ABUNDANCE OF AUSTRALIAN SEA LIONS *Neophoca cinerea* ALONG THE SOUTHERN AUSTRALIAN COAST, AND RELATED RESEARCH

REPORT TO THE WESTERN AUSTRALIAN DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT, SOUTH AUSTRALIAN NATIONAL PARKS AND WILDLIFE SERVICE AND THE SOUTH AUSTRALIAN WILDLIFE CONSERVATION FUND

20th July 1990

Nicholas J Gales
Murdoch University/Atlantis Marine Park

ABSTRACT

The abundance of the Australian sea lion, Neophoca cinerea along the southern Australian coast of Western and South Australia is assessed through direct census of pup numbers on breeding islands.

In Western Australia a total of 13 islands along the south coast are found to support breeding populations. A further 16 islands are listed as possible breeding sites. These islands require further visitation to confirm their actual status. An estimate of the total number of pups born on south coast islands confirmed as breeding sites is 429. Including a further 180 pups that are estimated to be born on the west coast of Western Australia, the state pup production each 1.5 years is c. 609.

In South Australia a total of 18 islands are found to support breeding populations. A further 18 islands are listed as possible breeding sites. An estimate of the total number of pups born on the islands that are confirmed breeding sites is 1354.

A method of predicting total population size from pup production is presented in the report and yields a predictive multiplication factor of 5.09 times the pup production. Therefore the estimates for population size of Neophoca in Western and South Australia are c. 3,100 and c. 6,900 respectively. This yields a total population of c.10,000. This is twice the value of the previous upper population estimate for Neophoca.

This increase in the population estimate for Neophoca does not suggest an expanding population, but rather that this work represents the first attempt to provide an accurate documentation of the population size of Neophoca. Furthermore, the estimate in this report is subject to change as more data on pup production is

required (this will be collected during the next 18 months) and the model calculating the predictive multiplication factor may be changed in the light of more information on the life history of this species.

The report also contains information on data collection for projects on reproductive physiology, foraging energetics and population genetics.

1 INTRODUCTION

1.1 GENERAL INTRODUCTION

The Australian sea lion Neophoca cinerea is one of Australia's most endangered marine mammals, and one of the rarest and most endangered pinnipeds in the world . As one of our very few native marine mammals Neophoca is a high profile species which is the basis for a growing tourism industry in South Australia. Despite this, it remains one of our least studied and understood endemics.

The total population is thought to be between 2000-5000 (King 1983), however this estimate is based on ad hoc counts on breeding and non-breeding islands at different times of year, and is therefore likely to be erroneous. Abbott (1979) and Robinson and Dennis (1986) provide the most recent population estimates for Western Australia (700 animals) and South Australia (2800) respectively. However a census of Neophoca over its entire range has hitherto not been attempted.

Pinnipeds are difficult to census. Their terrestrial habitats are commonly inaccessible and difficult to view or traverse, they frequently take alarm and rush into the sea when approached, they can be aggressive during the breeding season and an unknown proportion of the population will be at sea during a census of terrestrial sites. All these problems apply to the Australian sea lion.

Meaningful population surveys can only be conducted on land when a known proportion of the total population are hauled out, and preferably when all members of one age class are ashore. For most pinnipeds a suitable age class is newborn pups.

In Western Australia Neophoca is reported to range from Houtman Abrolhos to the South Australian border (Abbott 1979), however breeding has been described on only three islands, these being; North Fisherman Island (30°08'S., 114°57'E.) (Chapman and Kitchener 1977, Ling 1980), Rocky Island (120°52'E., 34°5'S.) (Gales and Lambert 1985) and Kermadec Island (refered to as Wedge Island, 34°05'S, 122°50'E)(Serventy 1953).

In South Australia Neophoca are found on most offshore islands as well as at some small mainland colonies. Robinson and Dennis (1986) provide the only list of known breeding locations (n=13) which they cite as: Seal Bay, Kangaroo island (35° 41'S, 136°53'E), Dangerous Reef (34°49'S, 136°13'E), The Pages (35°46'S, 138°18'E), English Island (34°38'S, 136°12'E), North Islet Island (35°07'S, 136°28'E), Franklin Island (32°27'S, 133°39'E), Freeling Island (32°29'S, 133°21'E), St. Francis Island (32°31'S, 133°18'E), Fenelon Island (32°35'S, 133°17'E), Lounds Island (32°17'S, 133°22'E), Purdie Island (32°17'S, 133°14'E), Olives Island (32°43'S, 133°59'E) and Albatross Island (35°04'S, 136°11'E).

As part of a long term study into the demography and reproductive biology of Neophoca a complete census over the full range of the species is being conducted, part of which is described in this report. The aim of the population survey work is to determine now many sea lion pups are born at breeding locations during a single breeding season. From these data it will be possible to estimate the size of the total population, and more importantly use the pup production data between seasons as an index to the status of the Neophoca population.

1.2 SCOPE OF REPORT

The Neophoca survey was conducted in conjunction with a survey of New Zealand Fur Seals Arctocephalus forsteri by Dr Peter Shaughnessy, CSIRO, Division of Wildlife and Ecology. Dr Shaughnessy will be reporting separately on the results of the fur seal survey and as such it will not be dealt with in this report.

The logistics of a survey of this magnitude mean that the whole operation is costly. Dr Shaughnessy and I were able to collaborate on funding the project. The following is an approximate breakdown of funding sources (excluding salaries) for the sea lion section of the survey:

*Boat charter and travel expenses in WA - Conservation and Land Management and Australian Research Council.

*Boat charter, travel and living expenses in SA - South Australian Wildlife Conservation Fund and Australian Research Council.

*Vehicle running expenses - Atlantis Marine Park

(Other organisations and individuals who assisted in the project are refered to in the acknowledgements).

All data from the 1989/90 sea lion survey in Western Australia and South Australia are included. Further survey work will be necessary to complete the census, a plan of which is contained in this report. Also contained in this report is a summary of work on reproductive physiology and foraging energetics carried out on Kangaroo Island during February 1990. A project on population genetics is also discussed.

2 METHODS

The survey was conducted from December 1989 to March 1990 and covered the region from Albany in Western Australia to The Pages in South Australia. The West coast of WA was not included in the survey as this area has been studied by this investigator during the past two breeding seasons. Population data from the West coast is now being prepared for publication and will be refered to in the results and discussion.

Previous surveys along the South coast of Western Australia by this investigator (none as extensive as that described in this report) have indicated that the breeding seasons of Neophoca are asynchronous between island locations. There is no seasonal, longitudinal or latitudinal pattern to this asynchrony. The pupping season on each island lasts 4-5 months. As such, surveys are conducted every six months for three consecutive surveys, over the course of which all breeding sites should be identified. Following this major 1989/90 survey it will not be necessary to visit all islands every six months. Rather, the islands selected for revisits will be those that showed some evidence of pupping. Data from previous surveys will also be reviewed in the results and discussion.

2.1 SURVEY TECHNIQUE

Previous experience with counting Neophoca pups has indicated that aerial photography is not a viable survey method. The pups utilise rock and vegetation holes in their natal habitats presumably for protection from sympatrics and for thermoregulation. As such they are impossible to sight from the air, and indeed some effort is required to find the animals when on land.

Breeding sites were defined by the discovery of active breeding or evidence of active breeding (pup carcases).

With the exceptions of Neophoca colonies at The Pages, Kangaroo Island and Dangerous Reef, all island pupping sites have been found to support relatively small populations, all producing less than 100 pups per season, and most producing less than 50. These small colonies are generally spread fairly evenly over a defined portion of the island (usually a portion of the periphery of the lee side of the island). As such, a direct count of animals is most appropriate, without the need to use mark-recapture techniques that become necessary in larger and denser colonies. As the pups are often very well hidden under rocks and vegetation, and the cows can be highly aggressive making movement around the colony difficult, there is clearly some degree of underestimation in the count of pups. From data collected from counts and tag/recapture estimates conducted on the West coast of WA the pup counts underestimate the pup production size by approximately 10% (unpublished data), and this figure will be used for all colonies for the purposes of population assessment in this report.

