct counting	7	0	7	0
Cape Gantheaume	Mark-recapture [c]	2946	17	2962 [c]	3120
Cape Gantheaume, west of colony	Direct counting	11	0	11	14
Subtotal, eastern end				**3832**	**3833**
SOUTH COAST					
Xenolith Point	Direct counting	1	0	1	1
Cave Point	Direct counting	30	0	30	25
Horseshoe Bay points	Direct counting	-	-	3 [b]	3
Cape Bouguer	Direct counting	-	-	17	17
Subtotal, South coast				**51**	**46**
CAPE DU COUEDIC					
Knife & Steel Point	Direct counting	147	0	147	98
Weirs Cove north	Mark-recapture	263	4	267	255
Weirs Cove south	Mark-recapture	112	0	112	103
Ladders North [d]	*Mark-recapture 97/98*	*254*	*3*	*257* [d]	*257*
Ladders South [d]	*Direct counting 97/98*	*21*	*0*	*21* [d]	*21*
Admirals Arch	Direct counting	12	1	13	14
Nautilus Rock	Mark-recapture	108	1	109	140
Nautilus North	Mark-recapture	437	5	442	463
Libke	Mark-recapture	924	9	933	975
Spooks North	Mark-recapture	358	6	364	260
Subtotal, Cape du	**Couedic area**			**2,665**	**2,586** [f]
North Casuarina Is.	Mark-recapture	287	22	**299**	**313** [e]
TOTAL				**6,847**	**6,778** [f]

[a] Includes some dead pups found during recapture sessions.
[b] From February 2006 (Shaughnessy 2006, Table 11).
[c] From Table 4, based on sectors.
[d] From January - February 1998 (Shaughnessy 1998, Table 8).
[e] Based on exponential interpolation from the February 1996 estimate of 499 pups (see text).
[f] Adjusted from the 2005-06 report because estimate for North Casuarina Is. is changed.

Table 12. Summary of mark-recapture estimates of New Zealand fur seal pups (including dead pups) at the largest colonies on Kangaroo Island between 1988-89 and 2006-07.
Data for 2006-07 are from this report.
Other data are set out in earlier reports (e.g., see Shaughnessy 2006, Table 12), but estimates for Cape Gantheaume are revised here using calculations by colony sectors.
Estimates in *italics* are by direct counting.

Year	Berris Point	Cape Ganth.	Weirs North	Weirs South	Nautilus Rock	Nautilus North	Libke	Spooks
1988-89		457			112	182	-	-
		(4.2)			(7.8)	(18.7)		
1989-90		525			116	208	-	-
		(6.3)			(3.3)	(9.2)		
1990-91		606			103	268	-	-
		(15.0)			(2.4)	(4.4)		
1991-92		736			-	-	-	-
		(5.78)						
1992-93		864			115	376	-	-
		(15.2)			(3.1)	(8.9)		
1993-94		938			125	428	-	-
		(10.8)			(3.0)	(6.3)		
1994-95		1114			129	439	*31*	-
		(11.4)			(2.5)	(5.3)	-	
1995-96	*0*	1405	*0*	*7*	141	533	*55*	-
		(23.3)			(2.8)	(8.8)	-	
1996-97	*4*	1579	*2*	*8*	154	566	*67*	-
		(19.5)			(4.0)	(8.0)	-	
1997-98	*11*	1932	*11*	*14*	164	632	166	-
		(25.0)			(4.0)	(8.8)	(4.2)	
1998-99	*17*	2048	*9*	*21*	172	623	254	-
		(16.1)			(2.9)	(6.2)	(5.6)	
1999-00	*22*	2132	*34*	*27*	174	631	345	-
		(19.7)			(2.9)	(6.3)	(6.0)	
2000-01	*66*	1655	*54*	*23*	160	539	372	-
		(12.8)			(3.1)	(6.3)	(6.8)	
2001-02	*109*	2131	*54*	*48*	196	584	499	-
		(20.7)			(3.3)	(6.2)	(8.6)	
2002-03	143	2170	101	69	172	525	596	*1*
	(3.6)	(13.4)	(3.2)	(2.8)	(3.1)	(9.1)	(9.6)	
2003-04	264	2635	161	71	171	497	744	*19*
	(3.4)	(23.6)	(3.9)	(2.3)	(3.2)	(7.1)	(14.5)	
2004-05	460	2980	319*	-	176	483	975	*83*
	(6.8)	(26.5)	(7.5)		(3.8)	(7.2)	(20.0)	
2005-06	697	3120	255	103	140	463	975	260
	(9.6)	(34.2)	(5.3)	(3.8)	(2.4)	(9.4)	(19.3)	(10.1)
2006-07	850	2963	267	112	109	442	933	364
	(15.3)	(24.7)	(8.5)	(4.6)	(2.1)	(7.7)	(16.8)	(7.0)

