Research to assess the demographic parameters of New Zealand sea lions, Auckland Islands: Draft Final Report November 2011 Contract Number: POP 2010/01

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Abstract

The New Zealand sea lion (NZ sea lion), *Phocarctos hookeri*, is New Zealands' only endemic pinniped. It is classified as Nationally Critical (Baker et al. 2010) and is estimated to be the world's rarest sea lion (Geschke & Chilvers 2009). This report summarises the annual survey 2010-11 of the Auckland Island area with the objective to collect data to allow quantification and estimation of demographic parameters of all NZ sea lions from the Auckland Islands.

The pup production estimate for the Auckland Island NZ sea lion population in 2010-11 was 1550 ± 41, a decline on the 2009-10 estimate. 1550 is the second lowest pup production estimate ever recorded for NZ sea lions. Field sightings of previously tagged, branded and/or passive integrated transponder (PIT) tagged animals were collected and recorded. The NZ sea lion database has had the 2010-11 field season's data entered, checked and data extraction has occurred to allow for the estimation of survival of previously marked NZ sea lions and reproduction by known age female NZ sea lions.

1. Objectives

The objectives of the project were:

1. To collect field data that will allow quantification and estimation of:
   - pup production,
   - survival of previously marked New Zealand sea lions,
   - reproduction by known-age female New Zealand sea lions;
2. To maintain and update the New Zealand sea lion database; and
3. To make available field data for relevant modelling work;

Due to logistical constraints resulting in a change to the planned methodology for estimating pup production on Dundas Island this report also aims to determine if any correction factor needs to be applied to allow for direct comparisons to time series data.

2. Logistics

The scientific trip was split into two parts to allow changes in personnel: December 4th - January 10th, and January 10th - February 20th. The first science team comprised of three people: Nathan McNally (DOC, Otago), Elaine Leung (University of Otago) and Andy Maloney (Contractor). The second team comprised of six people: Louise Chilvers (DOC, MCT), Kerri Morgan (Massey University), Amelie Auge (Otago University), Chris Muller (Contractor), Myles Riki (DOC, West Coast Tai Poutini) and Dave Johnson (DOC, Te Anu). Transport during the season was aboard the

Tiama and Evohe under charter to DOC R&D. All personnel were accommodated in the Sandy Bay hut.

A logistical constraint on this year's work was that a strong SE storm on 17th January, which lasted 2 days, dumped a layer of kelp 30m wide and 1m deep on the Sandy Bay beach behind the NZ sea lion team's boats. The weather then turned strong westerly for two weeks with both conditions restricting boat use until the 6th February. Even after this date boat launching and retrieval took all six field team members and could not be guaranteed on any day. Therefore members of the NZ sea lion team could not be left on Dundas Island because there was no guarantee that the big boat could be launched to go and pick up the other team members. These conditions lead to the Dundas Island pup mark-recapture to take place on the 6th of February rather than 21st January.

3. Methods

3.1 Collect data and maintain NZ sea lion sighting database to make field data available to allow modelling to estimate survival and reproductive ability of previously marked NZ sea lions.

3.1.1 Marking

New Zealand sea lion pups have been tagged at one month of age as part of a demographics study since 1979/80 at Sandy Bay, 1985/86 on Dundas Island and 1992/93 at SEP. Tagging has been intermittent and the numbers of animals tagged annually have varied from 0 to over 500 since 1979/80. Between 1979/80 and 1992/93 flipper tags used were uniquely numbered Alflex laser-marked button tags (Alflex NZ Ltd, Palmerston North, NZ), tagged in the right pectoral flipper only. In the 1997/98 and 1998/99 seasons the same tags were used but animals were tagged in both pectoral flippers. Since 1999/2000, uniquely numbered Dalton DAL 008 Jumbotags® coffin-shaped tags with a different colour each year (Dalton Supplies Ltd, Henley-on-Thames, UK) have been used to tag animals in both pectoral flippers. During the 1999/2000 season 297 pups and 135 adult females from Sandy Bay were also hot-iron branded (Wilkinson et al. 2011). Between 1999 to 2003 and in 2010 and 2011 pups were also injected with individually identifiable passive integrated transponders (PIT, Trovan, Ltd., Douglas, United Kingdom).

3.1.2 Presence and breeding status of marked animals

Daily tag resightings were conducted at Sandy Bay between early December to at least the 14th February each season. Daily resighting took up to four people, five hours a day to complete. All other areas around Enderby Island were surveyed at least once a week during December and early January each season and then surveyed at least once every second day from late January until the end of the field season. Resighting were undertaken at Dundas Island on 6 February 2011 when field staff were on the island. Resightings consisted of the date and place of sighting, the animals tag number, colour, shape and number of tags in which flippers, PIT presence (therefore alphanumerical series) or absence, animal sex and breeding status or behaviour. PIT tag checking was undertaken throughout the season. Given the need for close approach to scan for PIT tags (~10cm), there was a higher likelihood of getting access to all animals after mid-January, because until then the animals in the harem were packed so tight, with large territorial males defending areas, that many animals could not be accessed. All animals, whether they have tags or not are checked for PIT tags by passing the PIT reader over the hind quarters of a sleeping or otherwise distracted animal.

3.1.3 Presence and breeding status of marked animals away from known breeding areas

Presence and breeding status data were collected opportunistically from marked animals at all sites outside the breeding sites around the Auckland Islands when researchers were travelling near these areas. This year due to the limited ability to use the research boats, only Kekeno was visited by the NZ sea lion team. However, Otago University visited the Auckland Islands between the 13th and 26th of January 2011 and surveyed Carnley Harbour, the many inlets on the east coast of the Auckland Island and Ross Harbour, looking for information on sea lion diet (therefore specifically looking for areas where sea lions inhabit), and provided data on any sightings they made (Kinsey 2011).