A mark-recapture method of pup number assessment would have been preferable at The Pages, however our time at this colony was limited and it was not possible to return several days later for the recapture. The Neophoca colony at Seal Bay on Kangaroo Island was counted directly as this colony, despite numbering more than 100 pups is spread thinly along a stretch of coast that allows easy and straightforward counting. As the sea lion colony at Dangerous Reef was not pupping during the 1989/90 survey no pups were counted. It is planned to attempt direct counts for this colony, however, a mark-recapture technique may be used if possible.

The general technique that was used for each island survey was to circumnavigate the island slowly and search for evidence of pupping (or suitable pupping habitat) with binoculars. All animals were counted and classified. If there was any evidence of the island sustaining a breeding population, a landing was made. This was achieved by small dinghy or by swimming ashore, dependant on the sea conditions. The island was traversed thoroughly and all animals counted and classified. The sea lions were classified into the following categories:

Bulls - Mature males which have developed a white cap. These animals are of breeding age.

Sub-adult males - Males which are distinguishable from mature females by virtue of their larger size and darker ventral coat colour, but have not yet developed a white cap.

Cows - Females of breeding age. They are silvery grey dorsally and pale yellow ventrally.

Juveniles - Male and female juveniles with the same colouration as cows. These animals may still be sucking.

Pups - New born pups which still retain the chocolate-brown natal coat.

Moulted pups - Recently moulted pups which are developing the colouration of cows, but are less than one and a half years old. After this age it is difficult to distinguish them from the previous cohort, and they are then classed as juveniles.

2.2 POPULATION SIZE ASSESSMENT FROM PUP NUMBERS

An attempt has been made in this report to estimate the size of discrete populations of Neophoca based on the number of pups counted. The method by which the factor to multiply pup numbers has been determined (see below) is subject to revision as it is currently being prepared for publication. Although it is premature to estimate what the total pup production at each of the island breeding colonies is likely to be, some rough estimates are included in this report. It is hoped that sufficient data will have been collected by the end of 1991 to predict more accurately the Neophoca pup production and hence the total population size.

The model I have developed for estimating total population size from pup numbers is as follows:

$$N = M + F + J + P \qquad (1)$$

Where; N is the total population

M is the total population of males excluding pups but including juvenile males

F is the total population of mature females

J is the total number of juvenile females (ie immature females excluding pups)

P is the total number of pups

The following assumptions have been made;

- The Neophoca population is stable
- The sex ratio of male and female pups is 50:50
- There is no differential mortality between sex classes at any age
- 80% of adult females produce a pup each breeding season (Higgins, pers comm.)
- Age at first reproduction for females is 4.5 years (Higgins, pers comm.)
- Survivorship in the first and second cohorts (ie first and second 1.5 years of life) are 60% and 80% respectively
- The model is not density dependant
- These parameters are consistent between colonies.

Neophoca, unlike most pinnipeds, have an asynchronous breeding season from one colony to another. To overcome the conceptual time problems that arise from this I assume that what in reality is a continuous distribution in time infact occurs instantaneously (ie all pups are born at one time, and that all female juveniles turn into cows at the same time). Furthermore, the size of the population and the age-sex categories refer to the end of this "instantaneous" pupping season.

In order to calculate "N" each of the constituents of the equation needs to be expressed in terms of numbers of pups or "P". The number of pups counted ("x") is an unknown proportion of the total pups present. As described in section 2.1 the underestimation of pup production is approximately 10%. As such:

$$P = x\ (100/90)$$

$$= 1.11x \qquad (2)$$

If 80% of mature females produce a pup each breeding season, then:

$$F = P\ (100/80)$$

$$= 1.25P$$

$$= 1.39x \qquad (3)$$

Unlike virtually every other pinnipeds Neophoca have a unique eighteen month gestation. As such the model runs in cycles of 1.5 years as opposed to 1 year. Present, limited, data indicates that females give birth for the first time at 4.5 years of age (Higgins, personal communication), thereby conceiving at 3 years of age. Thus, excluding pups, there are two cohorts of immature females. As there are an equal number of male and female pups born, and the population is stable (therefore, so too are the number of pups born each season) then the number of females entering the juvenile cohorts can be calculated by dividing the pup numbers "P" by two. We currently have little data on annual mortality of Neophoca. These have therefore been estimated from data we have on mortality of pups in the first five months of life and from annual mortality rates of other species of pinnipeds. At present (and this may change prior to this model being published) we are assuming 60% survivorship in the first 1.5 years and 80% survivorship in the second 1.5 years. As such;

$$J = (P/2)(60/100) + (P/2)(60/100)(80/100)$$
$$= 0.54P$$
$$= 0.6x \qquad (4)$$

The total number of males, excluding pups ("M") is equal to the total number of females excluding pups (assuming no differential mortality). Therefore

$$M = F + J$$
$$= 1.39x + 0.6x$$
$$= 1.99x \qquad (5)$$

Therefore, as: $N = M + F + J + P$

Then: $N = 1.99x + 1.39x + 0.6x + 1.11x$

$$\underline{N = 5.09x} \qquad (6)$$

In other words the total population of Neophoca can be calculated by multiplying the number of pups counted by a factor of 5.09.

2.3 OTHER RESEARCH PROJECTS

2.3.1 Reproductive Physiology

An investigation into the reproductive physiology forms a major part of a long term study of Neophoca breeding biology by this investigator. Acquisition of blood samples from free ranging sea lions of known reproductive status and urine samples from captive sea lions form the basis of this study. It is hoped that through an investigation of reproductive hormones it may be possible to determine when, during the extremely long gestation period, the blastocyst implants. An understanding of this will go a long way towards understanding how and why Neophoca have evolved their unique breeding cycle.

Because of the length of gestation in sea lions it is not possible in one visit to collect samples that cover the full 18 month period. All field work has been conducted at Seal Bay, Kangaroo Island. Samples collected on this field trip are from animals in the first few months of pregnancy. These samples will be analysed along with those collected in February and March 1989 from animals in mid-term gestation. A further visit will be necessary to collect samples from late gestation.

Sealions were captured using a hoop-net. The design of this net enables the hoop and pole apparatus to be rapidly detached soon after capture. The net also has a built-in head bag thus facilitating easy handling and reducing the risk of injury to animal and handlers. The net design is highly recommended for future work on sea lions.

Once in the net the sealion was manually restrained by two handlers. A further person prevented the approach of other sealions using of a long pole.

Blood was collected by venipuncture using a 20 gauge, 2 inch needle into the lateral gluteal vein. Following experience gained over the past two years this difficult procedure has now been mastered and samples are collected rapidly, causing little stress to the animal. Up to 20ml of blood was collected from each animal.

The blood was centrifuged at 4000 r.p.m. for 10 minutes and the plasma removed. Samples of plasma and red blood cells were frozen in a conventional freezer.

Milk was also collected as part of this study in order to investigate the changes in milk composition during lactation. Investigating energy transfer from mother to pup may help in understanding the reasons for the extremely long lactation period of this species. As with the blood samples, several visits to Kangaroo Island will be necessary in order to collect samples that span the total period of lactation.

Milk was collected by direct manipulation of the nipple following the intramuscular injection of 10 I.U. of Oxytocin. The procedure is simple and rapid. Milk samples were also frozen.

Blood and milk samples will be analysed for reproductive hormones and basic constituents in various laboratories at a later date. The laboratory methods are not included in this report.