***** At Weirs Cove in 2004-05, for the two colonies combined, pup numbers were 319.

Table 13. Changes in numbers of New Zealand fur seal pups in sectors of the Cape Gantheaume colony, Kangaroo Island in nineteen breeding seasons to 2006-07.
Dead pups are included.
Data from 1990-91 to 2005-06 may differ from those Shaughnessy (2006, Table 13) because they have been revised here. Data for 2006-07 are from this report, Table 4.

	Sectors					
Year	Beach	Cave	A, B	C, D, E [a]	F to L [b]	Overall
1988-89 [c, d]	0	0	233	205	19	457
1989-90 [c]	0	0	237	234	54	525
1990-91	0	0	279	238	89	606
1991-92	2	0	312	310	112	736
1992-93	2	0	370	313	179	864
1993-94	22	0	380	311	225	938
1994-95	92	0	350	409	263	1114
1995-96	211	6	337	426	425	1405
1996-97	341	0	275	478	485	1579
1997-98	548	12	270	408	694	1932
1998-99	623	0	201	402	822	2048
1999-2000	590	8	132	408	994	2132
2000-01	523	5	73	222	832	1655
2001-02	633	22	71	289	1117	2131
2002-03	618	33	71	310	1138	2170
2003-04	692	45	85	370	1443	2635
2004-05	750	41	92	394	1704	2980
2005-06	731	41	106	360	1883	3120
2006-07	690	41	100	314	1817	2963

[a] Includes sector Ew each year, but did not include sector Ee until 1995/96.
[b] Includes sector Ee until 1995/96; data have been adjusted to include sector K from 1996-97 & sector L from 1999-2000.
[c] From Goldsworthy (1990, Table 8).
[d] All tagged.

Table 14. Mass (kg) and standard deviation (s.d.) of New Zealand fur seal pups at two colonies on Kangaroo Island on 27 January 2007.

Colony	**Male**			**Female**		
	Mean	s.d.	n	Mean	s.d.	n
Nautilus Rock	6.83	1.42	56	6.19	1.17	29
Cape Gantheaume	7.29	1.29	63	6.71	1.10	47

Table 15. Comparison of mass (kg) of New Zealand fur seal pups between colonies and sexes on Kangaroo Island, 27 January 2007.

Source	Degrees of freedom	Sums of squares	Mean square	F ratio [a]	Probability
Between sexes	1	14.68	14.68	9.12	0.003
Between colonies	1	11.12	11.12	6.91	0.009
Interaction	1	0.049	0.049	0.030	0.862
Error	193	307.30	1.609		
Total	194	333.15			

[a] All F ratios were determined using the Error (or Residual) mean square as the denominator, because both factors were considered fixed.

Table 16. Counts of Australian fur seals at sites on Kangaroo Island, January & February 2007.