3.1.4 Update NZ sea lion sighting database

All sighting field data were verified, entered into the NZ sea lion database and data extracted for relevant modelling work. Data verification was performed both during the season and at the end of the season. End of season verification involved the following procedures:

- all data is sorted by individual animal (current tag) and duplications (same animal on the same date) deleted,
- number of tags checked and assessed (during the season if animals were still identified as having only one flipper tag seen, notification was given to field staff to try and determine true tag number while the team were still in the field),
- colour and tag number matches checked,
- previous and original tag information entered where necessary for adult females, and
- class, tag year, age, tag location and status entered for all animals.

3.2 NZ sea lions pup production

There are two pupping areas (Northern Auckland Islands and Figure of Eight Island) at the Auckland Islands (Figure 1). Pups are born at Sandy Bay (50°30'S, 166°17'E) and South East Point (SEP) on Enderby Island (50°30'S, 166°19'E), Dundas Island (50°35'S, 166°19'E, Figure 1) and Figure of Eight Island (50°46'S, 166°01'E). Pup production at SEP and Figure of Eight Island was estimated using direct counts, whereas at Sandy Bay and Dundas Island the primary estimation method was a mark-recapture (M-R) estimate. For Sandy Bay, the M-R procedure was consistent with previous methodology (Chilvers 2011). Due to adverse weather conditions and the inability to move the transport boats from the Sandy Bay beach for several weeks, the Dundas M-R was undertaken on the 6th of February (rather than the planned date of 21st January), the M-R was undertaken in one day rather than over two days and two mark-recapture counts by three people were undertaken rather than three counts by each people. Methods used to determine if any correction factor must be applied to allow for direct comparisons to time series data are outlined in section 3.2.3.

3.2.1 Direct counts

Direct counts were conducted at SEP using surveys during the breeding season (December 4th to January 20th). SEP is a small, open, rocky coastal area which is easily surveyed. All counts were conducted from the rocky beach margin, with hand tally counters and counts recorded. Pup production was based on the counts of live pups and the cumulative total of dead pups (Gales & Fletcher 1999; Chilvers et al. 2007).

The remote location of Figure of Eight Island (over 60 km south of Enderby Island) prevented multiple visits during a season. Pup production was based on the mean of separate counts conducted by three people around the entire island made on a single day on the 10th of January.

Pups were also counted at Kekeno on the main Auckland Island (6th February 2011). Reports of any pups were sought from albatross researchers based at Adams Island in Carnley Harbour and Carnley Harbour and East Coast inlets (Figure 1) by researchers on the Otago University boat the Polaris (Kinsey 2011).

3.2.2 Mark-recapture experiments

A single M-R experiment was conducted at Sandy Bay on the 16th January 2011 and at Dundas Island on the 6th February 2011. Pups were marked with circular, 5 cm-diameter, flexible vinyl discs that were glued to the crown of their heads with a fast-setting cyanoacrylic glue (Loctite 454). The number of pups marked was approximately 40% of previous pup production estimate at Sandy Bay (148 pups marked) and 20% at Dundas Island (199 pups marked). Marking was spread as evenly as possible through the breeding area (based on pup density and distribution). Most discs were shed a few days to weeks after the experiment. Recaptures involved three observers moving systematically through the entire sea lion pupping area counting pups, with each observer conducting two or three replicate counts. Each pup was classified as either marked or unmarked and a tally of each was maintained by each observer using two hand-tally counters. Only pups where the entire head was visible were included in the counts, to minimise the risk associated with undercounting unmarked pups. As the discs were clearly visible on the heads of pups if only part of the head is viewed there is a greater probability that a marked pup would be correctly identified than an unmarked pup. Any greater probability of viewing marked caps would lead to an overestimate of the proportion of marked pups and underestimate of pup production. Consequently, any pups that could not be categorised as marked or unmarked, i.e., where the entire head was not visible, were excluded from the count.

The mark-recapture methodology at Dundas Island differed from that used in previous years (e.g. Chilvers 2011) in that it was completed on February 6th, 16 days later than planned. The logistical constraints meant no team could be left on Dundas Island over night for safety reasons. This meant no pups were tagged on Dundas Island, the mark-recapture was conducted on a single day rather than over two days, approximately 200 caps were placed out on pups rather than 400 and three people completed two recapture counts each rather than three.

Results of each recapture were used to calculate a modified Petersen estimate (Chapman 1952) of pup production P_i namely

$$P_i = \left[\frac{(M+1)(C_i+1)}{(R_i+1)} \right] - 1$$

where, for replicate i, M is the number of previously marked sea lion pups, C_i is the number of pups examined in the recapture sample, and R_i is the number of marked pups in the recapture sample. The overall estimate of pup production, P, is the mean of the Q individual estimates, i.e.,

$$\overline{P} = \frac{\sum_{i=1}^{Q} P_i}{\mathrm{Q}}$$

The standard error, of P was calculated directly from the individual estimates (Chapman 1952), as:

$$SE = \sqrt{\frac{1}{Q(Q-1)} \sum_{i=1}^{Q} (P_i - \overline{P})^2}$$

(consistent with previous methodology Gales & Fletcher 1999, Chilvers et al. 2007, Chilvers 2011).

The standard error for the total Auckland Island pup production estimate is calculated as:

$$SE_{Total} = \sqrt{SE_{SandyBay}{}^2 + SE_{Dundas}{}^2} + SE_{FigureofEight}{}^2$$

The assumptions for the M-R model were:
(1) all pups were born by mark-recapture dates;
(2) all pups were accessible for marking (i.e., capture probability was constant);
(3) all pups were mobile and mixed well after being marked;
(4) marks were not lost before M-R counts; and
(5) mortality was negligible and assumed to be zero in the time between marking and recapturing.

Numbers of pups known to have died up to the date of the M-R estimate were then added to produce a figure for total pup production (Chilvers 2011). All pups that died during the breeding season from Sandy Bay were counted and removed on a daily basis for autopsy, which resulted in the accurate assessment of numbers of dead pups from this site. For Dundas and Figure of Eight islands, dead pup numbers were estimated by counting all visible pup carcases the day of pup production estimate. Carcases were counted by up to four observers systematically covering the islands at the same time calling out and identifying carcases, so as not to overlap observer search areas, with one observer using a hand counter to tally the total carcase count.