2.3.2 Foraging energetics

This project is run by Dr Dan Costa of the University of California, Santa Cruz. Dan and I collaborated on the diving energetics project which is part of an ongoing project he has been involved in for several years. As Dan in the principal investigator of this project I shall not report on the work we undertook for three weeks on the female sealions as I assume Dan will report separately on this. However two male sealions were restrained physically, and in one case chemically, to facilitate the attachment of a time-depth recorder. As the animal that was anaesthetised with chloroform died I shall discuss this aspect of the work in the discussion.

2.3.3 Population Genetics

In January 1989 50 blood samples were collected from both Kangaroo Island and Dangerous Reef to investigate the degree of genetic relatedness between the two island populations of Neophoca. In February 1990, as part of this survey work, a further 37 blood samples were collected from sea lion pups at The Pages. The blood samples were collected and centrifuged in the same manner as the samples collected for reproductive physiology. They were then frozen in liquid nitrogen.

In July 1990 the samples will be surveyed electophoretically for protein variation. If starch-gel electophoresis proves a sufficiently sensitive tool for examination of protein differences between these colonies (if indeed, differences do exist) then further samples will be collected from a Neophoca colony in the far West region of South Australia as well as from two West Australian colonies. If electophoresis is not suitable then DNA examination will be attempted.

3 RESULTS

3.1 WESTERN AUSTRALIA

In Western Australia a total of 88 islands and rocks were surveyed between Albany and the eastern extreme of the Recherche Archipelago (data summarised in Table 1). Of these 25 were landed on for more detailed appraisal. A total of 837 sealions were counted.

Ten islands were found to support breeding colonies of sea lions. Only three of these colonies were actively breeding at the time of the survey (Spindle, Halfway and Round islands). The other seven breeding locations (Hauloff Rock, West, Rocky, Little, Mackenzie, Kermadec and Nook islands) were identified as such by finding carcases of pups from previous breeding seasons, or breeding had been identified during earlier surveys. A further three islands (Red Islet, Kimberley and Poison Creek islands), not visited in this survey, are known to sustain breeding populations of sealions along the south coast of Western Australia, thus bringing the total number of confirmed breeding locations of Neophoca in this region to 13 (Table 2). A further three breeding sites are known on the West Coast of Western Australia, and a small breeding population at the

Abrolhos Islands is suspected. Sixteen islands were listed as sites for possible breeding colonies (Table 2). These sites were classified in this way as there was suitable, utilised habitat that could sustain a breeding population. It is necessary to visit these locations during subsequent surveys to see if breeding occurs.

The confirmed and possible breeding locations of Neophoca for the South coast of Western Australia (West coast data not included) are listed in Table 2. There are currently insufficient data to predict the number of pups born, and hence total population, of Neophoca in Western Australia. However, in order to provide an indication of numbers based on the current data I have predicted pup production in three ways:

a) sum of pups counted in surveys (this provides a minimum estimate)

b) sum of estimated pup numbers on islands where pups have been counted. This estimate takes into consideration the stage of the pupping season during which the census was conducted (based on approximate age of the youngest pup seen and behaviour of bulls attending cows in oestrus) and the amount of utilised pupping habitat the sea lions were occupying at the time of the census.

c) sum of estimated pup numbers on all confirmed breeding islands. This includes the islands where pupping has been confirmed by the presence of a pup carcase from a previous pupping season, but no live pups have been counted. The number of pups for each of these island has been set as the mean number of pups born on other islands along the South coast of WA.

The resultant pup production estimates are; a) 211, b) 297, c) 429. Assuming that total population is 5.09 times the annual pup production (see section 2.2), then the total population estimates for Neophoca for the South coast of Western Australia are; a) 1074, b) 1512, c) 2184. Estimate "c" is the most realistic one as it takes into account all known breeding locations. Previous work conducted on the West coast of WA has indicated a pup production in the region of circa 180, which represents a total population of 916. An estimate for the total number of sea lions is Western Australia is therefore 3100.

It should be noted that the above estimates probably represent an underestimate of total pup production as an unknown number of the possible breeding islands may be found to support breeding populations, and these are not taken into account in the calculation.

3.2 SOUTH AUSTRALIA

In South Australia a total of 114 islands and rocks were surveyed (data summarised in Table 2). Of these, 47 islands were landed upon for a more detailed survey. A total of 4,343 sea lions were counted.

A total of 18 breeding colonies have now been confirmed for Neophoca in S. A (Table 4). Of these only four were actively breeding at the time of the census (Liguanea Island, Kangaroo Island and the two Pages Islands). Since the survey, Craig Wickham (Ranger, Protection Management of South Australian National Parks and Wildlife Service) has visited Peaked Rocks near Wedge Island (an area we were unable to survey during the census due to poor weather). He found an actively pupping Neophoca population that would have been pupping at the time of our survey. Two islands (North Islet Island and Albatross Island) are listed in table 4 as known breeding sites using data from Robinson and Dennis (1988). North Islet Island was listed as a possible breeding location during this survey as no evidence of breeding was found. Albatross Island could not be visited due to poor weather. Eighteen islands were listed as possible breeding sites for Neophoca (Table 4); these will require revisiting.

Calculating an estimate for the total number of pups born in South Australia, and hence an estimate of the total population, is difficult as little is known of the breeding status of the many remote islands, particularly those around the Eyre Peninsula. A more accurate picture should be able to be constructed in approximately two years time when further data has been collected. In order to provide an approximate estimate in the meantime, I have used the same three procedures as I used for Western Australia (see above).

If only direct counts of pups are used the total pup production is 707, resulting in an estimated total population of 3599. This figure is clearly too low as a total of 4,343 Neophoca was counted in South Australia during this survey. Estimating the number of pups on islands where pups have been counted yields a pup production figure of 1270, and hence a total population of 6464. For these estimates I have used data from Robinson and Dennis (1988) as well as from this survey. Where I have used their data I have not increased the estimated number of pups above the number directly counted as I have no information on their counting techniques or at what stage of the pupping season the counts were conducted. Furthermore, I have assumed that the counts in Robinson and Dennis (1988) which were made between 1973 and 1982 are still appropriate in 1989/90 (i.e. I have assumed a stable population). For the remaining islands that are known to support breeding populations from evidence such as pup carcases, but where no direct counts of pups have been made, I have used a mean figure of pup production based on all other breeding locations in South Australia with the exception of the four very large colonies of Dangerous Reef, Kangaroo Island and North and South Pages. The addition of these islands results in an estimate of total pup production for South Australia of 1354 and a population estimate of 6892.

As is the case with the estimates made for Western Australia the figure of circa 6,900 Neophoca for South Australia almost certainly represents an underestimate. The nineteen possible breeding locations (Table 4) have not been taken into account, and some of the estimations for island pup production are almost certainly underestimated.

3.3 OTHER RESEARCH PROJECTS

3.3.1 Reproductive physiology

A total of 49 blood and 49 milk samples were collected in the period of 6/2/90 to 23/2/90. Several of the blood and milk samples were collected from the same female, on separate occasions. These samples will not be fully analysed until a full representation of samples has been accrued, and hence the results may not be known until mid 1991.

Selection of many of the females for bleeding in this study was done so in collaboration with Dan Costa's and Leslie Higgin's program. This ensured that females were handled as little as possible. The bleeding procedure went extremely well and was more rapid and successful than the blood sampling conducted earlier in the year.

The expediency of the procedure minimised the amount of disturbance, and females often resumed suckling their pup immediately after being released.

3.3.2 Foraging energetics

Dan Costa will report separately on the exciting foraging energetics project conducted on ten female Neophoca. Time-depth recorders (TDRs) were also deployed on two male sea lions, only one of which was recovered. Dr Costa will also report separately on these diving data.

Mature male Neophoca are very large and difficult to restrain. As such we determined, for this portion of the study, to immobilise the males chemically once they had been physically restrained in a large purse-net. The time depth recorders were to be attached during chemical restraint. Because of the dangers of using intramuscular anaesthetics in eared seals it was decided to use chloroform, a drug that has been used with great success in other eared seals (Gales 1989).