Date	Colony	No.	Comments	Counter [a]
7 Jan	Cape Gantheaume A	25	Subadult males and juveniles	JMcK
23 Jan	Cape Gantheaume A,B	36	Adults, subadult males & juveniles	PDS
30 Jan	Cape du Couedic, Admirals Arch	41	From lookout on eastern side	PDS
31 Jan	South Casuarina Island	69	From helicopter, 2nd circuit of island	PDS
29 Jan	North Casuarina Island	328 + 11 pups	During pup marking (10[b] pups) & on circuit of the island (1)	PDS
31 Jan	North Casuarina Island	8 pups [b]	During 1st recapture	DS
31 Jan	North Casuarina Island	9 pups [b]	During 2nd recapture	DS
1 Feb	North Casuarina Island	313 + 7 pups [b]	During 4th recapture	AB

[a] Counters were A. Buck, Jane McKenzie, D. Snowball and P. Shaughnessy
[b] Pups were in the cave, in pools & on the rock platform between the cave and the sea.

Table 17. Counts of Australian sea lion pups at The Pages Islands, December 2006 to March 2007.
Animals on South-west Reef are included with data for South Page Island.

Date	Live pups	Dead pups [a]	Accumulated dead pups [b]	Estimated no. of pups [c]	Non-pups	Counters [d]
The Pages (combined)						
2 Dec 06	238	6	6	244	740	CK, MP, AZ
8 Jan 07	314	18	24	338	825	CK, AZ
10 Feb 07	361	18	42	**403**	763	CK, AZ, MP
24 Mar 07	314	8	50	364	587	CK, AZ, DS
North Page						
2 Dec 06	127	1	1	128	297	
8 Jan 07	154	6	7	161	346	
10 Feb 07	185	7	14	**199**	361	
24 Mar 07	171	6	20	191	237	
South Page						
2 Dec 06	111	5	5	116	443	
8 Jan 07	160	12	17	177	479	
10 Feb 07	176	11	28	**204**	402	
24 Mar 07	143	2	30	173	350	

[a] 'Dead pups' refers to those that died since the previous visit to the colony.

[b] 'Accumulated dead pups' refers to the number of dead pups counted in the season up to and including the current count.

[c] Sum of live and accumulated dead pups.

[d] Counters were: Clarence Kennedy, Mike Penhall, Derek Snowball, Albert Zepf.

Table 18. Estimated number of births of Australian sea lion pups on The Pages Islands for 13 pupping seasons between 1986-87 and 2006-07, and the extent of pup mortality.
No data were collected in the 1988 and 1994 pupping seasons.
Entries for live pups are maxima for each pupping season
'Accumulated dead pups' refers to the number of dead pups counted through the pupping season to when the estimated number of pups reached a maximum.

Pupping season	Live pups	Accumulated dead pups	Estimated no. of births	Pup mortality (%)
1986-87	462	-	-	-
1988	no visits	-	-	-
1989-90	506	16	522	3.1
1991	405	26	431	6.0
1992-93	399	49	448	10.9
1994	no visits	-	-	-
1995-96	195	244	439	55.6
1996-97	348	33	381	8.7
1998	387	58	445	13.0
1999-2000	438	53	491	10.8
2001	365	96	461	20.8
2002-03	523	84	607	13.8
2003-04	378	107	485	22.1
2005	384	193	577	33.4
2006-07	361	42	403	10.4
Average, with 1986-87	396 (s.d. 81.6)		-	-
Average, without 1986-87	-		474 (s.d. 67.1)	17.4 (s.d. 14.5%)

Table 19. Trends in abundance of Australian sea lions at The Pages Islands compared with that at Seal Bay on Kangaroo Island.
There is no entry below for the regression slope for Seal Bay because those regression analyses were done on a yearly basis (Shaughnessy et al. 2006), whereas the analyses for The Pages Islands were calculated per breeding cycle.

