

Final Report: New Zealand sea lion research at the Auckland Islands 2014/15

BPM-15-Final Report for NZ sea lion research at the Auckland Islands 2014-15 v2.2
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Table of Contents

1. Executive Summary	5
2. Methodology	6
3. Results	7
3.1 Logistics	7
3.2 General approach and timing of field work	8
3.3 Estimates of pup production	9
3.3.1 Sandy Bay, Enderby Island	9
3.3.2 Dundas Island	10
3.3.3 Figure of Eight Island	11
3.3.4 South East Point, Enderby Island	11
3.3.5 Total pup production for the Auckland Islands	12
3.4 Pup weights	12
3.5 Counts at Sandy Bay	13
3.6 Flipper tagging and microchipping	14
3.7 Resighting and management of mark data	14
3.8 Resighting effort	15
3.9 Pup mortality	16
3.10 Dundas Island follow-up trips	19
3.11 Mitigation of pup mortality in holes	19
3.12 Summary of other work	22
4. Issues for Future Consideration	22
5. Acknowledgements	24
6. References	24

List of Figures

Figure 1:	Map of the Auckland Islands showing sites mentioned in the text.	8
Figure 2:	Total estimated pup production for New Zealand sea lions at the Auckland Islands 1994/95 – 2014/15.	12
Figure 3:	Mean New Zealand sea lion pup weights for Sandy Bay colony by sex.	13
Figure 4:	Mean New Zealand sea lion pup weights for Dundas Island colony by sex.	13
Figure 5:	New Zealand sea lion counts at Sandy Bay, Enderby Island 2014/15.	14
Figure 6:	(a) Number of individual resighting records collected by the whole team per day; and (b) Total number of hours of resighting effort collected by the whole team per day in 2014/15.	16
Figure 7:	Daily and cumulative New Zealand sea lion pup mortality at Sandy Bay, Enderby Island 2014/15.	17
Figure 8:	Preliminary and provisional diagnosis (%) of cause of death of New Zealand sea lion pups at Sandy Bay, Enderby Island 2014/15 (n=59) to 25 March 2015.	18

Figure 9:	Preliminary provisional diagnosis of cause of death of New Zealand sea lion pups at Enderby Island by week.	18
Figure 10:	Figure of Sandy Bay showing locations of holes, ramps and movements of pups from the beach across the sward.	21
Figure 11:	Overview of GoPro and trail camera set up at ramp 10B.	21
Figure 12:	Trail camera with infrared flash at night image of pup escape on ramp 10B.	22
Figure 13:	GoPro daytime image of pup escape on ramp 10B.	22

List of Tables

Table 1:	Summary of New Zealand sea lion pup production estimates for Sandy Bay for 2014/15.	9
Table 2:	Summary of New Zealand sea lion pup production estimates for Dundas Island for 2014/15.	10
Table 3:	Summary of New Zealand sea lion pup production estimates for Figure of Eight Island for 2014/15.	11
Table 4:	Summary of New Zealand sea lion pup production estimates for South East Point for 2014/15.	11
Table 5:	Summary of mean New Zealand sea lion pup weights for the Auckland Islands for 2014/15.	12
Table 6:	Summary of New Zealand sea lion resightings for 2014/15 for which identification was possible.	15

Appendices

Appendix 1:	Annual estimates of live, dead and total pup production for each colony and for total Auckland Islands pup production 1994/95 – 2014/15.	25
Appendix 2:	Annual estimates of total pup production for each colony and for total Auckland Islands pup production.	26
Appendix 3:	Raw data for pup production estimates for Sandy Bay, Dundas Island and Figure of Eight Island.	28
Appendix 4:	Description of breeding area searched during pup counts at Sandy Bay, Enderby Island	30
Appendix 5:	Direct counts made at Sandy Bay, Enderby Island.	31
Appendix 6:	Approximate location of where mark-recapture caps were put out on pups on Dundas Island	32
Appendix 7:	Recording of effort data for resightings.	33
Appendix 8:	Survey of mud holes and existing ramps at Sandy Bay, Enderby Island.	34
Appendix 9:	Survey of mud holes and ramps at Dundas Island, Auckland Islands.	41
Appendix 10:	Description and location of mud holes and ramps installed at Sandy Bay, Enderby Island 2015	48

1. Executive Summary

Blue Planet Marine (BPM) was contracted by the Conservation Services Programme (CSP) of the Department of Conservation (DOC) to provide services for the CSP Project New Zealand sea lion (NZSL) ground component 2014/15. The field component of the work was completed on 27 March 2015. This document represents the final report for the project and replaces all previous and preliminary reports for it. This report also includes components of work that were not funded by CSP but separately by DOC and WWF. They have been included here for completeness.

In summary:

