# NZ sea lion research trip, Auckland Islands, November 28th 2005 to February 20th 2006

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## Executive Summary

This report outlines the work completed in the summer programme of the 2005/06 New Zealand sea lion (NZ sea lion, *Phocarctos hooker*i) research field trip to the Auckland Islands. The period covered in this report is from December 2nd 2005 when the first team arrived on Enderby Island through to the departure of the second team from the Island on February 17th 2006. The report is divided into three parts covering field trip logistics, population dynamics results, and survival and reproductive performance of female NZ sea lion. The latter two sections are summarised below.

1) Data from surveys of the Auckland Island breeding sites of the NZ sea lion conducted during the 2005/06 season, principally to obtain accurate estimates of pup production for use as an index of population size. In the 2005/06 season the Auckland Island pup production estimate was 2.8% less than the previous year with an estimate of 2089 pups born. This is the lowest estimate recorded since systematic estimates started. This low pup production level production leads to a species estimate of NZ sea lions as 11709 (95% CI 10172 - 13493, this includes the 2003 pup production estimate of 385 from Campbell Island). This is the third mean species estimate below 12000 animals in the last 4 years (Table 3).

2) Data on the estimates of survival and reproductive rates of adult female NZ sea lions, *Phocarctos hookeri,* in the 2005/06 season. Survival rates for females between the age of 13 to 19 show survival rates between 0.878 and 0.786 dropping with increasing age. Reproductive data shows a dropping pupping rate for the cohorts tagged as pups between 1990 and 1993 (13 to 16 yr old this season). Also, overall the number of females that pupped from all tagged cohorts seven years and older was lower this season than the 2004/05 season when they should be on the increase (7yrs plus are the cohorts that should represent the highest proportion of pup production for a sea lion breeding area, Childerhouse unpublished). No known age four year old female pupped this season. Only four females from the 1998 cohort (first major mass mortality event cohort) pupped this year. These eight year old females should be contributing approximately 15% of total pup production at the Sandy Bay NZ sea lion breeding area, this would equate to approximately 64 pups produced from this cohort however only 4 pups were born, less than 1% of this years pup production.

## FIELD TRIP LOGISTICS

### 1. Aims of the trip

This work continues annual surveys of the Auckland Island breeding sites of the NZ sea lions. The objectives were to: i) measure NZ sea lion pup production; ii) estimate sea lion survival by age and sex based on individually marked animals; iii) quantify reproduction by known-age female NZ sea lions; iv) tag pups produced during the 2005/06 breeding season; and v) retain the ability to identify known-age NZ sea lions.

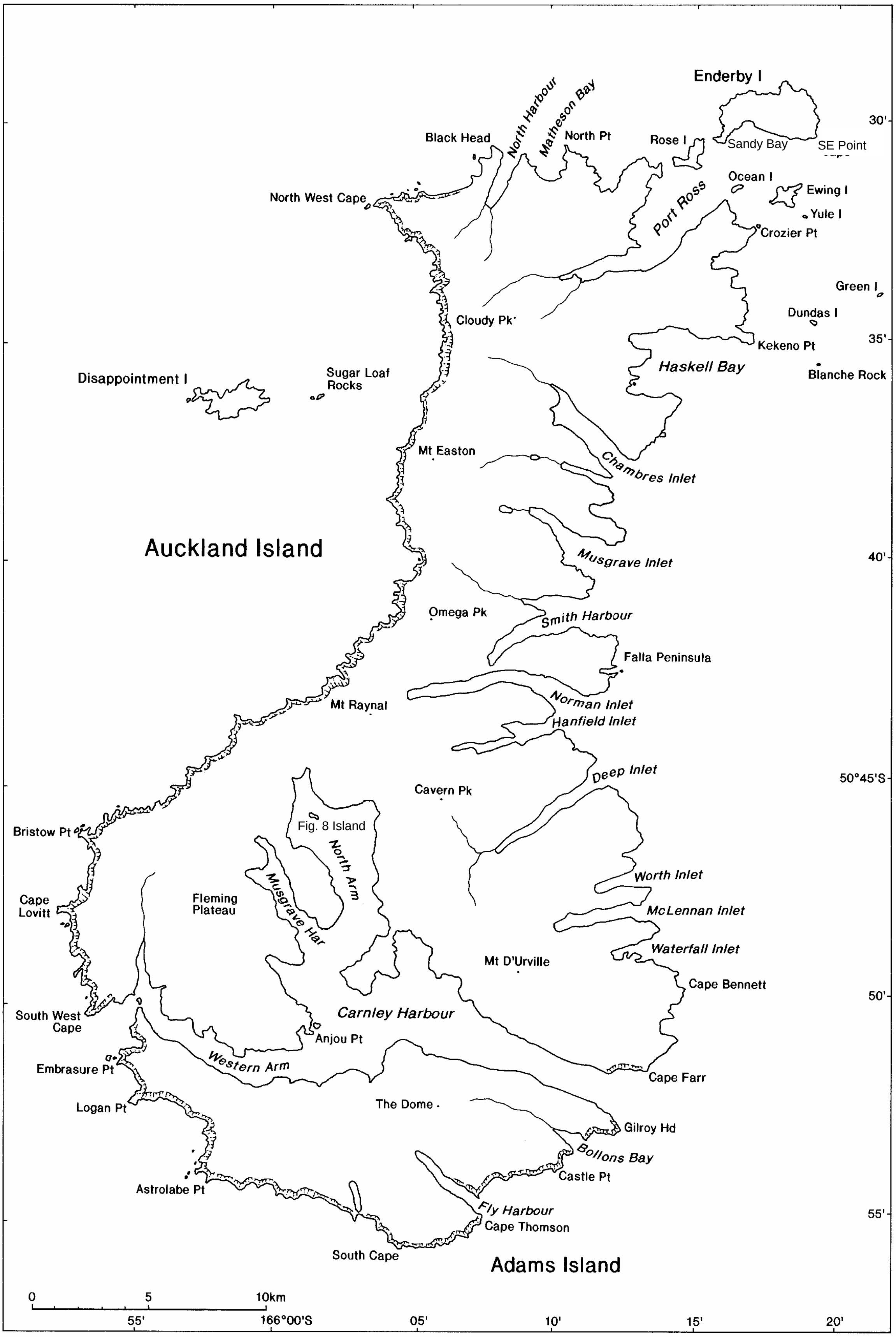


**Figure 1:** The Auckland Islands showing areas where sea lions were sighted: Figure of Eight Island, Dundas Island, Kekeno, Enderby Island and Rose Island.