Colony and count data	Pupping seasons	Regression slope	Change per breeding cycle	R^2	Probability
Pages Islands					
Live pups	1986-87 to 2006-07, n = 13	-0.0066	-0.653%	0.0144	0.70
Live pups	1986-87 to 2006-07, omitting 1995-96 n = 12	-0.0118	-1.172%	0.167	0.19
Live plus dead pups	1989-90 to 2006-07, n = 12	0.00779	0.782%	0.051	0.48
Seal Bay, KI					
Live pups	1985 to 2002-03	-	-1.14%	0.216	0.05<P<0.10

FIGURES

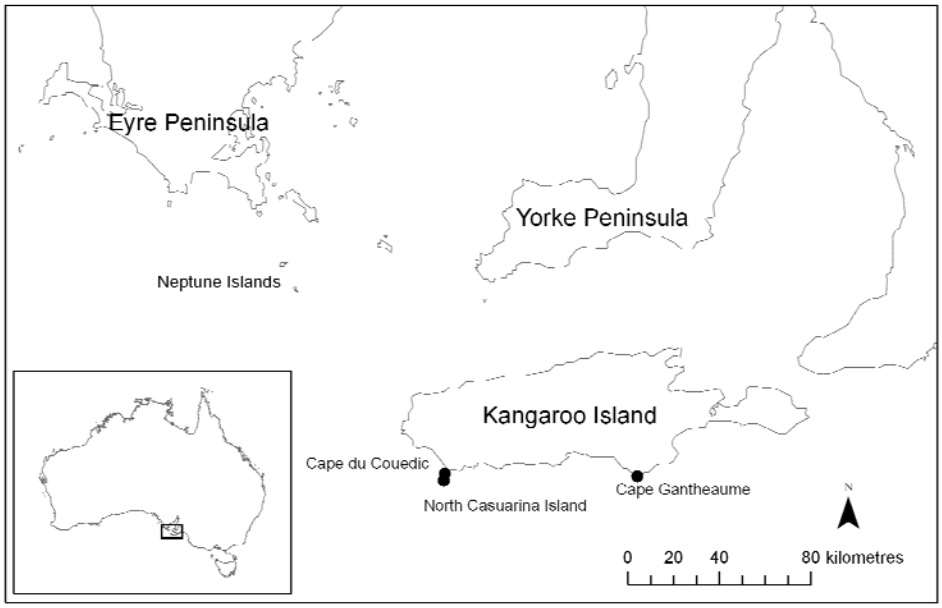

Figure 1. Map of central coastal regions of South Australian with locations of the major New Zealand fur seal colonies on Kangaroo Island and the Neptune Islands.