- Pup production was estimated for NZSL colonies at Sandy Bay (n=286), Dundas Island (n=1,230), Figure of Eight Island (n=60) and South East Point (n=0); with total pup production for the Auckland Islands in 2014/15 estimated as **1,576**. This total represents an increase of one pup from the 2013/14 estimate from last season, and is the fourth lowest total pup production recorded for the Auckland Islands;
- With the exception of the Figure of Eight colony, estimates of pup mortality to the date of the pup production estimate are broadly comparable to previous 'non-epidemic' years. However, these figures do not represent full season surveys and are not directly comparable to data collected prior to 2012/13, and so should be viewed as a minimum. Pup mortality estimates are: Sandy Bay 2%, Dundas Island 5% and Figure of Eight Island 22%. This is the highest ever level of pup mortality recorded at Figure of Eight Island and is considerably higher than the long-term average annual mortality level of 9%;
- Mean pup weights at Sandy Bay were 4% and 5% lower than 2013/14 for males and females respectively. Mean pup weights at Dundas Island were 6% and 12% higher than 2013/14 for males and females respectively. Pup weights were undertaken at Figure of Eight Island for the first time and were very similar to those at Sandy Bay;
- Seven hundred and twenty nine pups were marked at the Auckland Islands including: Sandy Bay – 147 flipper tagged and microchipped, and 140 microchipped only (Note that this was a new protocol implemented in 2014/15 with only approximately 50% rather than 100% of pups being tagged at Sandy Bay); Dundas Island – 391 flipper tagged only; and Figure of Eight Island – 40 flipper tagged only;
- Of the 63 dead pups recovered at Sandy Bay, 59 were in sufficient state for necropsy. Preliminary provisional diagnosis for cause of death includes 61% bacterial infection (suspected with *Klebsiella pneumoniae*), 17% open diagnosis (decomposed, scavenged or no significant findings), 15% starvation, 3% trauma, 2% hookworm and 2% stillbirth/peripartum death. It is important to note that these diagnoses are provisional and will be refined and/or confirmed once full histopathology analysis has been completed at Massey University pending funding;
- Between 10 January and 27 March 2015, there were a total of 14,762 resights of marked NZSLs of which 14,295 were suitable for use (i.e. contained sufficient information allowing positive identification). Flipper tags were used as the primary form of identification in these resight events (82%), followed by scanning for microchips (16%) and also viewing branding animals (2%). This season represents the most resighting records collected and is 29% more than was collected in 2013/14 but effort (i.e. time spent collecting resights) was also considerably higher than previous years (e.g. 586 hours in 2013/14 vs. 1,144 hours in 2014/15). Most resightings (97%) were collected on Enderby Island and most (87%) of these at Sandy Bay. A few resights were also collected from other areas of the Auckland Islands group including Dundas Island (n=364), Monumental Island (n=7) and Figure of Eight Island (n=2);

- In response to previous examples of pup mortality in holes at Sandy Bay, 12 wooden ramps were installed on streams and mud holes in order to allow pups to climb out of places where they otherwise would not be able to. A total of two pups were found dead in mud holes, however 65 were physically rescued by the NZSL team prior to ramp installation and 45 were seen exiting on ramps on review of GoPro and trail camera photos. Overall this programme of work has been very successful and has led to a direct reduction in NZSL pup mortality. This work was funded separately by DOC and WWF rather than by CSP, however, it did share resources with the CSP funded programme; and
- Further investigation of *Klebsiella pneumonia* included the capture of 48 yellow-eyed penguins and 32 brown skuas for cloacal swabbing to ascertain disease prevalence in avians. No northern giant petrels have been caught due to their large flight distance on approach and low likelihood of safe capture with a hand net. In addition, substrate samples of mud, sand and water have been collected around the Sandy Bay sward in January and February for testing of environmental *K. pneumoniae* burden throughout the season.

2. Methodology

A full description of methods used in this field study are provided in Childerhouse (2013), which is available from the CSP website and the author upon request. The research outlined here follows almost exactly the same methods as undertaken previously by DOC and as described in Chilvers (2012). There were some differences with previous surveys:

- The mark-recapture estimate on Dundas Island was undertaken two days earlier than in years prior to 2013/14 (i.e. 19 January rather than 21 January) at the request of DOC and as agreed by the CSP Technical Working Group;
- While all live pups at Sandy Bay on 16 and 17 January were microchipped, approximately half (n=147) were flipper tagged as well. In previous years, all live pups were flipper tagged as well as microchipped. This change was made by DOC, in conjunction with the CSP Technical Working Group, in order to reduce any possible impacts of flipper tagging and is based on an assessment by NIWA that a reduction in the number of individuals tagged is unlikely to reduce the precision of demographic parameters;
- Since 2013/14, detailed records of time spend collecting resighting information have been collected allowing for broad comparison of effort between years;
- Timing of trips has varied over the almost 20 year time frame of this long term monitoring project. Since 2012/13, surveys have started in early January in contrast to previous surveys that generally started in early December. The end date of surveys has also varied with 2012/13 ending on 31 January, 2013/14 ending in 11 March and 2014/15 ending on 27 March. These variations in the timing and length of seasons are likely to influence a range of results including things such as variation in the number of resighting records and estimates of pup mortality; and
- Additional survey and resighting effort was undertaken in 2014/15 following additional funding from DOC at other sea lion haul out sites including Monumental Island, Rose Island, Ewing Island and Ocean Island (see Figure 1).

A team of up to five NZSL researchers plus one wildlife vet (position supported by DOC separate to this CSP contract) undertook the research from early January 2015. Three researchers plus one wildlife vet remained on Enderby Island until 25 March 2015 in order to collect resight information and

necropsy deceased marked animals. All other dead NZSLs found at Enderby Island were assessed for cause of death and necropsied where possible.

The team of researchers undertaking the work included: Andy Maloney; Chris Pugsley; Derek Hamer; Lynn Adams; Sarah Michael; Simon Childerhouse; Stuart Cockburn; and Tom Burns. The data in this report are a credit to the hard work, dedication and expertise of these people.

3. Results

3.1 Logistics

The team assembled in Bluff on 3 January 2015 and, following discussions with the Master of *RV Tiama*, decided to leave one day earlier for the Auckland Islands than originally planned. This was in order to benefit from a more favourable weather window. The team departed on 6 January rather than 7 January. A summary of key dates:

- 6 January – Team of six departed Bluff aboard *RV Tiama* for the Auckland Islands;
- 8 January – Arrived Enderby Island, Auckland Islands and unloaded all field gear and equipment into the Sandy Bay huts. Reboarded *RV Tiama* for travel to Figure of Eight Island;
- 9 January – Surveyed Figure of Eight Island;
- 10 January – Returned to Figure of Eight Island for additional flipper tagging and resighting. Undertook surveys at Monumental Island then departed for Enderby Island;
- 11 January – Arrived at Enderby Island and the team was dropped off;
- 20 January – One team member departed for mainland by helicopter;
- 3 February – Three team members departed for the mainland and two new team members arrived;
- 25 March – Remaining team members departed Enderby Island and joined *RV Tiama* for surveys of other Islands in Port Ross;
- 26-27 March – Undertook surveys of Port Ross for NZSLs;
- 28 March – Departed Auckland Islands for mainland via the Snares; and
- 30 March – arrived Bluff.