## POPULATION DYNAMICS

### 2. Sea lion counts

Daily counts were undertaken of pups (live and dead, dead pup counts continued 4th December 2005 to 16th February 2006) and adults at the Sandy Bay (4th December 2005 - January 20th 2006) and South East Point (4th December 2005 - January 20th 2006) rookeries. Counts were made occasionally at East Bay and other areas around Enderby Island. One twelve day trip was made to Dundas Is. during the season to count, tag and resight animals. Figure of Eight Island was counted on January 11th with 26 females, 14 males, and 55 live and 7 dead pups being recorded. Counts and resightings were also conducted by the sea lion team at Rose Island and Kekeno on the main Auckland Island. Two groups of researchers studying Albatross were located on Adams Island and in the Western Arm of Carnley Harbour. Reports from these areas yield four tag resights and no sign of breeding in any of these areas. See Figure 1 for locations.

### 3. Pup production estimate

Estimates of pup production were calculated for the breeding sites in the Auckland Islands between 11 Jan to 21 Jan 2006 (Tables 1 and 2). Mark recapture estimates have been used as the estimates of pup production from Sandy Bay and Dundas Island, while Figure of Eight Island and South East Point areas were estimated using direct counts. The total pup production estimate was 2089 ± 33.5 (Fig. 2).

On the 16th of January, the mark-recapture estimate at Sandy Bay was 383 ± 3. On the 17th January all live pups were tagged at Sandy Bay with a total of 384 pups tagged. There were 39 dead pups from the area at the 16th January giving a total pup production for Sandy Bay for the 2005/2006 season of 422 ± 3. The mark recapture estimate at Dundas Island was completed on 21st January 2006 with an estimation of 1349 live pups ± 30.5. 232 dead pups were counted on the island on the same day giving a total pup production for Dundas Island of 1581 ± 30.5. Direct counts from Figure of Eight Island on the 11th Jan yielded a count of 55 pups + 7 dead giving a total of 62. The direct count at South East Point yielded 20 live pups + 4 dead giving a total of 24 pups.

The estimate of pup production from the Auckland Islands was 2.8% lower than that seen in 2004/05. Pup estimates from Figure of Eight dropped by 7% and by 6% at SE Point. Pup mortality during the first 8 weeks of the 2005/ 06 season, from all studied locations was 13.5% as of the 16th January (Table 2). Pup mortality at Sandy bay was 9% at the same date however was 16% by 17th Feb 2006. This increase in the level of pup mortality recorded between one and two months of age is seen consistently over the last eight years it has been recorded. This information needs to be included in management models for more appropriate survival and population estimates for NZ sea lions.

**Figure 2.** Annual pup production for the Auckland Islands 1994/95 to 2005/06.

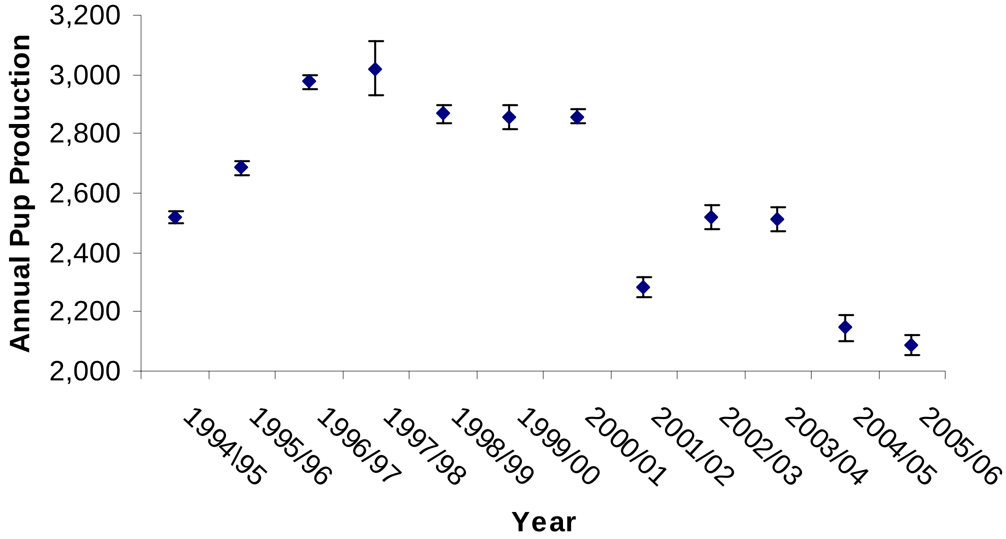


**Table 1:** Pup production estimates for Auckland Islands

| **Season** | **Sandy Bay** | | | **Dundas Island** | | | **Figure of Eight Island** | | | **South East Point** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | total | alive | dead | total | Alive | Dead | total | alive | dead | total | alive | Dead |
| 94/95 | 467 | 421 | 46 | 1837 | 1603 | 234 | 143 | 123 | 20* | 71 | 59 | 12 |
| 95/96 | 455 | 417 | 38 | 2017 | 1810 | 207 | 144 | 113 | 31 | 69 | 49 | 20 |
| 96/97 | 509 | 473 | 36 | 2260 | 2083 | 177 | 143 | 134 | 9 | 63 | 39 | 24 |
| 97/98 | 477 | 468 | 9 | 2373 | 1748 | 625 | 120 | 97 | 23 | 51 | 37 | 14 |
| 98/99 | 513 | 473 | 40 | 2186 | 1957 | 229 | 109 | 100 | 9 | 59 | 42 | 17 |
| 99/00 | 506 | 482 | 24 | 2163 | 2039 | 124 | 137 | 131 | 6 | 50 | 37 | 13 |
| 00/01 | 562 | 527 | 35 | 2148 | 1802 | 346 | 94 | 92 | 2 | 55 | 47 | 8 |
| 01/02 | 403 | 320 | 83 | 1756 | 1395 | 361 | 96 | 90 | 6 | 27 | 21 | 6 |
| 02/03 | 489 | 408 | 80 | 1891 | 1555 | 336 | 95 | 89 | 5 | 43 | 26 | 17 |
| 03/04 | 507 | 473 | 34 | 1869 | 1749 | 120 | 87 | 86 | 1 | 52 | 39 | 13 |
| 04/05 | 441 | 411 | 30 | 1587 | 1513 | 74 | 83 | 79 | 4 | 37 | 31 | 6 |
| **05/06** | **422** | **383** | **39** | **1581** | **1349** | **232** | **62** | **55** | **7** | **24** | **20** | **4** |

* Denotes that the number of dead pups was estimated from mean mortality rates derived from Sandy Bay and Dundas Island

**Table 2:** Total pup production from the Auckland Islands (NB. These estimates do not include an estimate of pup production from Campbell Island).