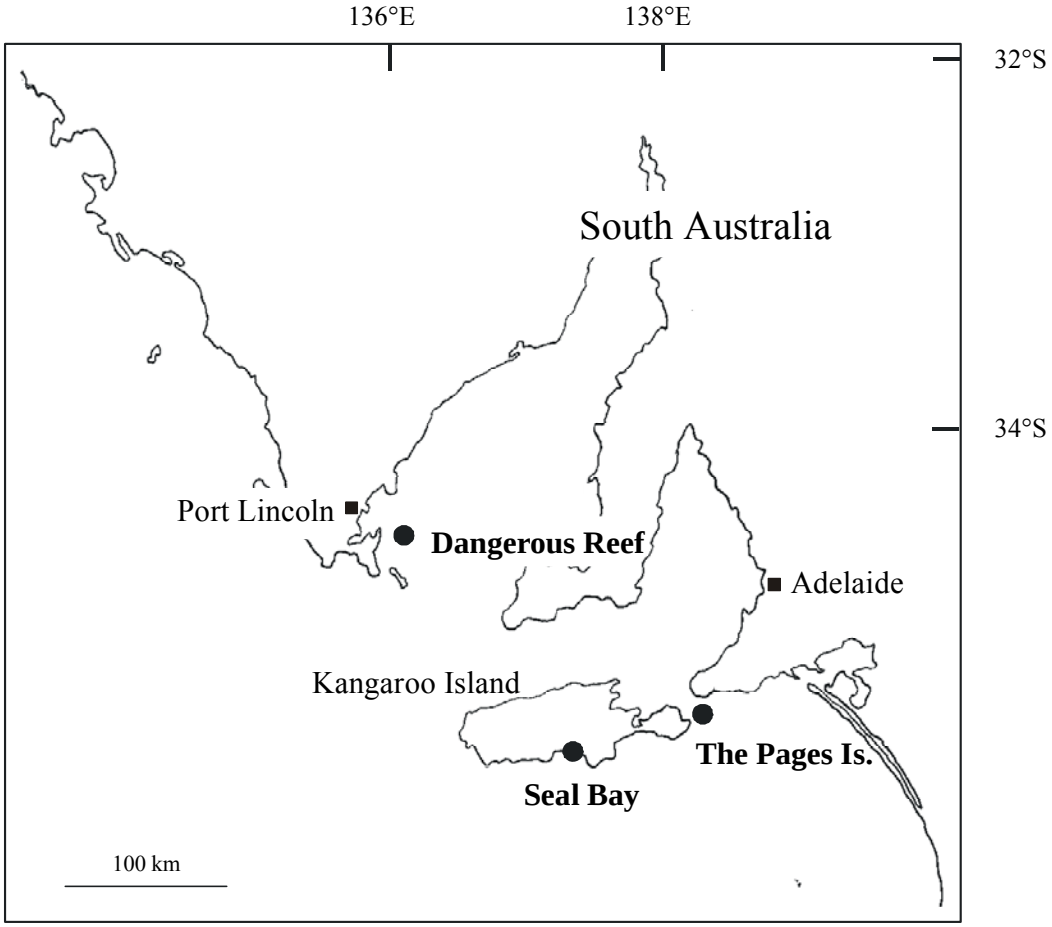

Figure 2. Location of three large colonies of the Australian sea lion in South Australia.

Figure 3. Trends in abundance of New Zealand fur seal pups on Kangaroo Island, January 1989 to 2007

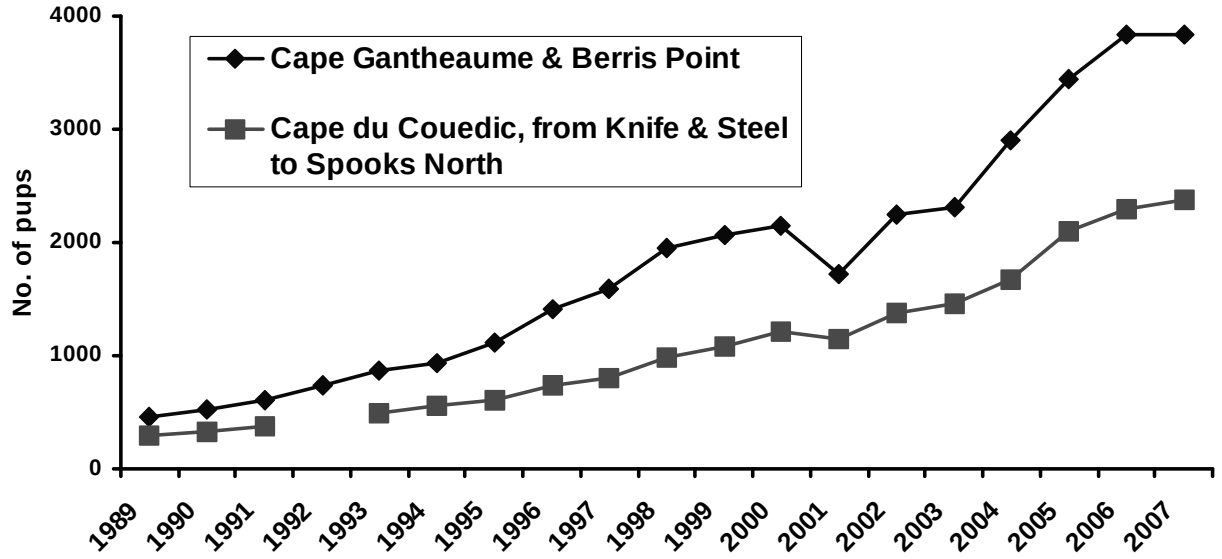

Figure 4. Trends in abundance of New Zealand fur seal pups in sectors of Cape Gantheaume colony, Kangaroo Island, January 1989 to 2007