The field work included 75 days on Enderby Island, 10 days on Dundas Island, 2 days on Figure of Eight Island, and one part day each on Monumental Island, Rose Island, Ocean Island and Ewing Island.

The field team comprised experienced and new NZSL researchers: Dr Simon Childerhouse, Dr Derek Hamer, Andy Maloney, Chris Pugsley, Lynn Adams, Stuart Cockburn and Tom Burns. In addition, Sarah Michael from DOC joined the team to undertake autopsies of dead NZSL adults and pups. She was funded separately by DOC. Although this work is technically not part of the CSP contract, it is included here for completeness. Michael also helped with other aspects of the CSP work programme when not involved in autopsies.

The size of the CSP field team varied throughout the season (e.g. 8-20 January: 5 people; 21 January – 3 February: 4 people; 6 February – 30 March: 3 people). Childerhouse returned to the mainland on 20 January and Hamer led the team from that time. Hamer, Adams and Cockburn returned to the mainland on 3 February and Maloney led the team from that time. Pugsley and Burns joined the team on 3 February. The team worked very well and achieved all the required tasks.

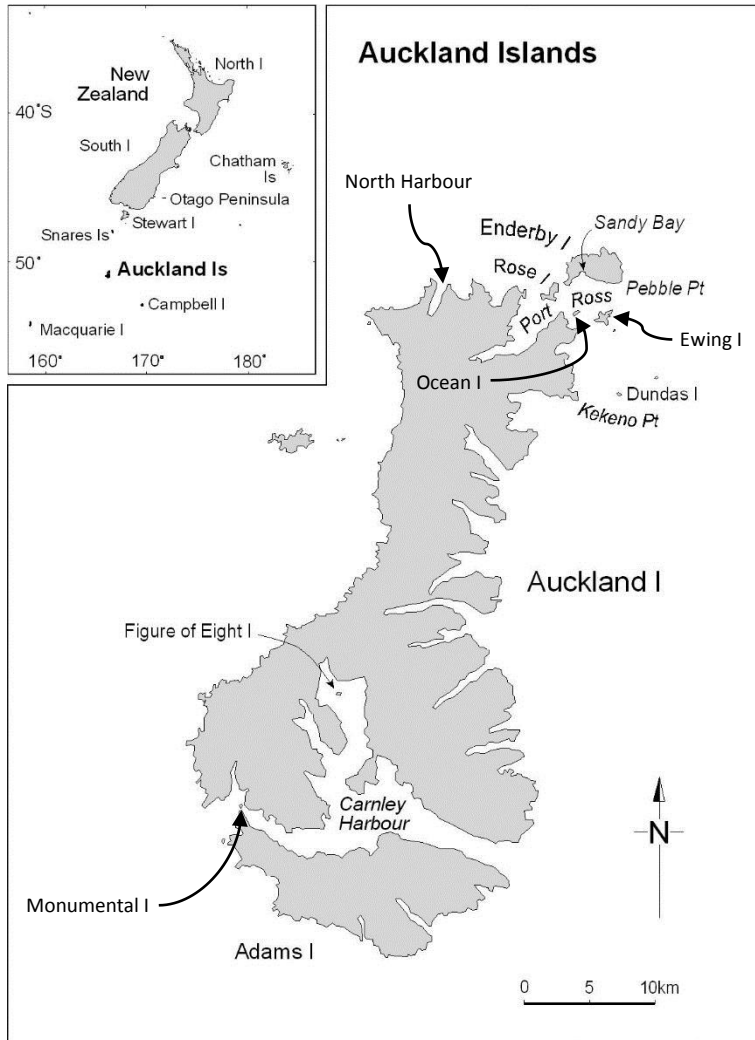


Figure 1: Map of the Auckland Islands showing sites mentioned in the text.

3.2 General approach and timing of field work

As stated previously, these results follow the methodology previously described in Childerhouse (2013) unless otherwise stated. In order to maintain consistency in data collection, the team planned to conduct work on the same key dates used for previous surveys:

- Figure of Eight Island – the pup census was undertaken on 10 January, however additional resighting effort was also undertaken on 9 January to increase resighting probabilities of marked individuals;
- Sandy Bay, Enderby Island – the mark-recapture was undertaken on 15 (marking) and 16 (recapture) January as planned;
- Dundas Island – the mark-recapture was undertaken on 18 (marking) and 19 (recapture) January as planned. This was two days earlier than the surveys have been undertaken previously due to a requirement to coordinate with the available helicopter for transport to and from Dundas Island. This change was agreed by the CSP Technical Working Group and has been undertaken since 2012/13;
- Sandy Bay – previously all pups alive at Sandy Bay have been both flipper tagged and microchipped. This year, with a view to investigating and reducing any impacts of research, only half the pups were both flipper tagged and microchipped and the other half were only microchipped.

3.3 Estimates of pup production

Annual estimates of pup production for each colony and for total Auckland Islands pup production from 1994/95 until 2014/15 are shown in Appendix 1. Figures showing annual estimates for pup production by colony are shown in Appendix 2.

3.3.1 Sandy Bay, Enderby Island

Table 1: Summary of New Zealand sea lion pup production estimates for Sandy Bay for 2014/15.