| Season | Annual pup production | | | % Annual change in no. pups born | % Mortality at mark recapture estimate date | | % Mortality at end of season (SB only) |
|---|---|---|---|---|---|---|---|
| | **Total** | **Alive** | **Dead** | | **Total** | **SB only** | |
| 94/95 | 2518 | 2206 | 312 | 5.4% | 12.4% | 10% | n.a. |
| 95/96 | 2685 | 2389 | 296 | 6.6% | 11.0% | 8% | n.a. |
| 96/97 | 2975 | 2729 | 246 | 10.8% | 8.3% | 7% | n.a. |
| 97/98 | 3021 | 2350 | 671 | 1.5% | 22.2% | 2% | 42% |
| 98/99 | 2867 | 2572 | 295 | -5.1% | 10.3% | 8% | 9% |
| 99/00 | 2856 | 2689 | 167 | -0.4% | 5.8% | 5% | 11% |
| 00/01 | 2859 | 2468 | 391 | 0.1% | 13.7% | 6% | 10% |
| 01/02 | 2282 | 1826 | 456 | -20.2% | 20.0% | 21% | 33% |
| 02/03 | 2518 | 2078 | 438 | 10.3% | 17.4% | 16% | 21% |
| 03/04 | 2515 | 2347 | 168 | -0.001% | 6.7% | 8% | 15% |
| 04/05 | 2148 | 2034 | 114 | - 14.6% | 5.3% | 7% | 12% |
| **05/06** | **2089** | **1807** | **282** | **- 2.8%** | **13.5%** | **9%** | **16%** |

## Number of cows breeding and daily Pup:Cow ratios

As is done every season, daily counts of all animals and resights of tags and brands on NZ sea lions were undertaken on Enderby Island to understand the composition of animals at this breeding site and to enable the calculation of survival, recruitment and fecundity of animals. Daily checks were undertaken at Sandy Bay with 6200 resights made on 1800 animals previously tagged or branded (including 84 individuals with double tag scars identified from a chip). A comparisons of the daily number of females ashore at Sandy Bay in 2006 (Fig. 3) and pup:cows ashore ratios (Fig. 4) with the previous seasons show that both the number of breeding females and the pup:cow ratio were similar to the 2002/03 and 2003/04 seasons (Fig. 4).

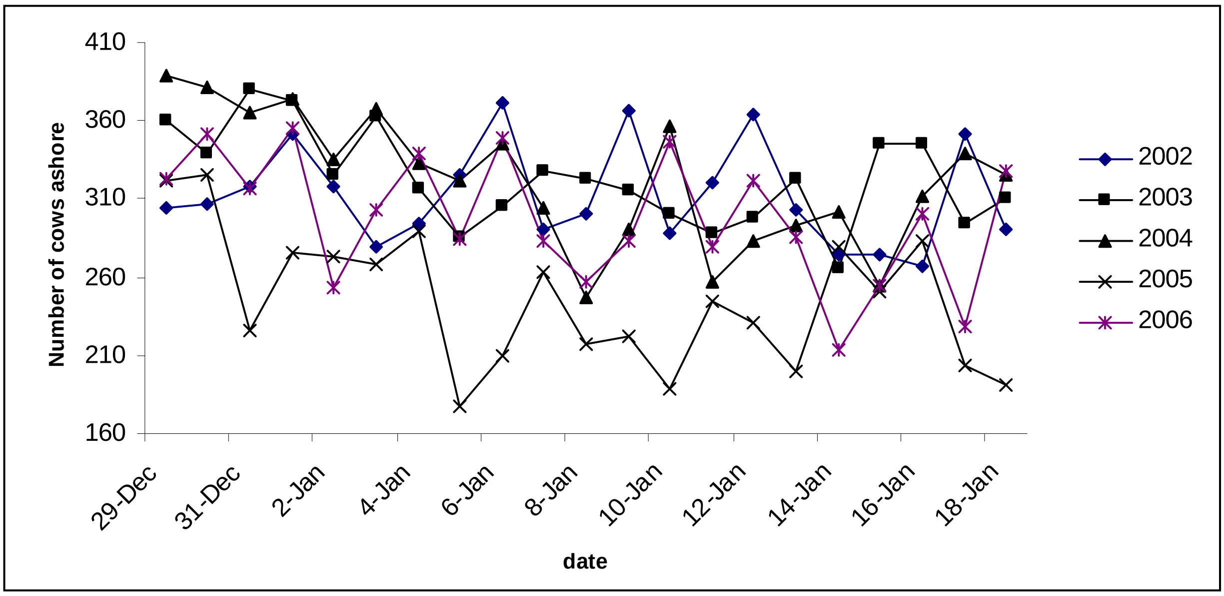


**Figure 3.** Numbers of females recorded ashore each day between 29th December and 18th January for the years 2001/02 to 2005/06.

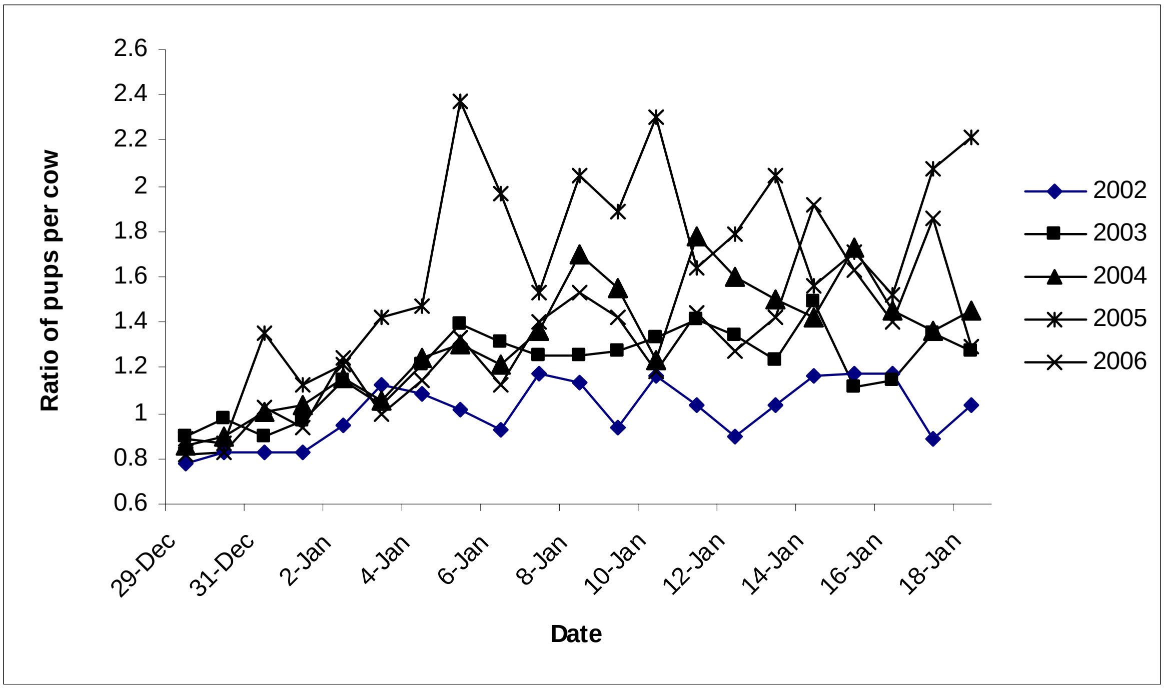


**Figure 4.** Pup:cow ratio at Sandy Bay between 30 December and 18 January for the years 2001/02 to 2005/06.

**Population estimation**

The low pup production numbers recorded in the 2005/06 season leads to the second lowest population estimate of NZ sea lions at 11709 (95% CI 10172 – 13493, Table 3) using Gales and Fletcher model (Gales and Fletcher 1999) for comparison with previous years. This is the third mean population estimate below 12000 animals in the last four years (Table 3).