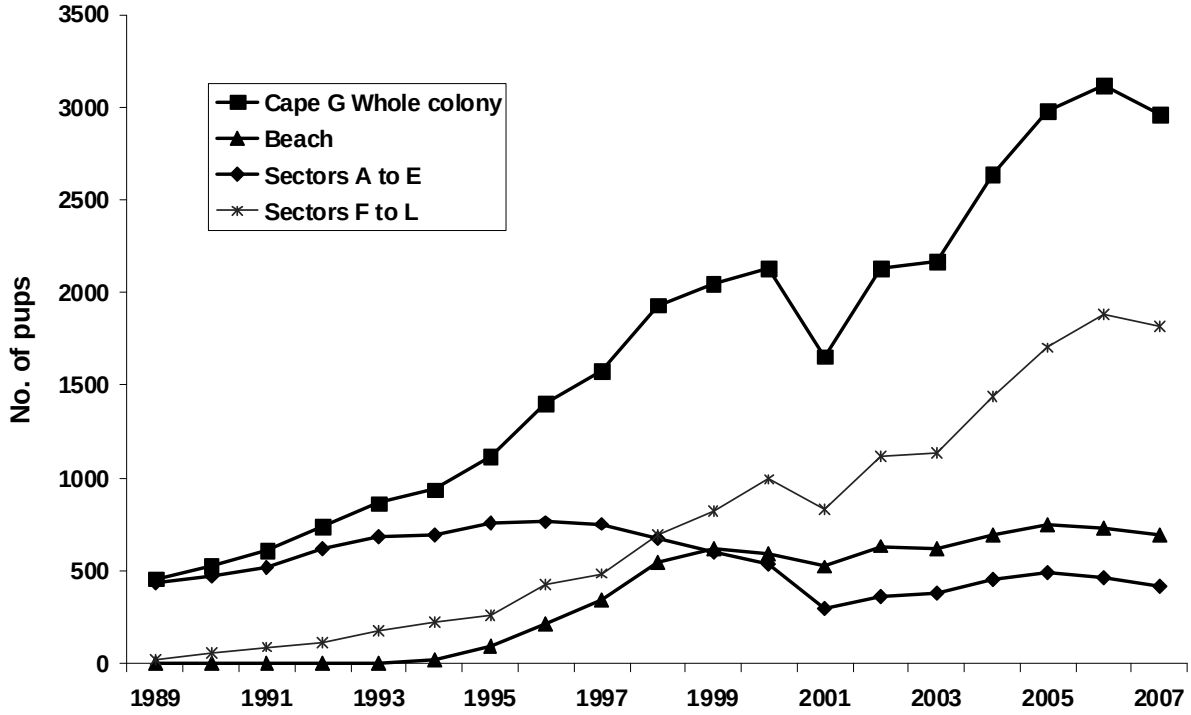

Figure 5. Trends in abundance of New Zealand fur seal pups at Cape du Couedic, Kangaroo Is., January 1989 to 2007