Method	Date	No. counts	Start/end time	Estimate (SE)
Mean direct live count	16 Jan 2015	10	09:10/10:45	277 (2.9)
Cumulative dead count to the day of the mark-recapture	16 Jan 2015	N/A	09:10/10:45	7
Mean mark-recapture estimate	16 Jan 2015	9	09:10/10:45	279 (3.2)
Total number pups individually marked	16-17 Jan 2015	N/A	N/A	287

Total pup production for Sandy Bay is estimated at **286** (279 live plus 7 dead pups) for 2014/15¹. This is the lowest estimate ever recorded for this colony. Figures showing annual estimates for the colony at Sandy are shown in Appendix 2. Raw data for counts at each of the colonies are provided in Appendix 3.

Estimates of pup production at Sandy Bay were completed successfully. A description of the breeding area searched during pup counts at Sandy Bay is provided in Appendix 4. Nine mark-recapture counts were undertaken (i.e. three counts by one person plus two each by three different people) and 12 direct counts were undertaken (i.e. two counts each by six people) of live pups (Appendix 3). In addition, a single direct count of live pups was undertaken daily between 8 and 22 January (Appendix 5), but counts of dead pups continued until the team left for the mainland on 28 March.

One hundred and forty caps were used as marks for the mark-recapture and were put out on 15 January (between 08:30 and 11:30). One cap was recovered from the ground prior to starting the mark-recapture counts on the 16 January. The number of marked pups was, therefore, considered to be 139 for the purposes of the mark-recapture estimation (Appendix 3).

The methodology for estimating the number of dead pups in 2014/15 differed slightly from previous years. Prior to 2012/13, all dead pups were counted daily and removed from the beach for autopsy throughout the season. In 2012/13, all dead pups were left on the beach to allow for helicopter aerial surveys to be undertaken to count both live and dead pups, and the first counts were made on January 11 when the team arrived with no counts prior to this. Since 2013/14 onwards, all dead pups found on the beach during the first survey on 8 January were counted and removed. After this time, daily counts were made with all new dead pups counted, removed from the beach and most of them autopsied (depending on their condition when recovered).

The first direct dead count was undertaken on 8 January with a total of two dead pups found. This estimate is not directly comparable with most previous dead pup counts as the previous estimates represent a cumulative count of dead pups removed from the colony through the season beginning in early December. The dead pup estimate from 2014/15 should, therefore, be considered a minimum

¹ Please note that the estimate of pup production at Sandy Bay has always been derived from the estimate from the mark-capture for live pups plus the number of dead pups to that date. In some cases, including this year, this estimate is actually lower than the number of pups marked at Sandy Bay so the estimate is negatively biased. It would be worth reviewing the best method for estimating total pup production at Sandy Bay and also if there is any evidence of a systematic bias in previous estimates.

estimate of dead pups and the overall estimate of pup production should also be considered a minimum for the same reason.

Overall the 2014/15 estimate of total pup production for Sandy Bay was 286 (279 live plus 7 dead pups), which is 1% lower than 2013/14. This is the lowest estimate recorded for this colony. Pup mortality was estimated as 2% on 16 January. This is the same level as recorded in 2013/14, although as discussed above, the estimates of dead pups for 2012/13, 2013/14 and 2014/15 are unlikely to represent the total number of dead pups to 16 January and are probably an underestimate.

3.3.2 Dundas Island

Table 2: Summary of New Zealand sea lion pup production estimates for Dundas Island for 2014/15.

Method	Date	No. counts	Start/end time	Estimate (SE)
Mean direct live count	19 Jan 2015	3	07:40/11:05	1,051 (13.3)
Mean direct dead count	19 Jan 2015	3	07:40/11:05	67 (0.0)
Mean mark-recapture estimate	19 Jan 2015	9	07:40/11:05	1,163 (20.9)
Total number pups tagged	18-20 Jan 2015	N/A	N/A	402

Total pup production for Dundas Island is estimated at **1,230** (1,163 live plus 67 dead pups) for 2014/15. Figures showing annual estimates for Dundas Island colony are shown in Appendix 2.

Estimates of pup production at Dundas Island were completed successfully. Nine mark-recapture counts were undertaken (i.e. three counts each by three different people) and three direct counts (i.e. three counts each by three different people) were undertaken for live pups. Three direct counts of dead pups were undertaken by the whole four-person team working together and all dead pups found were marked with spray paint in order to confirm they had been counted.

Four hundred mark-recapture caps were put out on pups on 18 January on Dundas Island. The approximate location of the pups that were capped is shown in Appendix 6. The aim was to mark approximately 20-25% of the live pups on the day of marking, therefore, caps were put out amongst pups in that approximate ratio (i.e. 1 cap for every 4-5 pups) across the whole area where pups were present. Four hundred caps were put out on 18 January but five caps were recovered from the ground prior to starting the mark-recapture counts on 19 January. The number of marked pups was, therefore, considered to be 395 for the purposes of the mark-recapture estimation (Appendix 3).

Overall the 2014/15 estimate of total pup production for Dundas Island was 1,230 (1,163 live plus 67 dead pups), which is 1% higher than 2013/14. Pup mortality to 19 January was estimated as 5%, which is slightly lower than the 6% recorded in 2013/14. The full data series for pup production at Dundas Island is shown in Appendix 1 and Appendix 2. Raw data for counts at Dundas Island are provided in Appendix 3.

3.3.3 Figure of Eight Island

Table 3: Summary of New Zealand sea lion pup production estimates for Figure of Eight Island for 2014/15.

Method	Date	No. counts	Estimate (SE)
Mean direct live count	9 Jan 2015	3	47 (1.5)
Mean direct dead count	9 Jan 2015	3	13 (0.0)
Total number pups tagged	9 Jan 2015	N/A	40

Total pup production for Figure of Eight Island is estimated at **60** (47 live plus 13 dead pups). Figures showing annual estimates for Figure of Eight Island colony are shown in Appendix 2.

Estimates of pup production at Figure of Eight Island were completed successfully. Three direct live counts were undertaken by three different people and three direct dead counts were undertaken by the whole team.