**Table 3:** Population estimates of New Zealand sea lions, 1994 / 95 to 2005 /06.

| Season | Pup Production (s.d.) | Population size estimate using Gales & Fletcher model# 1996 including Campbell Island estimates | |
|---|---|---|---|
| | | Mean | 95% CI |
| 94/95 | 2640 (20.8) | 12797 | 10883 – 14339 |
| 95/96 | 2807 (22.3) | 13606 | 11564 – 15239 |
| 96/97 | 3097 (25.5) | 14661 | 12732 – 16826 |
| 97/98 | 3143 (93.8) | 14868 | 12812 – 17175 |
| 98/99 | 2989 (32.5) | 14163 | 12337 – 16262 |
| 99/00 | 2978 (42.6) | 14104 | 12272 – 16230 |
| 00/01 | 2980 (24.3) | 14108 | 12305 – 16163 |
| 01/02 | 2404 (33.7) | **11376** | 9896 – 13058 |
| 02/03* | 2902 (70.0) | 13719 | 11849 – 15854 |
| 03/04 | 2899 (40.0) | 13716 | 11891 – 15698 |
| 04/05 | 2533 (44.5) | **11995** | 10391 – 13791 |
| **05/04** | **2474 (33.5)** | **11709** | **10172 - 13493** |

* Campbell Island estimate increased from 122 to 385 from the 02/03 season.
\# Gales and Fletcher model used for comparisons between years.

**4. Pup tagging**

Pups have been tagged to provide a pool of known age individuals for the estimation of parameters such as survival, recruitment and reproductive rate as part of the long-term study. Tags applied were Orange ‘coffin’ shaped Dalton ‘Jumbo’ tags with a four-digit number. All pups were tagged in both flippers. All live pups at both Sandy Bay (384) and South East Point (20), and 400 pups (100 males and 300 females) at Dundas Island were tagged with orange tags. 20 pups were tagged on Figure of Eight Island with red Dalton tags.

A sample of 100 (50 male/50 female) pups were weighed from both Sandy Bay and Dundas Island to investigate between site and inter-annual variation. Weights of both male and female pups have been similar for the last four years (Fig. 5).

251 pups were captured approximately 4 weeks after tagging and checked for tag loss, 3 pups had lost a single tag giving a probability of losing a single tag of 0.6%, within 4 weeks. Tag loss over the first 4 weeks during the first six years of use of Dalton tags has been 0.3%, 0.2%, 0.5%, 0.2%, 0.4%, 1.4% and 0.6%. Tag loss over the first 4 weeks has been consistently lower with the Dalton tags compared with the Allflex tags used previously (4 week single tag loss estimate 11.5%).

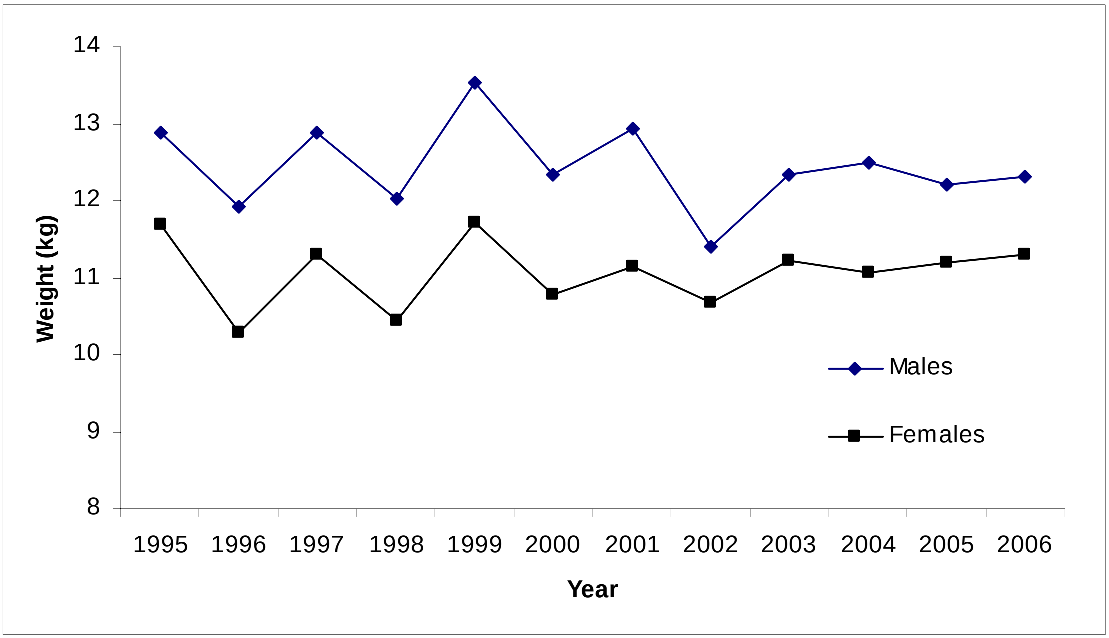


**Figure 5.** Interannual variation in mass of ~4 week old male (top line) and female (bottom line) pups at Sandy Bay, Enderby Island between 1995 and 2006.

## 5. Tag and brand resighting

Resighting effort of tags and brands has been excellent with daily checks of both Sandy Bay and South East Point during the season. Over 6200 resights were made of 1800 animals previously tagged or branded (including 84 individuals with double tag scars identified from a chip). Twelve days of resighting also occurred on Dundas Island with 182 resights of 104 animals.

# ESTIMATES OF SURVIVAL, RECRUITMENT AND REPRODUCTIVE RATES OF ADULT FEMALES

## 6. Methods

*Resighting data collection*

There has been intermittent tagging of NZ sea lions from the Auckland islands over the last 19 years to enable identification of individuals. During January 1987, 1990, 1991, 1992 and 1993, approximately four week old NZ sea lion pups at Sandy Bay, Enderby Island (50°30'S, 166°17'E) were tagged with uniquely numbered, yellow Allflex button tags in their right pectoral flippers. Resights of these animals have been made at the Auckland Islands, Campbell Island, Macquarie Island and the NZ mainland between their tagging up to the end of February 2006. Resighting effort has varied considerably during the period and across the different locations.