The first bull we restrained in the net was fully anaesthetised with chloroform in approximately ten minutes. The anaesthetic was administered by holding a cotton wool wad soaked in the drug over the animal's face, thus ensuring the drug was inhaled. Anaesthesia was maintained for approximately ten minutes and a complete recovery was observed after a further ten minutes. Induction, maintenance and recovery were all smooth and the three veterinarians present, Dr Carol Bray, Dr Pin Needham and myself were all very happy with the results.

Unfortunately the second bull we anaesthetised died before full induction was achieved. A post-mortem revealed no gross abnormalities. Following a careful assessment of the events we believe that the death was probably due to malpositioning of the animal. In order to restrain the bull sufficiently for chloroform administration it must be bunched up very tightly in the net and have several people lying over it. In this position the animal is able to breath (if somewhat laboured), however once the effects of the anaesthetic begin and the animal relaxes breathing can be seriously compromised, and this was probably the case with this animal. As such asphyxia was the probable cause of death.

Following this incident (and after consultation with South Australian National Parks and Wildlife officers) we deployed a further TDR on a bull using physical restraint only. This was achieved successfully, if somewhat dangerously, and the unit was retrieved in a similar fashion.

3.3.3 Electro-immobilisation

In conjunction with Terry Dennis and two farmers from Kangaroo Island we tested an electo-immobilisation devise on a sub-adult male sea lion. The devise is used routinely to immobilise farm animals for minor procedures and is reported to provide safe, painless immobilisation with immediate induction and recovery. This method therefore had great potential for use in Neophoca. Unfortunately the test was inconclusive. The sea lion was not adequately restrained as a result of the electric charge and further testing was aborted to avoid stressing the animal excessively. It was agreed that I would further test the system on smaller fur seals in Western Australia.

4 DISCUSSION

4.1 POPULATION ASSESSMENT

Extrapolation from the present data suggest that the total population of Neophoca may be circa 10,000, of which 3100 are in Western Australia and 6900 are in South Australia. Even though this estimate is twice the value of the previous upper population estimate for Neophoca it does not suggest an expanding population, but rather that this work represents the first attempt to provide an accurate documentation of the population size. There are two major factors that may cause a positive or negative bias on the estimate, these being;

a) The estimate of pup production. We presently have insufficient data on pup numbers for many small breeding colonies of Neophoca in Western and South Austrlalia. The plan below outlines an approach to improve this data set. However, further work will probably show the present pup number estimates to be conservative, leading to an underestimate of population size.

b) The multiplication factor for estimating total population from pup numbers may be inaccurate and is subject to ongoing work. For some other pinnipeds such factors have generally been lower than 5, more typically in the range of 3.5 to 4.5.

4.1.1 Proposed plan for future Neophoca surveys

A survey on the scale of the one described in this report will not be necessary to repeat, and the only islands that will require future visitation are those nominated in Tables 2 and 4 as breeding or possible breeding islands (n=29 for the South coast of Western Australia, n= 36 for South Australia). For some of these islands there is already sufficient data to predict approximate pup numbers and these need not be revisited. However, the islands are wide-spread and a major logistical effort is still required to complete the survey requirements. The co-operation of Conservation and Land Management in Western Australia and the National Parks and Wildlife Service and Fisheries Departments in South Australia will be sought to assist in finalising this project.

The approximate itinerary for the survey follows:

Western Australia:

West Coast	- Jurien Bay Islands	- Survey complete
	- Abrolhos Islands	- Final survey in October 1990
South Coast	- Albany to Esperance	- Final survey in July 1990
	- Recherche Archipelago	- Survey by sea in July 1990
		- Final survey by sea November '90

South Australia:

- Nuyts Archipelago	- Survey in August 1990
	- Final survey in February 1991
- Investigator Group	- Survey in August 1990
	- Final survey in February 1991
- Whidbey Group	- Survey in August 1990
	- Final survey in February 1991
- Sir Joseph Banks group	- Survey in August 1990
	- Final survey in February 1991
- Yorke Peninsula Islands	- Survey in August 1990
	- Final survey in February 1991
- Kangaroo Island	- Survey complete
- The Pages	- Survey complete

4.2 REPRODUCTIVE PHYSIOLOGY

A further two visits to Kangaroo Island will be necessary to complete the data collection for this project. The first is planned for October 1990 and the second in February 1991. Following this we will have collected blood and milk samples that are representative of all stages of gestation and lactation. These samples will be assayed for progesterone, oestradiol, oestrone sulphate, HCG and possibly Luteinising Hormone. Final results will be known by mid 1991 when they will be prepared for publication.

4.3 ENTANGLEMENTS

Australian sea lions were found entangled on ten occasions during the survey, eight of which were in South Australia (Table 5). Work on the west coast of Western Australia has identified Neophoca/fisheries conflicts in the form of net and bait-band entanglements and drownings in cray-pots.

The magnitude of the entanglement problem is difficult to determine. It is likely that the animals observed on islands with net around their head and neck represent only a small proportion of those that entangle and drown at sea. Future observations of this type need to be documented and fishers encouraged to inform the relevant government agencies of marine mammal/fishery interactions.

4.4 MANAGEMENT CONSIDERATIONS

Breeding populations of Neophoca are highly susceptible to disturbance. This is particularly true during the pupping seasons when cows are attending their pups and bulls are competing for cows. Disturbance at this time can lead to an increase in pup mortality and can be dangerous to the humans who enter such an area. With the exception of the Pages, Kangaroo Island and Dangerous Reef all the colonies of breeding sealions in Western and South Australia exist on small isolated islands. Whilst the isolation of these sites has afforded some degree of protection to the animals they remain vulnerable to malicious or innocent disturbance. Typically sea lions breeding on the protected aspect of an island, it is in these areas that people will come ashore. The most straightforward method of protecting the colonies is to give them a prohibited area status and this should be considered as a management strategy.

The high frequency of observations of entangled sea lions during this survey and previous tag returns from drowned sea lions in cray pots in Western Australia indicate that marine reserves may need to be considered as a management strategy. More data are required on the foraging behaviour and diet of Neophoca (work is currently underway) to allow effective, long term reserves to be created. In the meantime activities such as shark netting very close to major breeding locations and baiting the water to attract sharks close to sealion colonies should be prohibited. Furthermore, every effort should be made to educate the professional and amateur fishers to avoid sealion interactions and encouragement given to reporting these conflicts when they do occur.

ACKNOWLEDGEMENTS

A great many people have contributed enormously to the extensive field aspects of this project. In particular I am most grateful to, in Western Australia; A. Cheal (Murdoch University and Atlantis Marine Park), B. Haberely (CALM, Esparance), P. Collins (CALM, Albany), G. Pobar (CALM, Perth), P. Shaughnessy and J. Libke (CSIRO, Canberra), R. Stewart (Esperance), P. Gill and crew members of the "Alan and Vi Thistlethwaite" (Oceanic Research Foundation, Sydney), Volunteers of the Albany Sea Rescue group, A. Danks (CALM, Two Peoples Bay), V. Milne (Residency Museum, Albany), M. Whitfield and marine mammal staff (Atlantis Marine Park). In South Australia; T. Dennis, A. Maguire and Seal Bay guides (National Parks and Wildlife Service, Kangaroo Island), L. Higgins, D. Costa and volunteers (University of California, Santa Cruz), J. Wauchope (National Parks and Wildlife Service, Port Lincoln), D. Mount (National Parks and Wildlife Service, Ceduna), R. Leehman (Fisheries Department, Port Lincoln), B. Spriggs (Fisheries Department, Ceduna), C. Wickham and helpers (National Parks and Wildlife Service, Innes National Park).