Overall the 2014/15 estimate of total pup production for Figure of Eight Island was 60 (47 live plus 13 dead pups), which is 17% lower than 2013/14. Pup mortality to 10 January was estimated as 22%. This is higher than the 14% recorded in 2013/14 and was estimated using comparable methods to previous years. The full data series for pup production at Figure of Eight Island is shown in Appendix 1 and Appendix 2. Raw data for counts at Figure of Eight Island are provided in Appendix 3.

3.3.4 South East Point, Enderby Island

Table 4: Summary of New Zealand sea lion pup production estimates for South East Point for 2014/15.

Method	Date	No. counts	Estimate (SE)
Direct live count	12 Jan 2015	3	0
Direct dead count	12 Jan 2015	3	0
Total number pups tagged	12 Jan 2015	N/A	0

Total pup production for South East Point is estimated at **0** (0 live plus 0 dead pups). Figures showing annual estimates for South East Point colony are shown in Appendix 2.

No pups were recorded at South East Point this year. The last report of pups at South East Point was in 2011/12, when only a single pup was recorded there. The first count at South East Point in 2013/14 was undertaken on 12 January (in contrast to years prior to 2012/13, when there were regular counts from early December onwards). It is, therefore, possible that pups could have been born before this time but moved away or died and been washed away prior to the first visit. However, anecdotal reports from tourist vessels visiting South East Point prior to 12 January reported seeing no pups there. There were more than 10 surveys of South East Point between 11 January to 26 March and no pups were seen. With estimated pup production reaching zero for the third year in a row, this breeding site no longer exists.

Overall the 2014/15 estimate of total pup production for South East Point was 0 pups (0 live plus 0 dead pups), which is the same as recorded in 2013/14. The full data series for pup production at South East Point is shown in Appendix 1 and Appendix 2.

3.3.5 Total pup production for the Auckland Islands

Overall, total pup production for the Auckland Islands in 2014/15 was estimated to be **1,576** pups (1,489 live pups and 87 dead pups). This total represents an increase of one pup from the 2013/14 estimate and is the fourth lowest total pup production recorded from the Auckland Islands. Overall pup production for the Auckland Islands since 1994/95 is shown in Figure 2.

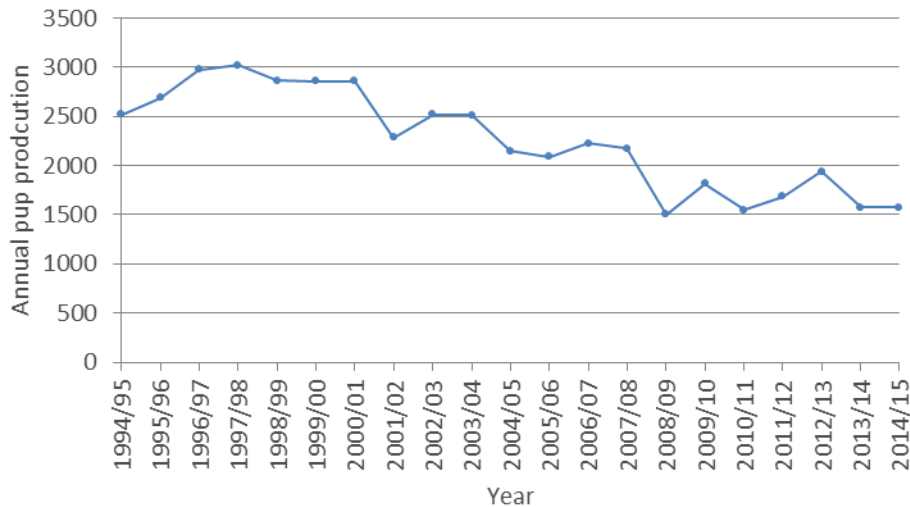


Figure 2: Total estimated pup production for New Zealand sea lions at the Auckland Islands 1994/95 – 2014/15.

(Data prior to 2012/13 from Chilvers (2012))

3.4 Pup weights

Table 5: Summary of mean New Zealand sea lion pup weights for the Auckland Islands for 2014/15.

Location	Female		Male	
	n	Mean weight kg (SE)	n	Mean weight kg (SE)
Sandy Bay	50	10.6 (0.3)	50	12.1 (0.3)
Dundas Island	50	11.4 (0.3)	50	12.3 (0.4)
Figure of Eight Island	18	10.4 (0.3)	22	11.7 (0.3)

A random sample of 100 pups (50 of each sex) were weighed at both Sandy Bay and Dundas Island on the same day as the mark-recapture count (16 and 19 January 2015 respectively). For the first time, pup weights were also collected from 40 pups at Figure of Eight Island. Mean pup weights at Sandy Bay were 4% and 5% lower than 2013/14 for males and females respectively. Mean pup weights at Dundas Island were 6% and 12% higher than 2013/14 for males and females respectively. Mean pup weights from previous surveys at Sandy Bay and Dundas Island are show in Figure 3 and Figure 4.