Prior to 1999 there was no dedicated resighting protocol. During the austral summer of 1999/00 an increased effort was made to resight marked animals. From 2000/01 to 2005/06 intensive resighting was undertaken between December and February annually at Enderby Island. Sightings were made on opportunistic basis at all other sites and times.

In January 2000, 135 adult females were hot branded at Sandy Bay with four digit numeric brands between 1364 and 1500 (Wilkinson *et al.* in press). All of these females had produced pups in 2000. Dedicated resighting effort was made at the Auckland islands in the austral summers of 2001 to 2006. Additional resights were obtained on an *ad hoc* basis from other sites.

Resighting data included the date, location and breeding status of animals sighted. To minimize the potential bias from tag or brand mis-reads on survival estimates, conditions were placed on the inclusion of a tag/brand resights for these analyses. With the assumption that the errors associated with mis-reading a mark are independent events, a resight was deemed valid for analysis if the animal was recorded on at least two occasions during a season. A single resight was only considered if the event was confirmed by photograph, confirmed by the reading of the animals' electronic identification tag or from the handling of the animal within that season.

*Survival estimate data analysis*

Capture-history matrices were constructed using the resighting data from the tagged cohorts and the branded cohort, treating multiple resightings within a year as a single sighting. Nineteen years of capture history were available for the 1987 cohort, 13 for the 1993 tagged cohort, and six for the branded cohort. The matrices were used as input files for the computer software package MARK (http://www.cnr.colostate.edu/~gwhite/mark/mark.htm), designed to obtain maximum-likelihood estimates of survival and capture probability rates from the resighting of marked individuals.

No corrections for mark loss were made in either the tagged cohorts, or among the branded females. For the tagged animals, no correction could be made as all individuals had been single tagged and therefore the calculation of the tag loss rate was not possible. For branded females, no corrections were made as all females were identifiable as individuals, and there was no loss of mark over time (Wilkinson *et al.* in press.). Not correcting for tag loss indicates survival estimates are minimum estimates.

The survival estimate models from MARK calculate two fundamental parameters; $\phi$ = the survival probability for all animals between the $i$th and $(i + 1)$th sample ($i = 1,\ldots,k-1$), and $p$ = the capture probability for all animals in the $i$th sample ($I = 1,\ldots,k$). This means survival estimates presented here represent only the survival estimates of each age class between the 2004/05 and the 2005/06 seasons. The removal of known to be dead animals from the data set after the season of their death minimizes bias in survival estimates and allows the most accurate calculation of capture probability. This results in survival estimates to be higher than if dead animals were not removed.

*Model selection*

Appropriate model selection is a critical step in the analysis of capture-mark-recapture data (Anderson *et al.* 1994). Determining model selection based on resighting data variability and accounting for temporal variance in recapture probabilities is an important phase in acceptable calculation of survival estimates. Within MARK this is accomplished using the Akaike Information Criteria (AIC). AIC is a standard procedure for model selection in a capture-mark-recapture context, and it weighs the quality of fit (deviance) and the precision (via the number of parameters), so as to select the most parsimonious model that adequately describes the data (Lebreton *et al*. 1992; Anderson *et al*. 1994). This method was used to select between the full time dependant model and the constant capture probability (assuming no year-to-year changes in capture probability) for each cohort. The model with the lowest AIC values was selected for each cohort.

*Pupping rates*

As an integral part of the intensive resighting of marked animals from Enderby Island, the reproductive status of all animals observed was recorded. Females observed giving birth or nursing pups were assumed to have given birth in that year. Those females seen with pups in close attendance on three or more occasions were deemed to have possibly pupped, and those never seen with a pup on three or more occasions were assumed to have not pupped. Females seen nursing yearlings were recorded as having pupped in the previous year. Given the observed fidelity of adult females to pupping location females not seen in one year (year *t*), but known to be alive due to resights in subsequent seasons (*t+1, t+2* etc) were assumed to have failed to pup in year *t*.

Minimum and maximum pupping rates were calculated by dividing the number of females known, and assumed to have pupped by the number of females known to be alive in that year. Where a female was seen in a given year, but no indication of her reproductive status determined, 0% of these females were assumed to have pupped when calculating minimum pupping rate, and 50% when calculating maximum pupping rates.

*Female recruitment into the breeding population*

Age at first reproduction was determined by examining resights of females tagged at Sandy Bay in 1998, 1999, 2000, 2001 and 2002 seen with and without pups during the 2001 to 2006 field seasons. Maximum recruitment rates were calculated by dividing the number of females known, and assumed to have pupped by the number of females known to be alive at that year. These estimates are considered maximum estimates as the resighting rate of young female NZ sea lions increases with their cohorts age (unpublished data). Therefore the actual recruitment rates in year *t* are likely to be lower than estimated at year *t*+n , because by *t*+1, *t*+2 etc higher numbers of females are usually known to be alive and therefore form a higher denominator for the recruitment calculation resulting in lower recruitment rates. There is no bias expected in this estimation due to females tagged at Sandy Bay giving birth at a different location given the high fidelity of females to pup at their birth location, and the high resighting coverage of the main breeding areas during the breeding season (unpublished data).

## 7. Results and Discussion

*Survival Probabilities*

The time dependant capture probability and constant survival model was selected for all five of the known age cohorts 1987 to 1993 (Table 4). All five tagged cohorts showed low capture probabilities associated with all bar the last six years of estimates which correspond with the intensified resighting effort undertaken since 1999. Annualized survival estimates with associated standard errors ranged between 0.878 ± 0.009 for the 1993 cohort and 0.786 ± 0.028 for the 1987 cohort (Table 5).

Recapture probabilities reflect the resighting effect over the course of the research with almost non-existent effort prior to 1999. This lack of resighting effort prior to 1999 prevents the accurate determination of juvenile survival rates in these cohorts.