To determine the accuracy of the mark-recapture procedure for NZ sea lions, mark-recapture estimates at Sandy Bay were validated by comparing the mark-recapture estimate taken at Sandy Bay with the number of pups flipper tagged at Sandy Bay as all live pups were tagged using coffin shaped Dalton DAL Jumbotags® (Dalton Supplies Ltd, Henley-on-Thames, United Kingdom) within 2 days of the mark-recapture.

4. Results

4.1 Collect data and maintain NZ sea lion sighting database to make field data available to allow modelling to estimate survival and reproductive ability of previously marked NZ sea lions.

4.1.1 Marking

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. All live pups at Sandy Bay (360 by the 17th January) were tagged with yellow 'coffin' shaped Dalton 'Jumbo' tags with a letter and three-digit number combination. One month after tagging there was no tag loss recorded for any pup at Sandy Bay. The 360 pups at Sandy Bay were also PIT tagged. Thirty one pups were tagged on Figure of Eight Island with orange coffin shaped Dalton 'Jumbo' tags. No pups were tagged at Dundas Island due to the logistical constraints described previously.

4.1.2 Sea lion counts

Daily counts of pups and adults (live and dead) were made from 4th December to 20th January at Sandy Bay at 9.30am each morning. Similarly, daily counts were made at South East Point from 4th December to 27th December, there after every second day until the 20th January and then a minimum of once a week. Counts were made at approximately one week intervals at East Bay and other areas around Enderby Island. Figure of Eight Island was counted on January 10th. Two researchers studying Albatross were located on Adams Island, Carnley Harbour during the same six week season (G. Elliot, K. Walker pers. comm.). Reports from this area yielded no tag resights and no sign of breeding. The Otago University boat the Polaris spent 10 days (15th January to 24th

January 2011) travelling throughout the Auckland Islands (Carnley Harbour and East coast inlets) and reported no sign of (pups) breeding in any of these locations (Figure 1).

Sea lion counts at Figure of Eight Island were 34 females, 17 males and 71 live and 8 dead pups on the 10th of January 2011.

4.1.3 Resighting of previously marked individuals

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 survivability, recruitment and fecundity of animals. Field sightings of previously tagged, branded and/or passive integrated transponder (PIT) tagged animals were collected and recorded. All relevant data has been entered into the NZ sea lion database, checked and data extraction has occurred to allow for the estimation of survival of previously marked NZ sea lions and reproduction by known age female NZ sea lions. Approximately 7538 resights made on 1125 animals previously tagged or branded (including 278 individuals identified from a PIT) were collected from Enderby Island. Five resights were collected from Dundas Island and three from Figure of Eight Island. Animals were checked at Kekeno on the main Auckland Island, however no tagged or branded animals were seen.

4.2 NZ sea lion pup production and mortality

Estimates of pup production were calculated for each breeding sites in the Auckland Islands between 10 January to 6 February (Tables 1 and 2, Figure 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 1550 ± 41 for 2011 (Figure 2).

On the 16th of January, the mark-recapture estimate at Sandy Bay was undertaken. The mark-recapture estimated 359 pups ± 7, there were 19 dead pups at that date giving a total pup production of 378 ± 7. 360 pups were tagged by the 17th of January. Comparison between M-R estimates and absolute pup numbers tagged on Sandy Bay showed a difference of 1 pup, demonstrating the accuracy of M-R methods for estimating pup production at colonial beach breeding sites (such as Dundas Island).

The mark recapture estimate at Dundas Island was completed on 6th February. The mark-recapture estimated 944 live pups ± 40 and 137 dead pups were counted giving a total estimate of 1081 ± 40 pups on the island. The area closest to Dundas Island where females and pups are known to swim to as pups get old enough (Kekeno), was visited on the same day as the mark-recapture on Dundas Island and eight pups were recorded, therefore these pups were added to the alive pup count of Dundas Island, giving a total estimate of 1089 ± 40. Note, there has never been any evidence of females pupping at this site which is why these pups are assumed to be from Dundas Island and are added to the Dundas Island count. No pups were tagged on Dundas Islands.

All M-R assumptions were believed to be met for this mark-recapture: (1) all pups were born by mark-recapture dates (given this assumptions stands for 16 days earlier in the season it is assumed to stand on the 6th of February); (2) all pups were accessible for marking; (3) all pups were mobile and mixed well after being marked (pups were very mobile and mixed well on the day (Figure 5), the dead pup count was conducted between the pups being marked and the recapture counts being undertaken so there was time for pup mixing to occur – approximately 2 hours);(4) marks were not lost before M-R counts (no marks were known to be lost during M-R counting); and (5) mortality was negligible and assumed to be zero in the time between marking and recapturing.

A direct count at Figure of Eight Island was made on the 10th January. 71 pups ± 2 + 8 dead pups were counted giving a total of 79 ± 2 pups.

Direct counts conducted up to and including the 15th of January at South East Point recorded 4 pups (2 confirmed dead, two absent) giving a total pup production estimate of 4 pups.

Pup mortality during the first 4 weeks of the 20010/11 season from Sandy Bay was 5% as of the 16th January (Table 2), by the 15th of Feb it was 8%.

The estimate of pup production from the Auckland Islands was 1550 ± 41, 15% lower than 2009/10 (Figure 2).

5. Discussion

There were differences in methodology between the 2009-10 and 2010-2011 Dundas mark-recapture experiments: 1) the mark-recapture was undertaken on the 6th February, 16 days later than planned; 2) the mark-recapture estimate was undertaken on one day not two; 3) approximately 200 caps and not 400 were placed on pups and 4) three people completed two recapture counts rather than three each. These factors could result in a negative or positive bias and could be expected to result in decreased precision of the pup production estimate for Dundas Island in 2010-2011.
A negative bias could arise through emigration of pups from Dundas after the peak pupping (i.e. because the mark-recapture was undertaken 16 days later than planned). A negative or positive bias could arise from incomplete mixing of tagged animals within the population, and reduced precision could be caused by the lower number of marked animals within the population and lower repetition by each person counting.