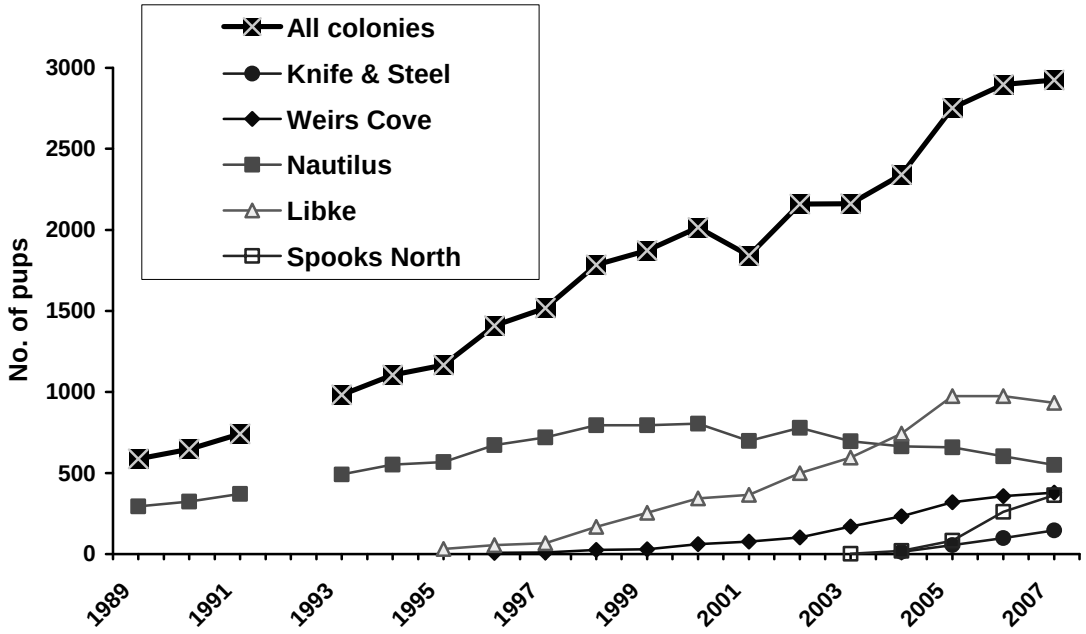

Figure 6. Counts of Australian sea lion pups at The Pages Islands, 2006-07

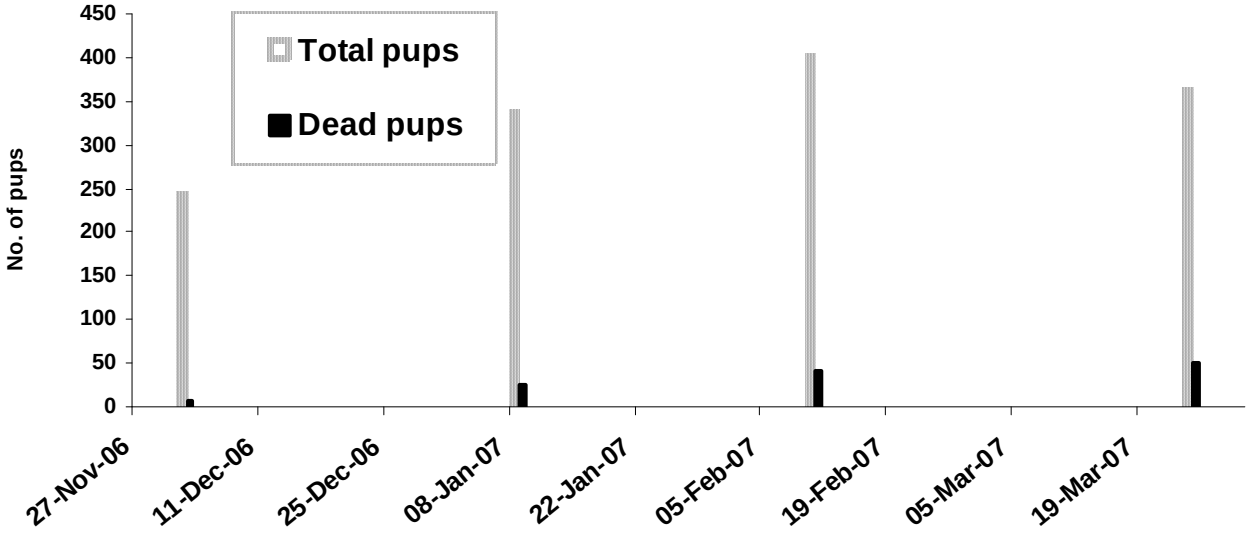

Figure 7. Trends in counts of live Australian sea lion pups at The Pages Islands, 1986-87 to 2006-07 (n = 13)