For organisational support and discussions I thank P. Williamson (Murdoch University), P. Shaughnessy (CSIRO, Canberra), T. Dennis, F. Vickery and A. Robinson (South Australian National Parks and Wildlife Service) and K. McNamara (CALM, Perth). Australian Research Council, CALM, South Australian Wildlife Conservation Fund and Atlantis Marine Park are acknowledged for financial support.

6 REFERENCES

Abbott, I. 1979. The past and present distribution and status of sea lions and fur seals in Western Australia. Records of the Western Australian Museum 7:375-390.

Chapman, A., and D. J. Kitchener. 1977. Mammals of Cockleshell gully reserve and adjacent areas. In A vertabrate survey of Cockleshell gully reserve, Western Australia. Records of the Western Australian Museum. Supplement no. 4:15-35.

Gales, N. J., and P. M. Lambert. 1985. Observations of the distribution of the New Zealand Fur Seal (Arctocephalus forsteri) in Western Australia. The Western Australian Naturalist 16:70-72.

Gales, N. J. 1989. Chemical restraint and anesthesia of pinnipeds: A review. Marine Mammal Science 5:228-256.

King, J. E. 1983. Seals of the World. British Museum (Natural History), London.

Ling, J. K. 1980. Sea lions breeding on North Fisherman Island, Western Australia. The Western Australian Naturalist, 14:203-204.

Robinson, A. C., and T. E. Dennis. 1988. The status and management of seal populations in South Australia. pp 87-101 in M.L. Augee (ed.) Marine Mammals of Australasia, field biology and captive management. The Royal Zoological Society of NSW,Sydney.

Serventy, V. N. 1953. Mammals. in The Archipelago of the Recherche, pt 4. Australian Geographical Society, Report No. 1.

Table 1 Summary of Neophoca survey results from Western Australia

Legend. Survey Method 1 - landed on island to conduct count

Survey Method 2 - Survey from boat

* - Could not land on island due to poor weather

* * - Not surveyed for Neophoca as past, recent surveys have recorded no animals

* * * - Could not get to this island due to poor weather

† - Not official island name. These names used by local fisherman

ISLAND	LAT/LONG	SURVEY DATE	SURVEY METHOD	NEOPHOCA CINEREA BULLS	SAMS	COWS	PUPS B.P.	MBP	DBP	JUVS	UNKNOWN	TOTAL	ISLAND STATUS	ARCTOCHALUS FORSTERI ISLAND STATUS (PUP NOS.)
ECLIPSE IS.	35°11'S, 117°53'E	31-Dec-89	1		1							1	Haul-out	Breeding (n=33)
COFFIN IS.	35°00'S, 118°13'E	31-Dec-89	2									Nil	Haul-out	Non-breeding,haul-out
BALD IS.	34 °56'S, 118°28'E	31-Dec-89	2			1				2	1	4	Haul-out	Non-breeding,haul-out
BIRD RK.	34°55'S, 118°29'E	31-Dec-89	2										Haul-out	Non-breeding,haul-out
HAULOFF RK.	34°42'S, 118°40'E	1-Jan-90	1	4	3	17		1		30	7	62	Breeding	Breeding (n=50)
SEAL RK.	34°21'S, 119°34'E	2-Jan-90	2								20	20	Haul-out	Non-breeding, haul-out
WEST DOUBTFUL IS.	34°22'S, 119°35'E	2-Jan-90	1									nil	Haul-out	Non-breeding, haul-out
MIDDLE DOUBTFUL IS.	34°22'S, 119°35'E	2-Jan-90	1	3		10				9		22	Possible breeding	Breeding (n=46)
EAST DOUBTFUL IS.	34°22'S, 119°35'E	2-Jan-90	1		2	8		6		3		19	Possible breeding	Breeding (n=2)
WEST IS.	34°06'S, 120°18'E	19-Jan-90	*									*	Breeding	*
ROCKY IS.	34°05'S, 120°52'E	19-Jan-90	1	5		15				15		35	Breeding	Breeding (n=26)
FIGURE OF EIGHT IS.	34°02'S, 121°37'E	16-Jan-90	1		1	1				4		6	Possible breeding	Occasional haul-out
FUR RK.	34°01'S, 121°39'E	16-Jan-90	2									nil		Occasional haul-out
RUG RK.	34°01'S, 121°39'E	16-Jan-90	2									nil		Occasional haul-out
SQUARE RK.	34°01'S, 121°39'E	16-Jan-90	2									nil		Occasional haul-out
SEAL RK.	34°01'S, 121°40'E	16-Jan-90	1			1						1	Haul-out	Breeding (n=183)
BOXER IS.	34°00'S, 121°40'E	16-Jan-90	2									nil	Haul-out	
CAPPS IS.	33°59'S, 121°41'E	16-Jan-90	2		1	7				3		11	Haul-out	
HECTOR IS.	34°00'S, 121°43'E	16-Jan-90	2									nil	Haul-out	
MIDDLE RK.	34°19'S, 121°51'E	15-Jan-90	2	1							7	8	Haul-out	
HENDY IS.	34°03'S, 121°54'E	16-Jan-90	2									nil		
LONG IS.	34°03'S, 121°58'E	16-Jan-90	2									nil		
CORBETT IS.	34°07'S, 121°59'E	14-Jan-90	2								3	3	Haul-out	Occasional haul-out
LITTLE IS.	34°28'S, 122°00'E	15-Jan-90	1	1	1	8			1	4	3	18	Breeding	Occasional haul-out
TERMINATION IS.	34°29'S, 122°00'E	15-Jan-90	1		1	8				3	1	13	Possible breeding	Occasional haul-out
REMARK IS.	34°04'S, 122°00'E	16-Jan-90	2									nil		
FREDERICK IS.	34°04'S, 122°01'E	16-Jan-90	2									nil		
HOOD IS.	34°09'S, 122°03'E	17-Jan-90	1			1						1	Haul-out	Breeding (n=32)
McKENZIE RKS. (3)†	34°13'S, 122°04'E	14-Jan-90	2								2	2	Haul-out	Occasional haul-out
MURRAY RK.	34°00'S, 122°05'E	18-Jan-90	2								9	9	Haul-out	
CLOUD IS.	34°03'S, 122°06'E	4-Jan-90	2			1						1	Haul-out	
PASCOE IS.	34°04'S, 122°06'E	4-Jan-90	2									nil	Haul-out	
HASTINGS IS.	34°06'S, 122°07'E	4-Jan-90	2			2				1	2	5	Haul-out	Occasional haul-out
McKENZIE IS.	34°12'S, 122°07'E	14-Jan-90	1	1	4	13			1	13	1	33	Breeding	Occasional haul-out
HOPE IS.	34°05'S, 122°10'E	4-Jan-90	2	1		3				1		5	Haul-out	
HUGO IS.	34°09'S, 122°19'E	14-Jan-90	2			3				1	4	8	Haul-out	
FINGER IS.	34°07'S, 122°21'E	4-Jan-90	2	1	1	4				2		8	Possible breeding	Occasional haul-out
PEARSON IS.	34°13'S, 122°21'E	14-Jan-90	2		2	2				3	3	10	Haul-out	
DRAPER IS	34°12'S, 122°30'E	***												
BEAMONT IS.	34°06'S, 122°33'E	4-Jan-90	1	3	1	11				9	2	26	Possible breeding	Breeding (n=39)
N/W YORK IS.	34°01'S, 122°35'E	4-Jan-90	2			2				2	2	6	Haul-out	
CENTRAL YORK IS.	34°01'S, 122°35'E	4-Jan-90	2								1	1	Haul-out	
N/E YORK IS.	34°01'S, 122°35'E	4-Jan-90	2									nil	Haul-out	
MARTS GROUP (9)	34°01'S, 122°38'E	5-Jan-90	2	1							1	2	Haul-out	
TIZARD IS.	34°01'S, 122°41'E	13-Jan-90	2		1	3				1	1	6	Haul-out	
WHARTON IS.	33°59'S, 122°43'E	5-Jan-90	2									nil	Haul-out	
SLIPPER IS.	34°03'S, 122°45'E	13-Jan-90	2		1	3				2		6	Possible breeding	
KERMADEC IS.	34°05'S, 122°50'E	5-Jan-90	1	2	2	10				8	1	23	Breeding	Occasional haul-out
TWIN PEAKS IS.(2)	34°00'S, 122°51'E	5-Jan-90	2									nil	Haul-out	
FOAM RKS.	34°08'S, 122°51'E	13-Jan-90	2									nil	Haul-out	
WESTALL IS.	34°05'S, 122°58'E	5-Jan-90	1	1		10				5		16	Possible breeding	Occasional haul-out
MANICOM IS.	34°07'S, 123°02'E	5-Jan-90	2									nil	Haul-out	
HASLER IS.	34°07'S, 123°04'E	5-Jan-90	2								2	2	Haul-out	
HELBY IS.	34°07'S, 123°04'E	5-Jan-90	2									nil	Haul-out	
GLENNIE IS.	34°06'S, 123°06'E	5-Jan-90	2			1					3	4	Possible breeding	
MIDDLE IS.	34°06'S, 123°11'E	5-Jan-90	**									nil		
GEORGE IS.	34°03'S, 123°15'E	6-Jan-90	2	1		2				1	6	10	Haul-out	
WICKHAM IS.	34°01'S, 123°17'E	6-Jan-90	1		2	15				9		26	Possible breeding	Occasional haul-out