5.1 Emigration of pups

There are three sources of information relevant to assessing whether the Dundas pup production estimate is negatively biased by emigration of pups away from Dundas after peak pupping.

Gales and Fletcher (1999) describe pup counts over time at three breeding sites, and provide strong evidence that the pup numbers for SEP and Sandy Bay, Enderby Island drop after January, because pups are taken by their mothers up into the surrounding bush (therefore are difficult to count as they are hidden in the bush). No evidence was presented to show a significant drop in pup numbers at Dundas, and, given the differences between the sites, there is no evidence to suggest the pattern described for Enderby applies at Dundas. In fact Gales and Fletcher (1999) note that "Cows and pups moved into the surrounding rata forest and grasslands at the two Enderby Island colonies and those on Dundas Island moved more widely over the entire island", i.e. they did not point to movement of pups off the island.

The area closest to Dundas Island where females and pups are known to swim to as pups get to two or three months of age (Kekeno) had 8 pups found on the same day as the mark-recapture on Dundas Island. This indicates that mother pup movements away from Dundas Island had been very low or only just begun. This would have been expected as the weather conditions between 17th January and the 6th February had been exceptionally bad (even for the sub-antarctics) and would reduce females taking their pups to water as there would be a higher likelihood of them drowning. This emigration of 8 pups would cause a negative bias to the Dundas pup production estimate, so to counter this bias the total pup production estimate for Dundas was increased by 8 to include the pups counted at Kekeno. No untagged pups, or mother and pup pairs had been observed at Sandy Bay or any other area near Dundas at or on the 6th February. Dundas Island sits 2 Nm from the main

Auckland Island where the volcanic habitat makes it almost impossible for adult female NZ sea lions, let alone pups, to climb up rock platforms and cliffs to get to shore, except at areas like Kekeno.

From mark-recapture estimates of pup production conducted on Dundas Island during the 2001/02 season on the 21st, 23rd, 25th, 27th and 29th of January (previously unpublished) no downward trend was observered (Figure 3, Raw data available in Appendix 3 Results: 21st 1395 + 361 dead = 1756 ± 31; 23rd 1468 + 366 dead = 1834 ± 44; 25th 1474 + 366 dead = 1840 ± 27; 27th 1459 + 395 dead = 1854 ± 30; 29th 1495 + 395 dead = 1890 ± 47). All mark-recapture methodology of the mark-recaptures were the same as Chilvers (2011), apart from the differences in date and on the 21st four people did two counts each, while on the 25th two people did four counts each rather than 3 people doing 3 counts each. These mark-recapture comparisons show that mother and pup movements from Dundas Island did not occur in any significant numbers any time between 21th to 29th January. This finding is supported by observational data as the NZ sea lion team has had team members living out on Dundas Island during the 01/02, 04/05, 05/06 and 06/07 season until the 2nd of February, during which times females and pups were observed leaving Dundas Island only in ones or twos on fine days (which is consistent with the observation of 8 pups being recorded at Kekeno this season).

Other than adjustments for the limited dispersal of pups to other areas, as applied, none of this evidence supports the hypothesis that the pup production estimate obtained was negatively biased.

5.2 Mixing of marked and unmarked pups

All pups were very mobile and mixed well after being marked (Figure 5). This is the first contact these pups had had with humans and were moving and mixing due to our presence, our marking of them and our walking around the island to undertake the dead pup count. The dead pup count was conducted between the pups being marked and the recapture counts being undertaken so there was time for pup mixing to occur – approximately 2 hours. The active mixing observed, combined with the small size of the island, suggest this aspect of the applied methodology is unlikely to result in either a negative or positive bias, and if a bias is present, there is no clear information on whether that bias would be negative or positive.

5.3 Reduced precision due to lower number of marked animals within the population and lower repetition by each person counting.

The standard error of the 2010/11 Dundas Island estimate (1089 ± 40**)** is of similar magnitude to previous years indicating that the lower number of animals marked and lower number of recapture counts did not affect the precision of the estimate (Table 1).

5.4 Relative pup production and mortality between sites.

The number of dead pups counted on Dundas Island on the 6th February is a similar proportion of estimated pup production to the proportion of dead pups counted relative to the pup production estimate for Dundas in 2009/10 (11% dead 2010 vs 12.7% dead 16 days later in 2011). A similar proportion of mortality was also seen on Enderby Island and trends across both islands, although highly variable between years, have been similar for the last 17 years except in the mass mortality year 1998 (Figure 4). Together these indicate that there was no mass dispersal of live pups from Dundas in 2011 which would have resulted in a much higher ratio of dead to remaining live pups.

The trend of pup production between Enderby and Dundas Islands (Figure 6) shows a steady downward trend over the last decade. It is not unusual for the Dundas and Enderby pup production estimates to differ from year to year. There have been several instances during the time series 1995

to 2011 when Enderby and Dundas pup production trends have shown opposite trends with one island showing an increase or stable trend while the other showed a decline (e.g. between 1997-98, 2000–01 and 2003–04). In 2011 both islands show the same trend of a decrease. The decrease at Dundas is larger than at Enderby, but as shown in Figure 6, the differences in trends between islands have historically been greater (e.g. between 2001 – 2002 & 2004 - 2005). To investigate these trends between sites further, the ratio of pup production between Dundas and Sandy Bay, Enderby is plotted in Figure 6b. Whilst a clear decline in ratio is seen between 2010-11, changes of similar magnitude (both negative and positive) have been observed previously (1997, 1998 & 1999 and 2001, 2002 & 2003). There is also some indication of an apparent trend in declining ratio since 1998.