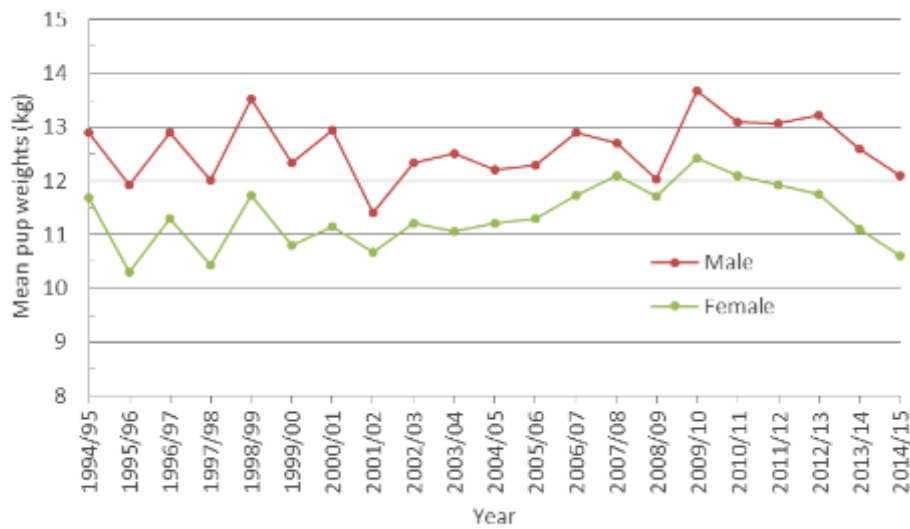


Figure 3: Mean New Zealand sea lion pup weights for Sandy Bay colony by sex.
(Data prior to 2012/13 provided by Dr Louise Chilvers)

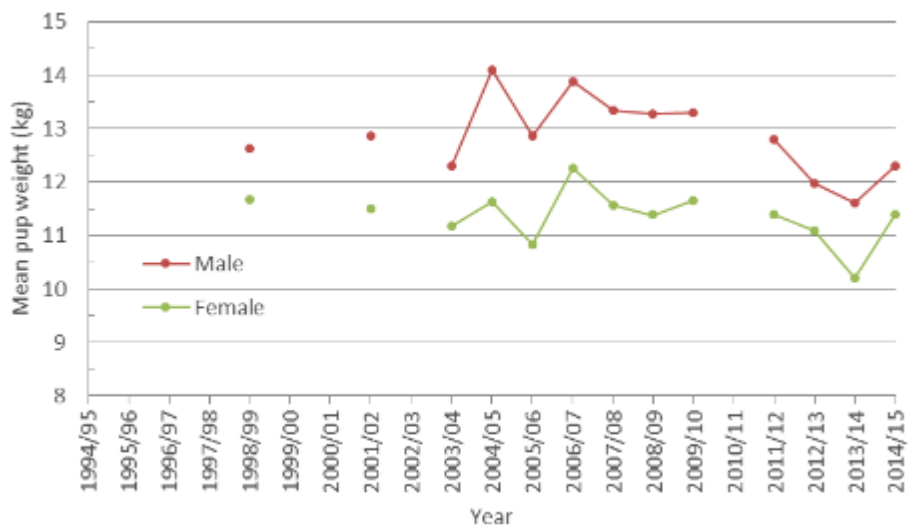


Figure 4: Mean New Zealand sea lion pup weights for Dundas Island colony by sex.
(Data prior to 2012/13 provided by Dr Louise Chilvers)

3.5 Counts at Sandy Bay

Direct counts of live and dead pups, adult females, adult and sub-adult males were made at Sandy Bay from 8 to 22 January 2015 (Figure 5). There was no count on 9 and 10 January as the team was away from Enderby undertaking surveys at Figure of Eight Island.

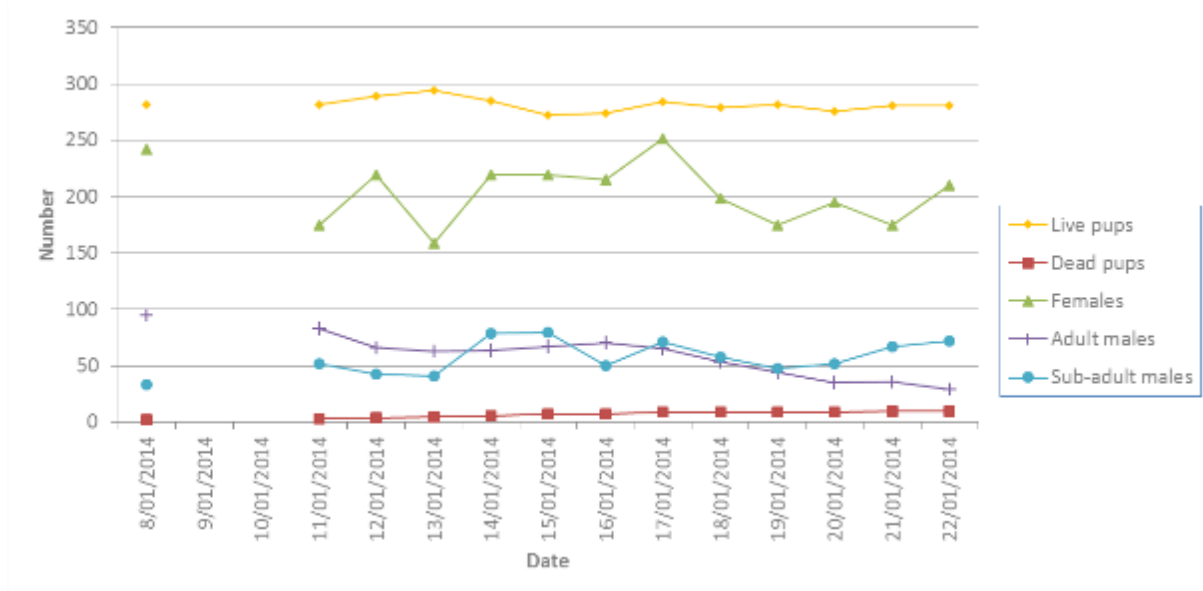


Figure 5: New Zealand sea lion counts at Sandy Bay, Enderby Island 2014/15.

3.6 Flipper tagging and microchipping

Flipper tagging and subcutaneous microchipping were also undertaken. Summary of pup marking was:

- Dundas Island – 391 pups flipper tagged (comprising 100 males and 291 females);
- Figure of Eight Island – 40 pups flipper tagged (comprising 22 males and 18 females), which was as many as could be tagged in the time available; and
- Sandy Bay – All live pups on 16 and 17 January were marked with unique marks. 147 pups both flipper tagged and microchipped and a further 140 pups microchipped only. This is the first time since 1998 that all pups at Sandy Bay have not been flipper tagged although they were all microchipped.