SALISBURY IS.	34°22'S, 123°33'E	12-Jan-90	1	2	2	18				5		27	Possible breeding	Breeding (n=444)
PASELY IS.(+3 Rks)	34°01'S, 123°34'E	6-Jan-90	2	1	1	1				2	3	8	Possible breeding	Occasional haul-out
COOPER IS.	34°14'S, 123°37'E	12-Jan-90	1	2	4	2				2		10	Possible breeding	Breeding (n=119)
BELLINGER IS.	33°53'S, 123°38'E	6-Jan-90	2	1		4						5	Possible breeding	
ROUND IS.	34°06'S, 123°53'E	11-Jan-90	1	9	2	15	7		2	8	1	44	Breeding	
ROUND RK.†	34°06'S, 123°54'E	11-Jan-90	2	2		8				2	3	15	Haul-out	Occasional haul-out
WEE RK.†	34°05'S, 123°54'E	11-Jan-90	2	4	1	8				3	4	20	Haul-out	
RODONA IS.	33°50'S, 123°55'E	11-Jan-90	2			2				2		4	Haul-out	
TADPOLE IS.†	33°44'S, 124°02'E	6-Jan-90	2			2						2	Haul-out	
HALFWAY IS.†	33°46'S, 124°02'E	11-Jan-90	1	7		21	11	4	2	3		48	Breeding	
CRANNY IS.†	33°43'S, 124°05'E	8-Jan-90	1		1	8				4		13	Haul-out	Breeding (n=60)
DAW IS.	33°51'S, 124°06'E	7-Jan-90	1	1	7	21				12		41	Possible breeding	Breeding (n=67)
NEW YEAR IS.	33°52'S, 124°06'E	8-Jan-90	1	1	1	5						7	Haul-out	Breeding (n=28)
NEW YEAR RK.†	33°52'S, 124°06'E	9-Jan-90	2									nil	Haul-out	Occasional haul-out
NOOK IS.†	33°44'S, 124°06'E	8-Jan-90	1	6	1	9				9		17	Breeding	
HIGH NORTH IS.†	33°43'S, 124°06'E	6-Jan-90	2	2	8	16				5	3	34	Haul-out	
SPINDLE IS.†	33°44'S, 124°10'E	9-Jan-90	1	8	2	34	22	28	3	3	9	109	Breeding	