It is clear that year to year differences in pup production and mortality are not closely mirrored between Dundas and Enderby, but both sites show trends of declining pup production. None of the information presented here on these year to year differences suggest that the Dundas pup production estimate is biased in comparison previous years.

6. Conclusion

From evaluating the information available and considering how pup production estimates at Dundas may have been biased negatively or positively due to the differing methodologies used in the 2010-2011 season, we conclude there is no evidence for a significant bias in the 2010-11 estimate. To further test the conclusion that the change in methodology this season did not result in a significant change to the total pup production estimate a comparative M-R estimates could be performed at Dundas on 21 January and 6 February 2012, or similar to Wilkinsons' 2002 experiment, several M-R experiments could be undertaken across this time period. Both of these research proposals would be highly weather dependant. In conclusion, the pup production estimate for 2011 is 1550±41, 15% lower than 2010.

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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
06/07	437	414	23	1693	1587	106	70	67	3	24	19	5
07/08	448 ± 5	425	23	1635 ± 44	1512	123	74 ± 1	72	2	18	13	5
08/09	301 ± 2	289	12	1132 ± 16	1065	67	54 ± 1	48	6	14	8	6
09/10	385 ± 6	364	21	1369 ± 35	1218	151	55 ± 1	48	7	5	1	4
10/11	**378** ± 7	**359**	**19**	**1089** ± **40**	**952**	**137**	**79** ± 2	**71**	**8**	**4**	**2**	**2**

* 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		12%	10%	n.a.
95/96	2685	2389	296	6.7%	11%	8%	n.a.
96/97	2975	2729	246	10.8%	8%	7%	n.a.
97/98	3021	2350	671	1.5%	22%	2%	42%
98/99	2867	2572	295	-5.1%	10%	8%	9%
99/00	2856	2689	167	-0.4%	6%	5%	11%
00/01	2859	2468	391	0.1%	14%	6%	10%
01/02	2282	1826	456	-20.2%	20%	21%	33%
02/03	2518	2078	438	10.3%	17%	16%	21%
03/04	2515	2347	168	-0.1%	7%	8%	15%
04/05	2148	2034	114	- 14.6%	5%	7%	12%
05/06	2089	1807	282	- 2.8%	14%	9%	16%
06/07	2224	2087	137	6.4%	6%	5%	16%
07/08	2175±44	2022	153	-2.3%	7%	5%	14%
08/09	1501±16	1410	91	- 31%	6%	4%	12%
09/10	1814±36	1631	183	20.8%	10%	5%	15%
10/11	1550±41	1384	166	-14.6%	11%	5%	8%
Actual number of pups recorded as dead 10/11					166	19	30

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

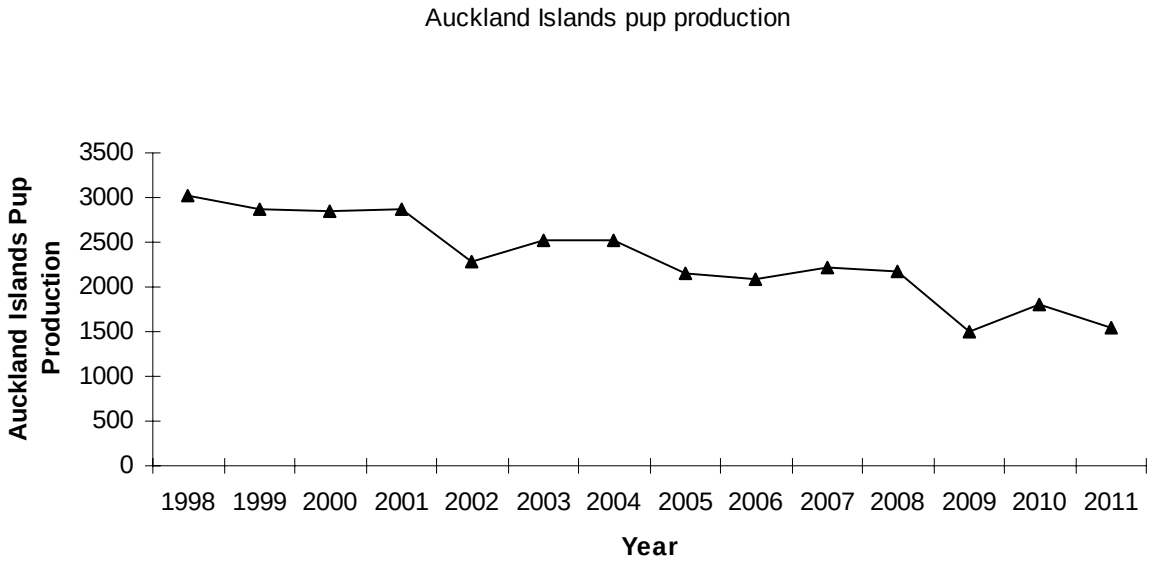

Figure 2. Annual pup production for the Auckland Islands 1998/99 to 2010/11.