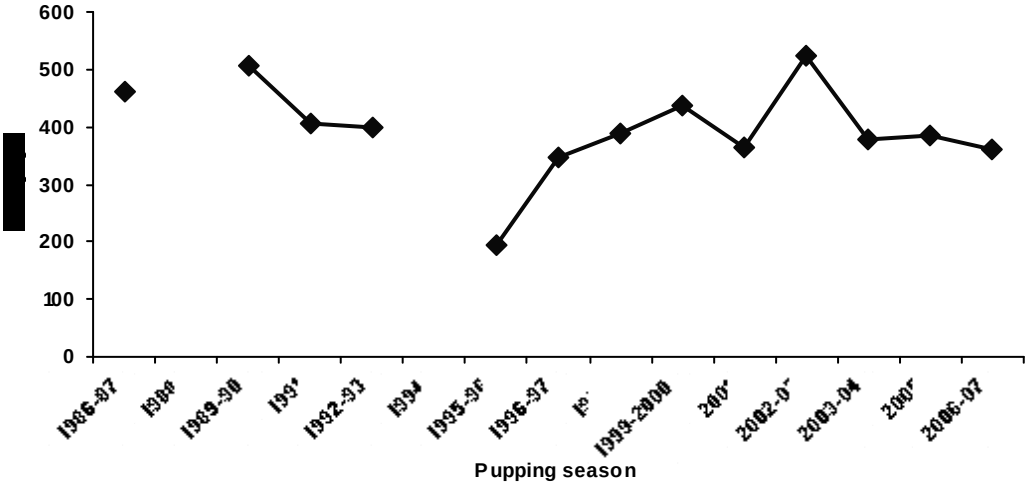

Figure 8. Trends in counts of live and dead Australian sea lion pups at The Pages Islands, 1989-90 to 2006-07 (n = 12)

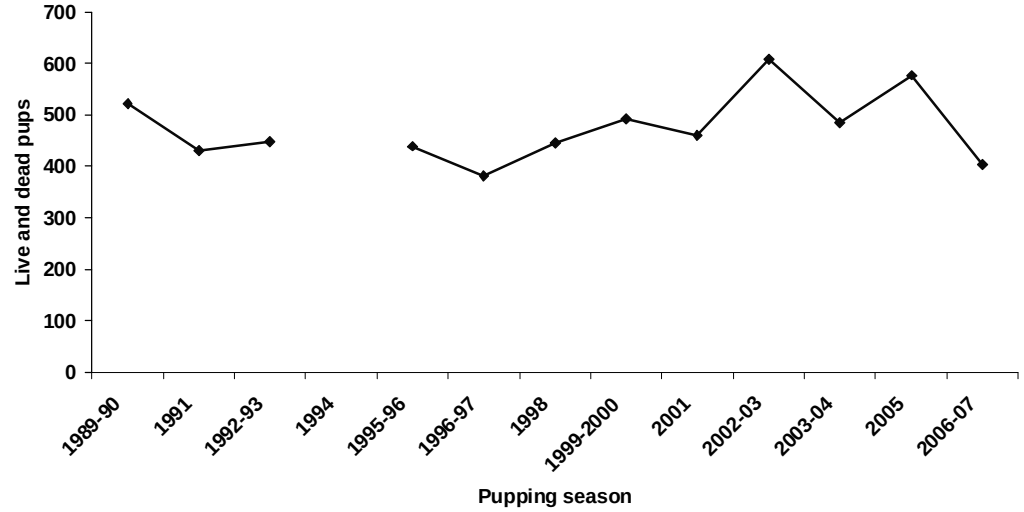

Figure 9. Pup mortality at The Pages Islands, 1989-90 to 2006-07