Table 2 Summary of Neophoca survey results from South Australia

Legend

Survey Method 1 - landed on island to conduct count

Survey Method 2 - Survey from boat

* - too rough to check island adequately

* * - island survey conducted later by SAPWS personnel

ISLAND	LAT/LONG	SURVEY DATE	SURVEY METHOD	NEOPHOCA CINEREA BULLS	SAMS	COWS	PUPS B.P.	PUPS MBP	PUPS DBP	JUVS	UNKNOWN	TOTAL	ISLAND STATUS	ARCTOCHALUS FORSTERI ISLAND STATUS (PUP NOS.)
WESTERN NUYTS REEF	32°07'S, 132°08'E	3-Mar-90	1	19	28	37				38		122	Breeding	Occasional haul-out
SOUTHERN NUYTS ROCK	32°08'S, 132°08'E	3-Mar-90	1	1		3				1		5	Haul-out	Occasional haul-out
MIDDLE NUYTS REEF	32°08'S, 132°09'E	3-Mar-90	1	3		8			3	6		17	Breeding	
EASTERN NUYTS REEF	32°08'S, 132°10'E	3-Mar-90	1	7	6	25				34		72	Haul-out	
ROCK NEAR CAPE ADEAU	32°03'S, 132°10'E	3-Mar-90	2		1	7				9		17	Haul-out	Occasional haul-out
SINCLAIR IS.	32°09'S, 132°59'E	1-Mar-90	2			1				2	21	24	Haul-out	
RKS S/W OF PT. BELL	32°14'S, 133°07'E	1-Mar-90	2		1	12		1		8	3	25	Haul-out	
HART IS	32°39'S, 133°08'E	2-Mar-90	2			6						6	Haul-out	Occasional haul-out
PURDIE IS.	32°17'S, 133°14'E	1-Mar-90	1	5	4	17			2	16		44	Breeding	
PURDIE RKS (3)	32°16'S, 133°15'E	1-Mar-90	2		2	3				3	1	9	Haul-out	
WEST IS.	32°31'S, 133°15'E	2-Mar-90	1		2	6				4	2	14	Possible breeding	
RK B/W WEST AND ST. FRANCIS	32°31'S, 133°16'E	2-Mar-90	2			7				3		10	Haul-out	
FENELON IS.	32°35'S, 133°17'E	2-Mar-90	1	12	14	26		1	2	17		70	Breeding	Occasional Haul-out
MASSILON IS.	32°34'S, 133°18'E	2-Mar-90	2	5	4	15				11		35	Haul-out	
ST. FRANCIS	32°31'S, 133°18'E	2-Mar-90	2									nil		
SMOOTH IS.	32°29'S, 133°19'E	1-Mar-90	2									nil		
EGG IS.	32°29'S, 133°19'E	1-Mar-90	2		1							1	Haul-out	
DOG IS.	32°29'S, 133°20'E	2-Mar-90	2		1	4				4	3	12	Haul-out	
FREELING IS.	32°29'S, 133°21'E	2-Mar-90	2			1						1	Haul-out	
RKS 2NM. NW OF LACY IS.	32°22'S, 133°21'E	1-Mar-90	2			2				1	1	4	Haul-out	
LOUNDS IS.	32°17'S, 133°22'E	1-Mar-90	2			5				5		10	Haul-out	
LACY IS.	32°24'S, 133°23'E	28-Feb-90	2		3	11				2		16	Haul-out	Occasional Haul-out
EVANS IS.	32°23'S, 133°29'E	28-Feb-90	2	1		2				2		5	Haul-out	
FLINDERS REEF	32°23'S, 133°33'E	28-Feb-90	2									nil		
SOUTH FRANKLIN RKS	32°28'S, 133°38'E	28-Feb-90	2	1						3	8	12	Haul-out	
SMALL SOUTH FRANKLIN IS.	32°28'S, 133°39'E	28-Feb-90	1	7	11	11				12		41	Possible breeding	
FRANKLIN IS.	32°27'S, 133°39'E	28-Feb-90	2									nil		
SMALL N/E FRANKLIN IS.	32°26'S, 133°42'E	28-Feb-90	1	2	7	53				53		115	Breeding	
OLIVE IS.	32°43'S, 133°59'E	27-Feb-90	1	11	8	10			1	11		41	Breeding	
POINT LEBATT	33°09'S, 134°16'E	23-Jan-90	1	6	3	7				8	18	42	Possible breeding	
JONES IS.	33°11'S, 134°22'E	23-Jan-90	1	3	4	20				6		33	Breeding	
DOROTHEE IS.	34°00'S, 134°15'E	22-Jan-90	1	8	5	16						29	Possible breeding	Occasional haul-out
SOUTH VETERAN ISL.	33°59'S, 134°16'E	22-Jan-90	2									nil		
NORTH VETERAN ISL.	33°59'S, 134°16'E	22-Jan-90	2			2						2	Haul-out	Occasional haul-out
PEARSON IS.	33°57'S, 134°16'E	22-Jan-90	1	8	9	27		1		42		87	Possible breeding	Occasional haul-out
S/E WARD IS	33°46'S, 134°18'E	23-Jan-90	2								6	6	Haul-out	
WARD IS.	33°45'S, 134°18'E	23-Jan-90	1	13	9	27			2	26		77	Breeding	Breeding (n=64)
FLINDERS IS.	33°43'S, 134°31'E	23-Jan-90	2									nil		
TOP GALLANT IS.	33°43'S, 134°38'E	23-Jan-90	2								2	2	Haul-out	
THE WATCHERS RKS	33°36'S, 134°41'E	25-Jan-90	2									nil		
WEST WALDEGRAVE IS.	33°36'S, 134°45'E	25-Jan-90	2	6	6	17				7	2	38	Possible breeding	
EAST WALDEGRAVE IS.	33°36'S, 134°47'E	25-Jan-90	2									nil		
CAPP IS.	33°57'S, 135°07'E	25-Jan-90	2									nil		
ROCKY IS. NORTH	34°16'S, 135°16'E	25-Jan-90	1								40	40	Possible breeding	Occasional haul-out
ROCKY IS. SOUTH	34°59'S, 134°48'E	29-Jan-90	1	4	4	10				4		22	Possible breeding	Breeding (n=72)
GREENLY IS.	34°39'S, 134°45'E	22-Jan-90	1	13	16	14				6	2	51	Possible breeding	Breeding (n=11)
SOUTH HUMMOCK IS.	34°47'S, 135°02'E	29-Jan-90	1	8		7				4	5	24	Haul-out	Breeding (n=10)
CENTRAL HUMMOCK IS	34°46'S, 135°02'E	29-Jan-90	1	2		7				3		12	Haul-out	Breeding (n=30)
NORTH HUMMOCK IS.	34°45'S, 135°02'E	29-Jan-90	1	2		8				8		18	Possible breeding	Occasional haul-out
LITTLE N/E HUMMOCK IS	34°45'S, 135°05'E	29-Jan-90	1	1	2	3				3		9	Haul-out	Breeding (n=7)
PERFORATED IS.	34°44'S, 135°10'E	29-Jan-90	2									nil		
PRICE IS.	34°43'S, 135°17'E	29-Jan-90	2	3		2				2	12	19	Possible breeding	
GOLDEN IS.	34°42'S, 135°20'E	29-Jan-90	2			1						1	Haul-out	
STUART REEF	34°49'S, 135°22'E	30-Jan-90	2									nil		
CAPE RK	34°54'S, 135°32'E	30-Jan-90	2			1				1		2	Haul-out	
LINUANEA IS.	35°00'S, 135°37'E	30-Jan-90	1	16	5	54	18	3	2	11	3	112	Breeding	Breeding (n=550)
CURTA RKS	34°56'S, 135°52'E	30-Jan-90	2	1							3	4	Haul-out	
WILLIAMS IS.	35°02'S, 135°58'E	30-Jan-90	1	4	2	5				4		15	Haul-out	Occasional haul-out

SMITH IS.	34°59'S, 136°02'E	30-Jan-90	2								8	8	Haul-out	
LITTLE IS.	34°57'S, 136°02'E	31-Jan-90	2			10				2	2	14	Haul-out	
LEWIS IS.	34°57'S, 136°02'E	31-Jan-90	1	6	6	44				49		105	Possible breeding	
HOPKINS IS.	34°58'S, 136°04'E	31-Jan-90	1	6	3	34				20	37	100	Haul-out	
TALYLOR IS.	34°53'S, 136°01'E	31-Jan-90	2									nil		
GRINDAL IS.	34°55'S, 136°02'E	31-Jan-90	2									nil		
THISTLE IS.	35°00'S, 136°09'E	31-Jan-90	2								10	10	Haul-out	
ALBATROSS IS.	35°04'S, 136°11'E	31-Jan-90	2 *	1							4	5	?	
LOW RKS	35°10'S, 136°05'E	1-Feb-90	2								8	8	Haul-out	Occasional haul-out
NTH NEPTUNE IS. (EAST)	35°14'S, 136°04'E	1-Feb-90	1	6	3	16				6		31	Possible breeding	Breeding (n=7)
NTH NEPTUNE IS. (WEST)	35°14'S, 136°04'E	28-Jan-90	1	1	1	4						6	Haul-out	Breeding (n=c.1500)
STH NEPTUNE IS. (NTH)	35°20'S, 136°07'E	28-Jan-90	1	13	2	13				6		34	Haul-out	Breeding (n=c.2000)
ROCK BETWEEN STH NEPTUNE IS.	35°20'S, 136°07'E	28-Jan-90	1	5	3	3				4		15	Haul-out	Breeding (n=22)
STH NEPTUNE IS (STH)	35°20'S, 136°07'E	1-Feb-90	1							1		1	Haul-out	Occasional haul-out
S/W ROCK	35°11'S, 136°25'E	1-Feb-90	2 -	1							4	5	Haul-out	Occasional haul-out
PEAKED RKS.	35°11'S, 136°29'E	31-Jan-90	2 **									?	?	?
WEDGE IS.	35°09'S, 136°28'E	31-Jan-90	2									nil		
NORTH IS.	35°07'S, 136°28'E	31-Jan-90	1	4	2	14				15		35	Possible breeding	
REEVESBY IS.	34°32'S, 136°17'E	1-Mar-90	1									nil		
MARUM IS	34°31'S, 136°15'E	1-Mar-90	2									nil		
PARTNEY IS	34°32'S, 136°15'E	1-Mar-90	2									nil		
LUSBY IS	34°33'S, 136°15'E	1-Mar-90	2									nil		
KIRKBY IS	34°33'S, 136°13'E	1-Mar-90	2									nil		
DALBY IS	34°34'S, 136°14'E	1-Mar-90	2									nil		
BLYTH IS	34°34'S, 136°17'E	1-Mar-90	2									nil		
HAREBY IS	34°35'S, 136°18'E	1-Mar-90	2									nil		
SMITH RCK	34°35'S, 136°16'E	1-Mar-90	1	7	1	15				11	56	99	Possible breeding	
LANGTON IS.	34°36'S, 136°15'E	1-Mar-90	1	11		3				4		17	Haul-out	
ROKBY IS.	34°36'S, 136°19'E	1-Mar-90	2									nil		
SIBSEY IS	34°40'S, 136°20'E	1-Mar-90	2									nil		
ENGLISH IS	34°38'S, 136°12'E	1-Mar-90	1	6	5	53				84		148	Breeding	
BOUCAUT IS.	34°39'S, 136°22'E	1-Mar-90	2									nil		
SEAL RCK	34°39'S, 136°22'E	1-Mar-90	2									nil		
SPILSBY IS.	34°40'S, 136°20'E	1-Mar-90	2									nil		
DUFFIELD IS.	34°39'S, 136°19'E	1-Mar-90	2									nil		
STICKNEY IS.	34°41'S, 136°16'E	1-Mar-90	2									nil		
BUFFALO REEF	34°43'S, 136°28'E	1-Mar-90	1	9	7	34				69	42	161	Possible breeding	
DANGEROUS REEF (N/W)	34°49'S, 136°13'E	27-Feb-90	1	2	5	97		2		88		194		
DANGEROUS REEF (MAIN REEF)	34°49'S, 136°13'E	27-Feb-90	1	6	7	9				12		34		
DANGEROUS REEF (S/E)	34°49'S, 136°13'E	27-Feb-90	1	2	3	93				98		196		
GREEN IS.		31-Jan-90	2									nil		
WHITE RCKS.		31-Jan-90	1	22	2							24	Haul-out	
GOOSE IS.		31-Jan-90	2									nil		
LITTLE GOOSE IS.		31-Jan-90	2									nil		
WARDANG IS.		31-Jan-90	2									nil		
LITTLE ALTHORPE (STH)	35°22'S, 136°51'E	30-Jan-90	1	10	12	9				9		40	Possible breeding	Occasional haul-out
LITTLE ALTHORPE (NTH)	35°22'S, 136°51'E	30-Jan-90	1	5	3	13				9		30	Possible breeding	Occasional haul-out
ALTHORPE IS.	35°22'S, 136°52'E	30-Jan-90	2	1	2					1		4	Haul-out	Occasional haul-out
HAYSTACK IS.	35°19'S, 136°54'E	30-Jan-90	2	1	4							5	Haul-out	
SEAL IS.	35°20'S, 136°55'E	30-Jan-90	1	4	1	2				1		8	Possible breeding	Occasional haul-out
KANGAROO ISLAND														
CAPE DE COUDIC REGION	36°04'S, 136°42'E	10-Feb-90	1	2	2	2					1	7	Haul-out	Breeding
PUP COVE	35°41'S, 136°53'E	23-Feb-90	1	11	8	35	45		6	3		108	Breeding	
WESTERN PROHIBITED AREA	35°41'S, 136°53'E	23-Feb-90	1	13	5	20	42			11		91	Breeding	
EASTERN PROHIBITED AREA AND MAIN BEACH	35°41'S, 136°53'E	23-Feb-90	1	24	22	72	53			57		228	Breeding	
CAPE GANTHEAUME	36°05'S, 137°28'E	24-Feb-90	1	7	6	16	3			15		47	Breeding	
NORTH PAGES ISLAND	35°46'S, 138°18'E	7-Feb-90	1	34	27	218	272		8	36		595	Breeding	
SOUTH PAGES ISLAND	35°47'S, 138°17'E	7-Feb-90	1	28	14	123	234		8	18		417	Breeding	
S/W PAGES REEF	35°47'S, 138°17'E	7-Feb-90	3								140	140	Haul-out	