3.7 Resighting and management of mark data

A total of 14,762 individual flipper tag, brand and microchip resightings were made during the field season. These records do not represent different individuals but rather the total number of all resights collected and includes multiple resights of some individuals. Of these, 467 did not contain sufficient information to identify an individual (e.g. one or more digit missing from the recorded tag number), which left 14,295 records suitable for uploading into the NZSL database.

Of these 14,295 records, most of the resighting records were from flipper tags (n=11,679; 82%) with microchip resighting comprising 16% (n=2,273) and brands 2% (n=343). Of those individuals for which sex could be determined (83% of all sightings), 75% were records from females and 25% from males.

This season represents the most resighting records collected and is 29% more than was collected in 2013/14. Most resightings (97%) were collected on Enderby Island and most (87%) of these at Sandy Bay. A few resights were also collected from Dundas Island (n=364), Monumental Island (n=7) and Figure of Eight Island (n=2).

Table 6: Summary of New Zealand sea lion resightings for 2014/15 for which identification was possible.

Resight type	No.	No. of different individuals	No. of times individuals resighted
Flipper tags	11,679	1,572	1-74
Brands	343	22	1-58
Microchips	2,273	424	1-37
Total	14,275	2,018	1-74

Some other summary statistics include:

- Mean number of resights per individual = 9.1 (SE = 0.27);
- Maximum number of resighting per individual = 74;
- Number of individuals identified from 3 methods (i.e. microchip, brand, flipper tag) = 11; and
- Number of individuals identified from 2 methods (i.e. microchip, brand, flipper tag) = 180.

3.8 Resighting effort

Detailed effort information was collected during resighting surveys. Collection of information including start and end of effort, personnel undertaking it, location and weather conditions. A sample of these data is available in Appendix 7. Figure 6 shows (a) the number of individual resighting records collected by the whole team per day and (b) the total number of hours of resighting effort undertaken by the whole team per day. The size of the field team varied through the season (e.g. 8-20 January: 6 people; 21 January – 3 February: 5 people; 4 February – 28 March: 4 people), which should be accounted for when considering relative effort.

Gaps in these data series generally coincide with either very bad weather days (when resighting is not possible) or with visits of tourist ships to Enderby Island when the resighting programme is generally stopped so as to not work closely around NZSLs while tourists are present. The number of resights collected per day is obviously a direct function of effort (i.e. time spent) but is also a function of other factors including weather, colony density (e.g. tightly packed on the beach versus spread out on the sward and forest), number of marked individuals available for sighting and individual animal behaviour (e.g. territorial versus dispersed). These additional factors are difficult to assess and therefore the interpretation of sighting data should not be confined to resighting effort alone.

A key element of this research was to ensure that data were collected in an accurate and robust fashion and that they are provided in an electronic format suitable for upload into the NZSL database. All of the groomed and reviewed data have been uploaded into the NZSL database and are available online² as open access information.

² <http://data.dragonfly.co.nz/nzsl-demographics/>

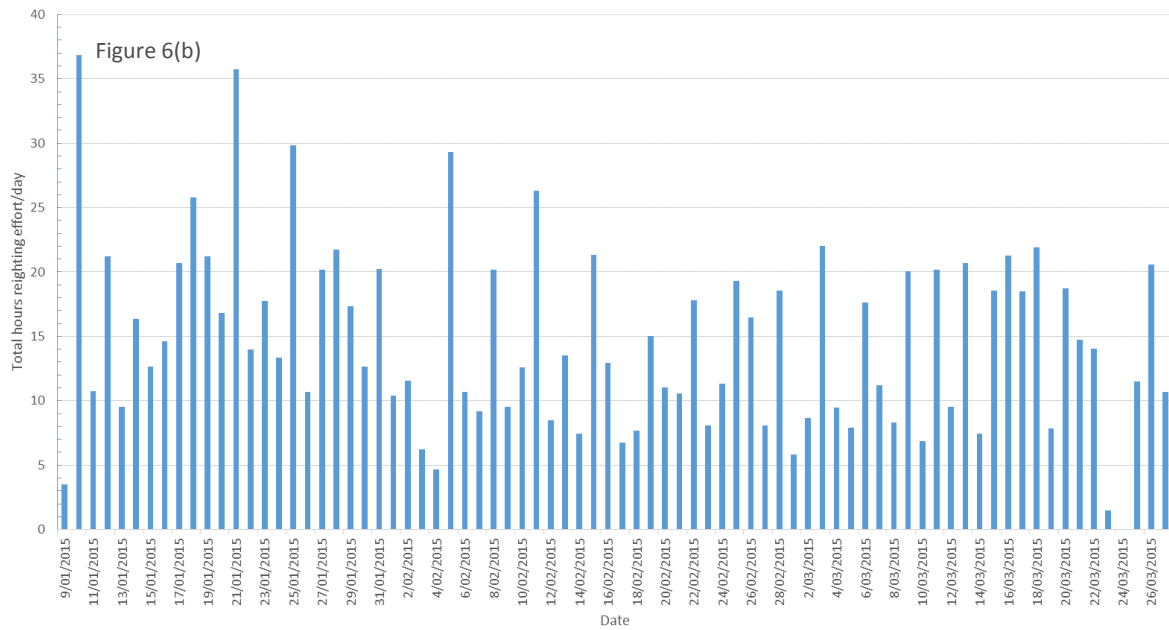
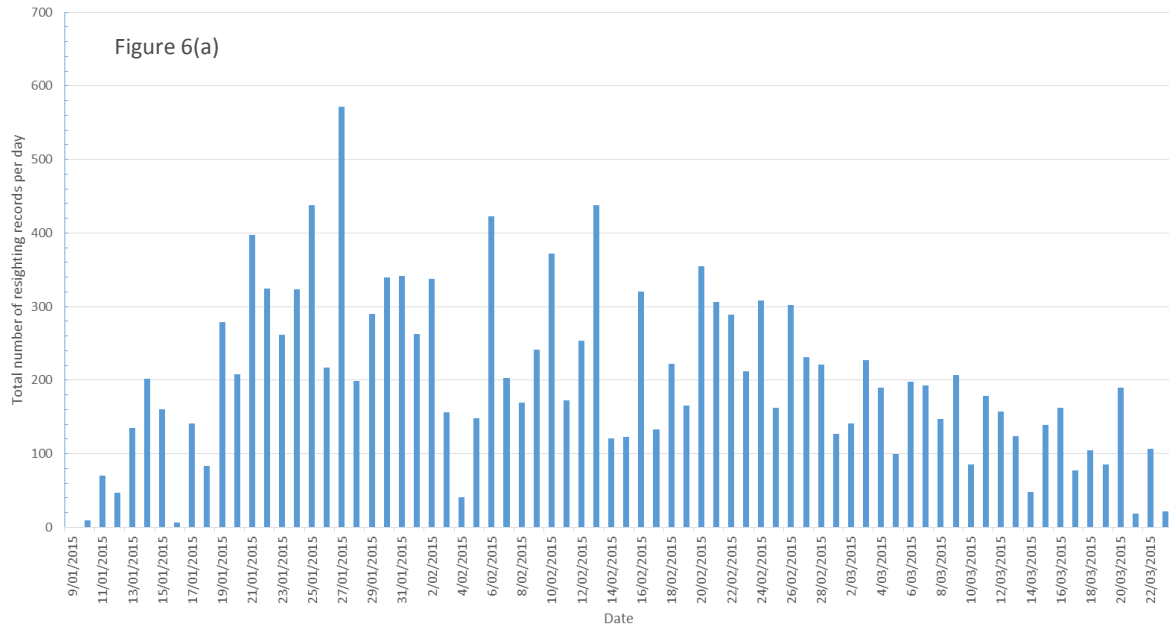