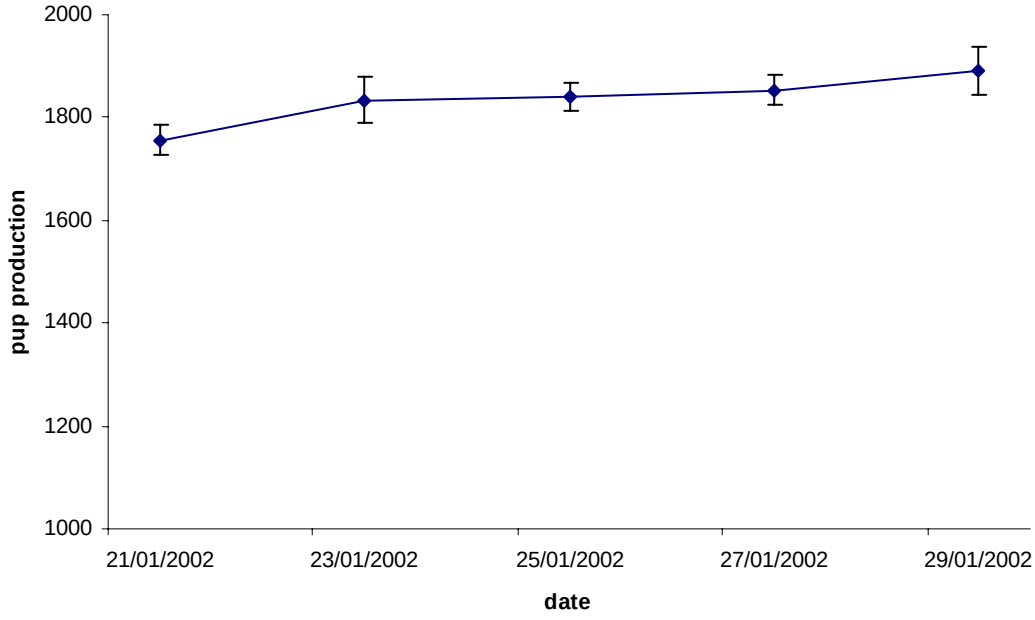

Figure 3. Results of mark-recapture estimates undertaken at Dundas Island between 21/1/2002 and 29/1/2002. M-R estimates ± s.e.

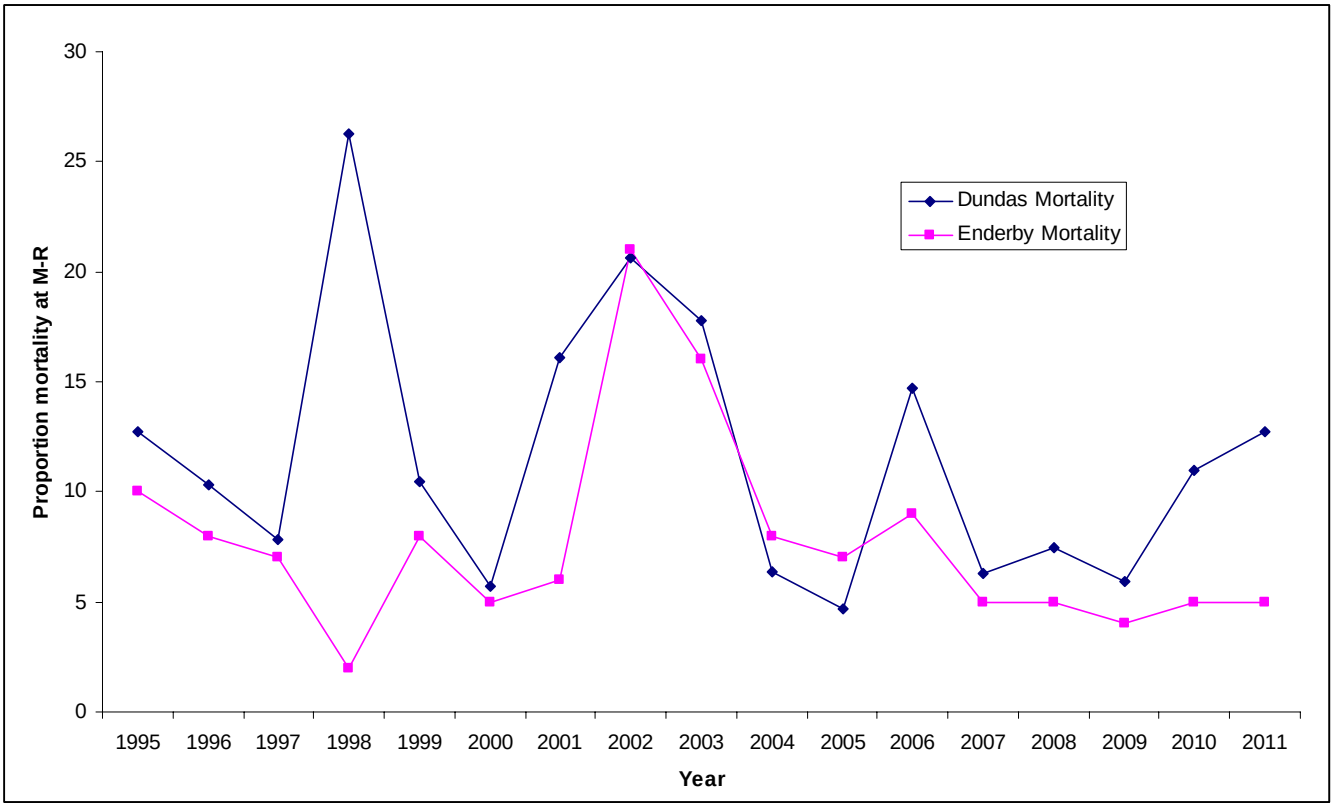

Figure 4. Proportion of pup mortality at when mark-recapture estimates are made annually 1995 to 2011.