BREEDING ISLAND	LAT/LONG	MAX PUPS COUNTED	ESTIMATED PUP PRODUCTION
HAULOFF RK.	34°42'S, 118°40'E	29	40
RED ISLET	34°02'S, 119°47'E	27	35
WEST IS.	34°06'S, 120°18'E	19	25
ROCKY IS.	34°05'S, 120°52'E	17	22
LITTLE IS.	34°28'S, 122°00'E	?	33
McKENZIE IS.	34°12'S, 122°07'E	?	33
KIMBERLEY IS.†	33°57'S, 122°28'E	38	50
POISON CREEK IS.†	33°55'S, 123°20'E	2	5
KERMADEC IS.	34°05'S, 122°50'E	?	33
ROUND IS.	34°06'S, 123°53'E	9	30
HALFWAY IS.†	33°46'S, 124°02'E	17	30
NOOK IS.†	33°44'S, 124°06'E	?	33
SPINDLE IS.†	33°44'S, 124°10'E	53	60
		Total =211	Total =429

POSSIBLE BREEDING ISLANDS	LAT/LONG
MIDDLE DOUBTFUL IS.	34°22'S, 119°35'E
EAST DOUBTFUL IS.	34°22'S, 119°35'E
RED IS.	33°53'S, 121°21'E
FIGURE OF EIGHT IS.	34°02'S, 121°37'E
TERMINATION IS.	34°29'S, 122°00'E
FINGER IS.	34°07'S, 122°21'E
BEAMONT IS.	34°06'S, 122°33'E
SLIPPER IS.	34°03'S, 122°45'E
WESTALL IS.	34°05'S, 122°58'E
GLENNIE IS.	34°06'S, 123°06'E
WICKHAM IS.	34°01'S, 123°17'E
SALISBURY IS.	34°22'S, 123°33'E
PASELY IS.(+3 Rks)	34°01'S, 123°34'E
COOPER IS.	34°14'S, 123°37'E
BELLINGER IS.	33°53'S, 123°38'E
DAW IS.	33°51'S, 124°06'E

BREEDING ISLAND	MAX PUPS COUNTED	ESTIMATED PUP PRODUCTION	POSSIBLE BREEDING ISLANDS
WESTERN NUYTS REEF	?	28	WEST ISLAND
MIDDLE NUYTS REEF	?	28	SMALL STH FRANKLIN IS.
PURDIE ISLAND	49*	49	POINT LEBATT
FENELON ISLAND	8*	50	DOROTHEE ISLAND
SMALL N/E FRANKLIN IS.	43*	43	PEARSON ISLAND
OLIVE ISLAND	25*	25	WEST WALDEGRAVE IS.
JONES ISLAND	2***	2	ROCKY IS. NTH
WARD ISLAND	?	28	ROCKY IS. STH
LIGUANEA ISLAND	23	25	GREENLY ISLAND
ALBATROSS ISLAND*	12*	12	NTH HUMMOCK ISLAND
NORTH ISLET ISLAND*	8*	8	PRICE ISLAND
PEAKED RKS**	23**	30	LEWIS ISLAND
ENGLISH ISLAND	40*	40	NTH NEPTUNE ISLAND
DANGEROUS REEF (N/W)	236*	236	SMITH ROCK
DANGEROUS REEF (S/E)			BUFFALO REEF
KANGAROO ISLAND	162	180	LITTLE ALTHORPE STH
NTH PAGES ISLAND	280	310	LITTLE ALTHORPE NTH
STH PAGES ISLAND	242	260	SEAL ISLAND
	Total = 707	Total = 1354	

Table 5. Records of entanglements of Neophoca

Animal type	Location	Date	Material	Body site	Comments
Juvenile (c. 3 y.o.)	Hopkins Island South Australia	31-Jan-90	Monofilament shark net	Cut into muscle on neck and face	Net removed at capture
Cow	North Pages Is South Australia	7-Feb-90	Monofilament shark net	Cut into skin around neck	
Moulted pup (c. 4-5 m.o.)	North Pages Is South Australia	7-Feb-90	Monofilament shark net	Cut into blubber around neck	Net removed at capture
Cow	Kangaroo Island South Australia	20-Feb-90	Bait band	Cut into neck	
Juvenile	Dangerous Reef South Australia	27-Feb-90	Bait band	Cut into blubber around neck	
Juvenile	Dangerous Reef South Australia	27-Feb-90	Monofilament shark net	Cut into muscle around neck	
Juvenile	Buffalo Reef South Australia	1-Mar-90	Monofilament shark net	Cut into muscle around face and neck	
Juvenile	Smith Rock South Australia	1-Mar-90	Monofilament shark net	Cut into muscle around neck	
Bull	Anvil Island Western Australia	8-Jan-90	Bait band	Cut into muscle around neck	
Bull	Round Island Western Australia	11-Jan-90	Bait band	Cut into muscle around neck	