Table 4. Model selection results for female NZ sea lions tagged as pups 1987 to 1993. ($\phi$ (.) = constant survival probability, $\phi$ (t) = time dependent probability, p(.) = constant recapture probability, p(t) = time dependant recapture probability). The preferred time dependant capture probability with constant survival shown highlighted in each year.

| Cohort Year | Model | AICc | Delta AICc | AICc Weights | Number Parameters | Deviance |
|---|---|---|---|---|---|---|
| 1987 | $\phi$ (.) p(t) | 132.17 | 0.000 | 0.999 | 20 | 27.54 |
| | $\phi$ (t) p(t) | 148.73 | 16.57 | <0.001 | 27 | 21.66 |
| | $\phi$ (.) p(.) | 175.66 | 43.49 | <0.001 | 20 | 71.03 |
| | $\phi$(t) p(.) | 177.94 | 45.77 | <0.001 | 2 | 118.13 |
| | | | | | | |
| 1990 | $\phi$ (.) p(t) | 500.23 | 0.000 | 0.966 | 17 | 125.92 |
| | $\phi$ (t) p(t) | 506.92 | 6.68 | 0.034 | 25 | 113.63 |
| | $\phi$(t) p(.) | 727.7 | 227.48 | <0.001 | 17 | 353.39 |
| | $\phi$ (.) p(.) | 816.66 | 316.42 | <0.001 | 2 | 474.78 |
| | | | | | | |
| 1991 | $\phi$ (.) p(t) | 854.24 | 0.000 | 0.936 | 16 | 187.16 |
| | $\phi$ (t) p(t) | 859.62 | 5.37 | 0.064 | 25 | 172.56 |
| | $\phi$(t) p(.) | 1251.60 | 397.36 | <0.001 | 16 | 584.52 |
| | $\phi$ (.) p(.) | 1413.97 | 559.73 | <0.001 | 2 | 776.23 |
| | | | | | | |
| 1992 | $\phi$ (.) p(t) | 1038.36 | 0.000 | 0.984 | 15 | 163.20 |
| | $\phi$ (t) p(t) | 1046.59 | 8.24 | 0.015 | 27 | 145.53 |
| | $\phi$(t) p(.) | 1732.59 | 694.23 | <0.001 | 15 | 857.44 |
| | $\phi$ (.) p(.) | 1951.63 | 913.27 | <0.001 | 2 | 1103.32 |
| | | | | | | |
| 1993 | $\phi$ (.) p(t) | 929.73 | 0.000 | 0.98 | 14 | 157.71 |
| | $\phi$ (t) p(t) | 938.78 | 9.05 | 0.011 | 23 | 147.32 |
| | $\phi$(t) p(.) | 1520.10 | 590.37 | <0.001 | 14 | 748.08 |
| | $\phi$ (.) p(.) | 1687.05 | 757.31 | <0.001 | 2 | 939.87 |

Table 5. Estimated probabilities of survival ($\phi$) calculated in the 2005/06 season of the 5 known age cohorts of NZ sea lion females, derived from $\phi$(.) p(t) models. Animals deemed to be alive if seen on more than one occasion unless single sighting confirmed by photo, chip read or tag read when animal handled (retagged adult or animal dead).

| Cohort | Known numbers of each cohort alive | Estimate of $\phi$ | Standard error of estimate |
|---|---|---|---|
| 1993 | 25 | 0.878 | 0.0097 |
| 1992 | 21 | 0.870 | 0.0089 |
| 1991 | 12 | 0.866 | 0.0104 |
| 1990 | 6 | 0.839 | 0.0140 |
| 1987 | 1 | 0.786 | 0.0282 |

For the branded females the highest weighted model was for and constant recapture and survival probability (Table 6). Recapture probability was estimated at 0.894 ± 0.0142, with survival estimates of 0.914 ± 0.117 (n=66).

Table 6. Model selection results for female NZ sea lions branded as adults in 2000. (ϕ (.) = constant survival probability, ϕ (t) = time dependent probability, p(.) = constant recapture probability, p(t) = time dependant recapture probability).

| Model | AICc | Delta AICc | AICc Weights | Number Parameters | Deviance |
|---|---|---|---|---|---|
| ϕ (.) p(.) | 719.66 | 0.00 | 0.833 | 2 | 65.39 |
| ϕ (t) p(.) | 723.32 | 3.53 | 0.142 | 7 | 58.76 |
| ϕ (.) p(t) | 727.32 | 7.66 | 0.018 | 7 | 62.89 |
| ϕ (t) p(t) | 729.51 | 9.84 | 0.006 | 11 | 56.80 |

*Pupping Rates*

Estimates of branded female NZ sea lion minimum pupping rate range from 0.593 in 2002 to 0.862 in 2003 (Table 7). The minimum pupping rate has dropped consecutively since the 2003 high to be 0.667 this year (Table 7). The maximum pupping rate shows the same trend with the lowest being recorded in 2002 at 0.694, highest 0.867 in 2003 and dropping over the last two years to be 0.712 this year (Table 7).

Table 7. Minimum and maximum estimated pupping rates of branded females in the 2001 to 2006 breeding seasons.

| Year | Known # of cows alive | Min # known to have pupped | Max # assumed to pupped | Min pupping rate | Max pupping rate |
|---|---|---|---|---|---|
| 2000 | 135 | 135 | 135 | 1.00 | 1.00 |
| 2001 | 123 | 99 | 101.5 | 0.805 | 0.825 |
| 2002 | 108 | 64 | 75 | 0.593 | 0.694 |
| 2003 | 94 | 81 | 81.5 | 0.862 | 0.867 |
| 2004 | 83 | 66 | 69 | 0.795 | 0.831 |
| 2005 | 72 | 51 | 55.5 | 0.708 | 0.771 |
| 2006 | 66 | 44 | 47 | 0.667 | 0.712 |

The 2005/06 reproductive rates among the five tagged as pups, female NZSL cohorts (Fig. 6 – 9) show a consistent pattern of dropping minimum and maximum pupping rates over the last years, similar to the branded female data. The exceptions to this rule is the 1987 cohort which is only represented by one known to be alive animal that has pupped consecutively the last three years, therefore resulting in a 100% pupping rate (graph not included) and the 1991 cohort which shows a increase this year as 15 year olds. The sample sizes for these pupping rates also continue to show the dropping numbers of tagged females that were observed to be present or to pup this season.

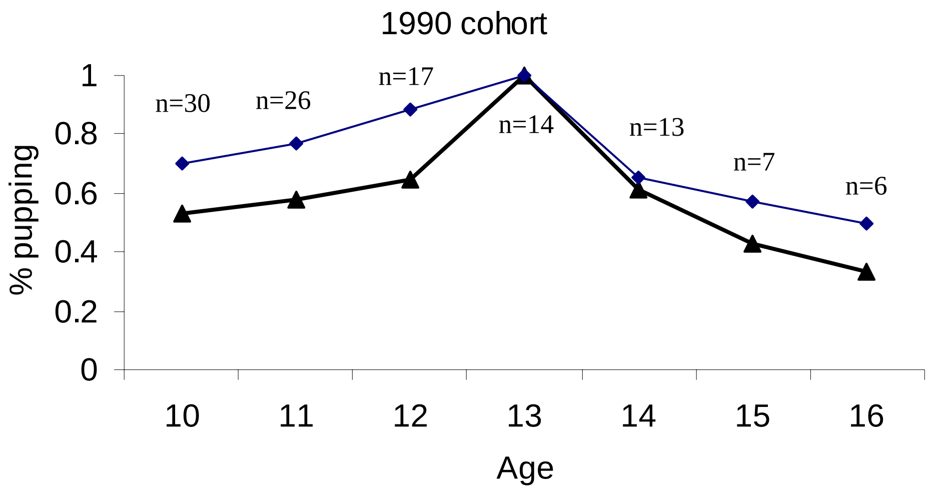


Figure 6: Maximum and minimum estimates of pupping rate for females tagged as pups in 1990 resighting between 2000 and 2006. Sample sizes shown as n=#.