Figure 5: Mobile and mixing NZ sea lion pups 6th February, Dundas Island

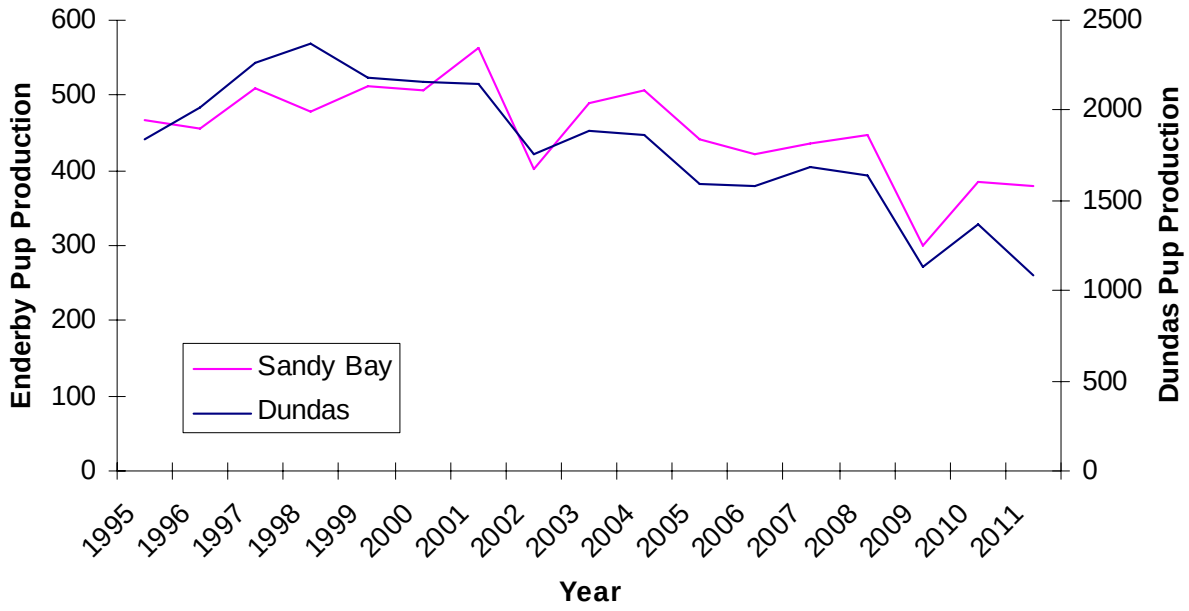

Figure 6a. Dundas and Enderby Island pup production mark-recapture values from 1995 to 2011.

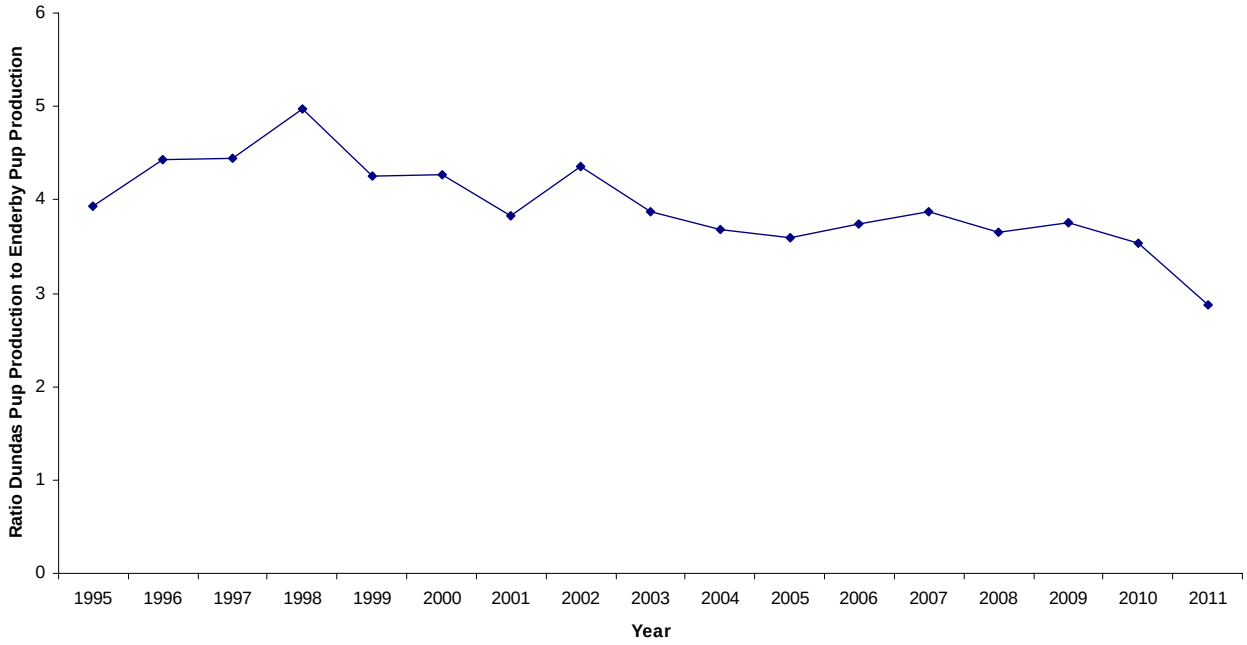

Figure 6b. Ratio of pup production between Dundas and Sandy Bay, Enderby Island

Appendix 1 Raw mark-recapture values (for Sandy Bay and Dundas) and direct counts (for Figure of Eight) for the 2010/11 season

	2010/11	
Sandy Bay	Marked	Unmarked
Pups capped / marked	148	
Counter 1a	56	87
1b	57	93
1c	68	82
Counter 2a	58	76
2b	62	94
2c	63	101
Counter 3a	94	121
3b	87	123
3c	92	131
Dundas		
Pups capped / marked	199	
Counter 1a	70	244
1b	100	379
Counter 2a	82	376
2b	98	371
Counter 3a	134	411
3b	117	453
Figure of Eight	Alive	Dead
Count 1	74	8
Count 2	72	8
Count 3	66	

Appendix 2 Raw mark-recapture values for two Dundas estimates undertaken on the 13th and 21st of January 2010.

	2010/11	
Dundas 13th January 2010	Marked	Unmarked
Pups capped / marked	389	
Counter 1a	238	475
1b	240	509
1c	241	468
Counter 2a	241	518
2b	202	382
2c	133	283
Counter 3a	152	352
3b	159	367
3c	179	382
Dundas 21st January 2010		
Pups capped / marked	389	
Counter 1a	127	238
1b	96	183
1c	72	175
Counter 2a	249	572
2b	227	552
2c	213	536
Counter 3a	181	359
3b	207	382
3c	167	332

Appendix 3 Raw mark-recapture values (for Dundas Is) undertaken during the during the 2001-02 season between the 21st and 29th of January.

Dundas 21 January 2002	Marked	Unmarked
Pups capped / marked	394	
Counter 1a	275	754
1b	257	653
Counter 2a	293	737
2b	282	599
Counter 3a	277	706
3b	250	711
Counter 4a	236	624
4b	228	547
Dundas 23 January 2002		
Pups capped / marked	396	
Counter 1a	237	561
1b	248	685
1c	255	675
Counter 2a	225	680
2b	204	683
2c	238	693
Counter 3a	230	580
3b	245	581
3c	246	603
Dundas 25 January 2002		
Pups capped / marked	399	
Counter 1a	268	619
1b	256	671
1c	242	658
1d	255	656
Counter 2a	265	778
2b	264	738
2c	266	745
2d	260	735
Dundas 27 January 2002		
Pups capped / marked	396	
Counter 1a	279	731
1b	270	709
1c	254	715
Counter 2a	255	718
2b	247	732
2c	244	737
Counter 3a	237	567
3b	219	560
3c	237	565
Dundas 29 January 2002		
Pups capped / marked	395	
Counter 1a	265	695
1b	224	684
1c	239	740
Counter 2a	245	749
2b	240	768
2c	255	755
Counter 3a	232	540
3b	249	568
3c	234	584

Appendix 4. Response to feedback from the CSP Technical Working Group[1]

Comment	Response
Comments from SeaFIC, 7 July 2011	
Reported uncertainty on total pup production is misleading as it does not include uncertainty arising from the timing of mark-recapture experiments	The pup production estimate for NZ sea lions at the Auckland Islands is made at similar times of the year, each year, at each site, weather and logistics permitting. For Enderby Island, it has been documented that soon after the current pup production mark-recapture date, pups disperse widely with their mothers up into the sward and rata forest, making them difficult to find and mark on the 710 ha island. This indicates that the results on Enderby Island are sensitive to the timing of this mark-recapture. The review in this paper of information relevant to the influence of timing on the 2011 Dundas pup estimate found no evidence that the change in timing significantly influenced the pup production estimate, so no additional uncertainty was included in the reported values.
Pg 5 number of pups marked in mark recaptures	The number of caps put out in the 2011 mark-recapture was corrected to 148 and 199 as shown in Pg 13
Pg 5 Equations	= changed for +, subscripts added and equation for total SE added
Changes to figures in tables	Changes made including data starting from 1995, correcting Sandy Bay alive pup number
Breen should not be acknowledged	Thanks to Paul Breen for reviewing pup production estimates in previous years has been removed from acknowledgements at this request. SeaFIC / Paul Breen were provided with the marked/unmarked data from 2005 through to 2011 and Paul Breen provided independent estimates of pup production and their standard error. Reported values were amended where inconsistencies were found.
Suggestion that no inference about dispersal can be made from the proportion of dead pups because of natural high variability in pup mortality	See Figure 4 – the proportion of mortality on Dundas across the last 17 years (except 1998 which was a mass mortality year) has shown similar trends to Enderby Island including the 2010 and 2011 years. Therefore, although there is high variability between years at both islands, the proportion of dead pups is an indicator that there was no mass dispersal of live pups from Dundas in 2011 because it shows a similar trend to Enderby.
Suggestion that only 8 pups at Kekeno gives no indication how many animals had dispersed or where they went	The geology of the near by Auckland Islands from Dundas Island is volcanic with many steep sided coastlines that restrict landings of NZ sea lion adults (let alone pups). There are very limited places female NZ sea lions and their pups can move to from Dundas Is – therefore from the years of work that has been undertaken in this area – the areas where mothers and pups may move to are well known and are few, with Kekeno being the main one. Also, as previously reported by Gales and Fletcher (1999), after peak pupping "Cows and pups …… on Dundas Island moved more widely over the entire island" not away from the island. Therefore having only 8 pups at Kekeno is a good indication that mother pup movements away from Dundas Island had been very low or only just begun.

[1] All feedback has been posted at http://www.doc.govt.nz/conservation/marine-and-coastal/commercial-fishing/marine-conservation-services/meetings-and-project-updates/21-june-2011/

Suggestion that the 2002 multiple M-R estimates shows limited change between 23 and 29 January but do not shed much light on how much dispersal would have occurred by 6 February	The 2002 mark-recapture estimates taken between the 21 and 29 January were undertaken as describe in this report, and are the best information available that investigate the possible changes in pup counts at Dundas in late January. These are mark-recapture counts – not direct counts, that are known to be far less accurate. As SeaFIC stated, the series of mark-recaptures show limited change in numbers and therefore clearly show that in 2002 the pup numbers at Dundas Island did not decrease during late January, indicating that this would also be the case this year as there is no known reason why this would have changed over time.
Additional information presented on pup counts at Sandy Bay by Wilkinson (2003)	The change in pup counts at Enderby Island over January and February are not comparable to Dundas as has been documented in Gales and Fletcher (1999), the Wilkinson 2002 data and this report.
Additional information presented on pup counts at Dundas - Wilkinson (2000)	The 2002 mark-recapture data supersedes the count and modelling data presented as Wilkinson (2000). This is one of the reasons Wilkinson undertook the collection of the 2002 mark-recapture data on Dundas to test his 2000 model predictions and he found them to be inaccurate for Dundas. Hence the Wilkinson 2000 data is no longer relevant to this discussion as it has been superseded and shown to be incorrect.
Suggestion that pup mixing was limited in the 2011 Dundas M-R experiment	See Figure 5 and updated text. All pups were very mobile and mixed well after being marked. This is the first contact these pups had had with humans and were moving and mixing due to our presence, our marking of them and our walking around the island to undertake the dead pup count. The dead pup count was conducted between the pups being marked and the recapture counts being undertaken so there was time for pup mixing to occur – approximately 2 hours.
Overall trends in pup counts at Enderby Is vs Dundas Is – need for objective discussion	See Figure 6 and discussion in main report (section 5.4).
Additional comments made at the CSP TWG meeting of 21 June 2011	
Was this the first year Kekeno had been counted for pups	No, resighting of animals is always attempted at Kekeno every year when possible, but not always on the same day each year. There has never been any evidence pups are born at Kekeno