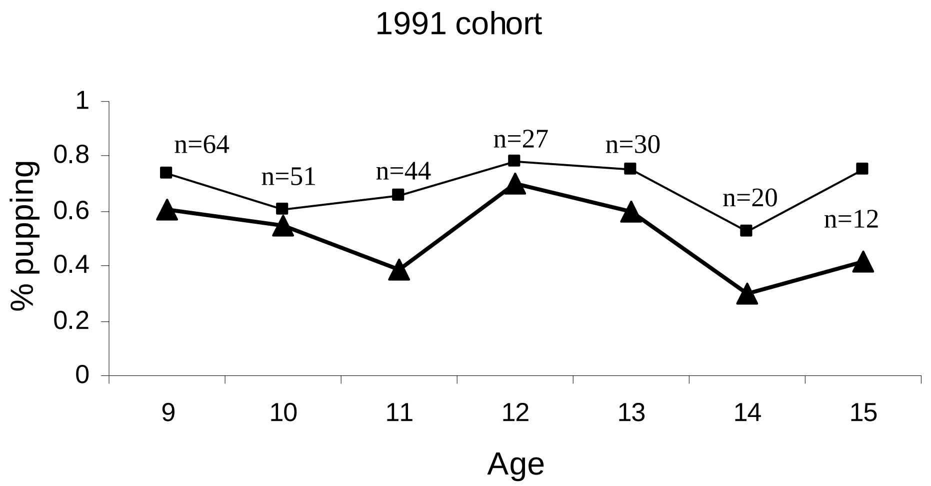


Figure 7: Maximum and minimum estimates of pupping rate for females tagged as pups in 1991 resighting between 2000 and 2006. Sample sizes shown as n=#.

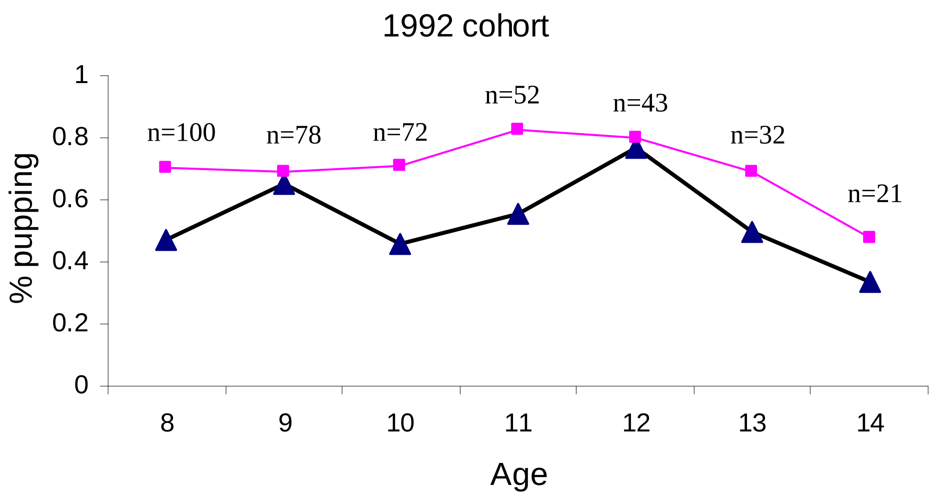


Figure 8: Maximum and minimum estimates of pupping rate for females tagged as pups in 1992 resighting between 2000 and 2006. Sample sizes shown as n=#.

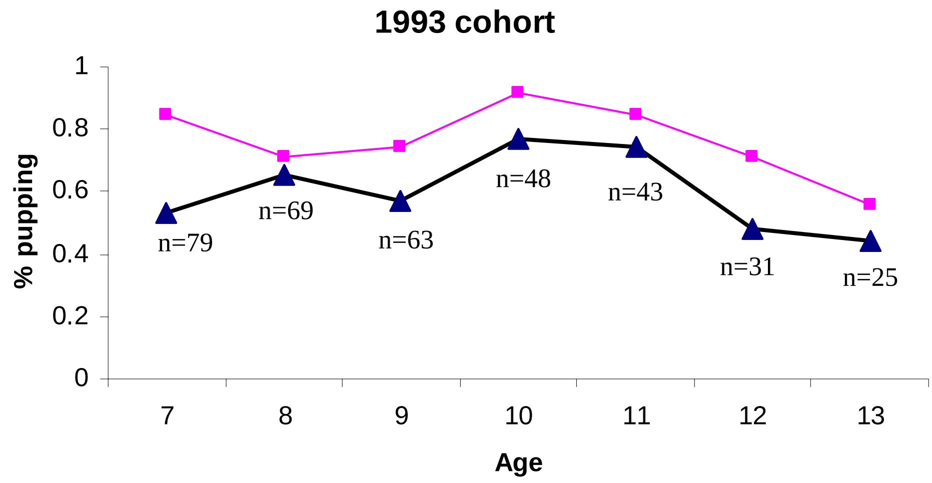


Figure 9: Maximum and minimum estimates of pupping rate for females tagged as pups in 1993 resighting between 2000 and 2006. Sample sizes shown as n=#.

The dropping pupping rate for all of these cohorts is likely to be due to the aging of these cohorts. The occurrence, and if it occurs, timing of reproductive senescence in otariids varies between species. It has been reported to occur as low as 12 years of age (Bester 1995), while others report declines in reproductive rates at beyond 15 years of age (Boyd *et al.* 1995). NZ sea lions are recorded to have pupped up to the age of 18, however there does appear to be a sharp decline in the number of females pupping after the ages of 12 to 13 years (Childerhouse unpublished). Understanding if and when senescence occurs and the drop off of pupping for older females has significant management implications as it will help define the limit of females NZ sea lions reproductive period which will led to a better understanding of the number of reproductive outputs possible per individual female.

*Recruitment of females to breeding population*

The five fully tagged cohorts of maturing females that were tagged as pups between the 1998 and 2002 seasons provide the recruitment data for female NZ sea lions (Table 8 & 9). No known-age three year old female has given birth on the northern Auckland Island breeding areas. This year no known-age four year old pupped either. Table 8 shows female cohort year (the year they were born and tagged), the year in which the observations of their pupping and survival were made (year of recruitment), their age in this year, the number of females that were confirmed to pup from that cohort in that year, the number of females observed to be alive in that year and therefore the estimate of the percentage of female from that cohort known to be alive that pupped in that year. These estimates of percentage pupped in the year of recruitment from Table 8 are considered maximum estimates that will decrease each season as more females from those cohorts are identified as being alive, therefore reducing the known-to-bred to known-to-be-alive recruitment ratio. This is a critical reason for the continued intensive resighting protocol of this research because as resighting continues the accuracy and precision of all demographic parameters will increase with greater understanding of how many animals are alive. Table 9 gives examples of the greater accuracy that can be obtained through a more precise known-to-bred to known-to-be-alive recruitment ratio. Table 9 shows the same columns as in Table 8, plus the minimum number of females known to have been alive in year of recruitment when taking into account the resightings from year of recruitment through to 2006, and therefore allows the calculation of a more precise percentage pupping. The most dramatic examples of the differences seen in precision of estimated pupping rates with concurrent years data are for the oldest cohort as the greatest number of years of resightings have been collected. For example for the 1998 cohort as four year olds their estimated percentage pupped was 5% at year of recruitment but drops to 1.7% in 2006 after three more years of resighting, similarly as five year olds their percentage pupped drops from 17.6% to 5.7% and as six year olds from 42.9% to 14.6%. The figures for this cohort, 1998, are considered to have large errors and may not represent the true recruitment or population demographics of the NZ sea lion population due to high early mortality of this cohort as pups (>50% pup mortality in the first 3 months of their life), resulting in a small sample size and therefore larger errors for any demographic estimates. However similar types of drops in pupping percentage are also seen in the following cohort with the most notable being the difference as 5yr olds with the pupping percentage at year of recruitment being 40% of all known individuals which dropped to 27.5% given two more years resighting data.

Table 8. Cohort, year of recruitment, age, number of individuals known to have pupped, maximum observed numbers of female NZ sea lions in year of recruitment and estimation of percentage pupping in year of recruitment.

| Cohort: Year born & tagged | Year of Recruitment | Age | Number with a pup in year of recruitment | Number observed alive in year of recruitment | Percentage pupping calculated at year of recruitment % |
|---|---|---|---|---|---|
| 1998 | 2002 | 4 | 1 | 20 | 5.0 |
| 1998 | 2003 | 5 | 3 | 17 | 17.6 |
| 1998 | 2004 | 6 | 6 | 14 | 42.9 |
| 1998 | 2005 | 7 | 5 | 16 | 31.2 |
| 1998 | 2006 | 8 | 4 | 13 | 30.8 |
| | | | | | |
| 1999 | 2003 | 4 | 0 | 51 | 0.0 |
| 1999 | 2004 | 5 | 14 | 35 | 40.0 |
| 1999 | 2005 | 6 | 19 | 50 | 38.0 |
| 1999 | 2006 | 7 | 17 | 41 | 41.5 |
| | | | | | |
| 2000 | 2004 | 4 | 2 | 34 | 5.9 |
| 2000 | 2005 | 5 | 13 | 37 | 35.0 |
| 2000 | 2006 | 6 | 18 | 37 | 48.6 |
| | | | | | |
| 2001 | 2005 | 4 | 7 | 54 | 13.0 |
| 2001 | 2006 | 5 | 12 | 54 | 22.0 |
| | | | | | |
| 2002 | 2006 | 4 | 0 | 37 | 0.0 |

Table 9. Cohort, year of recruitment, age, number of individuals known to have pupped, maximum observed numbers of female New Zealand sea lions in year of recruitment and revised known to be alive numbers up to and including 2006 observations, and therefore estimation of percentage pupping in year of recruitment and revised pupping percentage estimates for numbers known to be alive up to and including 2006.

| Cohort: Year born & tagged | Year of Recruitment | Age | Number with pup in year of recruitment | Maximum number alive in year of recruitment | Minimum number known to have been alive in year of recruitment when considering sightings up to 2006 | Percentage pupping calculated at year of recruitment % | Percentage pupping calculated at 2006 % |
|---|---|---|---|---|---|---|---|
| 1998 | 2002 | 4 | 1 | 20 | 60 | 5.0 | 1.7 |
| 1998 | 2003 | 5 | 3 | 17 | 53 | 17.6 | 5.7 |
| 1998 | 2004 | 6 | 6 | 14 | 41 | 42.9 | 14.6 |
| 1998 | 2005 | 7 | 5 | 16 | 28 | 31.2 | 17.9 |
| 1998 | 2006 | 8 | 4 | 13 | 13 | 30.8 | 30.8 |
| | | | | | | | |
| 1999 | 2003 | 4 | 0 | 51 | 68 | 0.0 | 0.0 |
| 1999 | 2004 | 5 | 14 | 35 | 51 | 40.0 | 27.5 |
| 1999 | 2005 | 6 | 19 | 50 | 54 | 38.0 | 35.2 |
| 1999 | 2006 | 7 | 17 | 41 | 41 | 41.5 | 41.5 |
| | | | | | | | |
| 2000 | 2004 | 4 | 2 | 34 | 43 | 5.9 | 4.6 |
| 2000 | 2005 | 5 | 13 | 37 | 42 | 35.0 | 30.9 |
| 2000 | 2006 | 6 | 18 | 37 | 37 | 48.6 | 48.6 |
| | | | | | | | |
| 2001 | 2005 | 4 | 7 | 54 | 61 | 13.0 | 11.5 |
| 2001 | 2006 | 5 | 12 | 54 | 54 | 22.0 | 22.0 |

**Summary**

Overall, the trip was a success with all work accomplished effectively and safely. We are grateful to Southland Conservancy and the Southern Islands Area for excellent logistics support. I would also like to thank Otago Conservancy Office and Southern Islands area office for allowing Jim Fyfe and Gilly Adams to assist with field work this season, their help was invaluable. We also thank Conservation Services Programme (CSP), the Squid Fishery Management Company and Department of Conservation for funding the programme.

This season saw the lowest NZ sea lion pup production estimate in 12 years for the Auckland Island colonies with total pup production at 2089 pups (Fig. 2, Table 2). This supports last years findings and the growing evidence that there is a drop in numbers and reproductive ability of breeding age female NZ sea lions and overall decreasing population. This evidence includes the results shown here that all tagged cohorts that breed this season 1987 to 2001 showed equal or dropping total numbers of females observed at the breeding area and for all of the major breeding cohorts (7 years +), the number of females confirmed to have pupped has also dropped. For the 1998 and 1999 cohorts which were aged 7 and 8 this season, their numbers both observed and breeding should be increasing from one year to the next as their cohort recruits and begins to fully breed, the reverse was seen this season. The dropping number of pups produced at the two Auckland Island breeding areas suggests that the other breeding area for NZ sea lions, Campbell Island, needs to be re-surveyed to access the status of pup production there.