Figure 6: (a) Number of individual resighting records collected by the whole team per day; and (b) Total number of hours of resighting effort collected by the whole team per day in 2014/15.

3.9 Pup mortality

NZSL pup mortality was monitored daily throughout the season at Sandy Bay and intermittently at other sites around Enderby Island. Total mortality between 10 January and 25 March was 63 pups. Figure 7 shows the daily and cumulative total number of dead pups at Enderby Island.

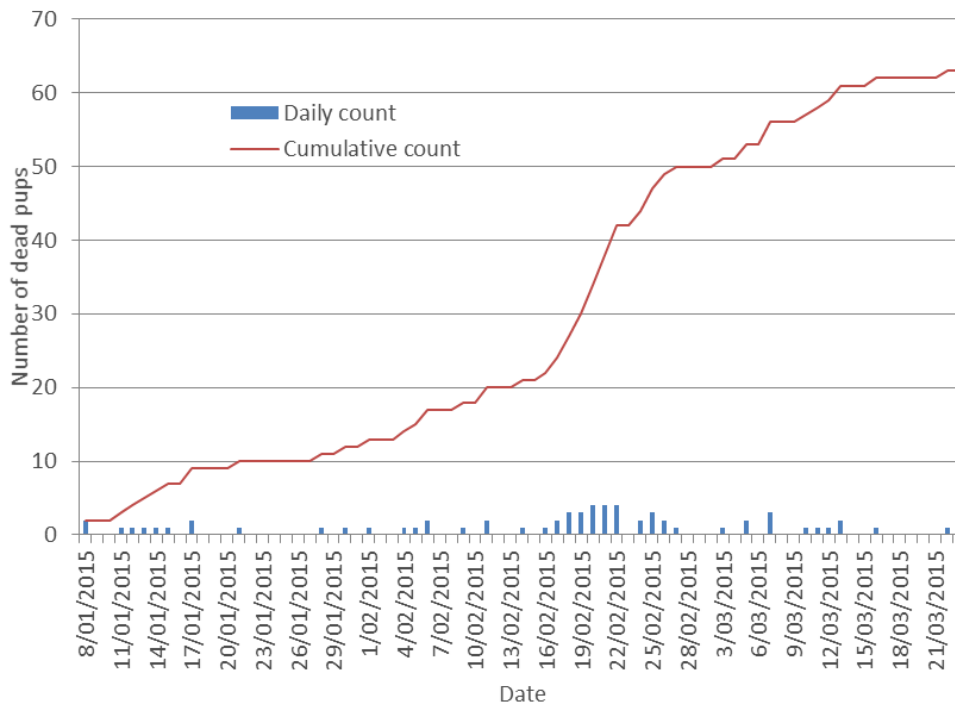


Figure 7: Daily and cumulative New Zealand sea lion pup mortality at Sandy Bay, Enderby Island 2014/15.

All dead pups were found at Sandy Bay except for three found at Teal Lake in mid- to late March, consistent with late season distribution of pups. Of the 63 dead pups, four were confirmed as being from Dundas Island (i.e. they had an orange cap from Dundas Island mark-recapture or were flipper tagged on Dundas) and eight were presumed to have originated from Dundas Island or elsewhere (i.e. no flipper tag or microchip). Pups from Dundas Island routinely start to arrive at Sandy Bay from late January. This year pups confirmed or suspected to originate from Dundas Island died at Enderby Island between 4 February and 16 March. Fifty nine dead pups were in sufficient state for necropsy. Preliminary provisional diagnosis based on gross necropsy examination alone includes 61% bacterial infection (suspected with *Klebsiella pneumoniae*), 17% open diagnosis (decomposed, scavenged or no significant findings), 15% starvation, 3% trauma, 2% hookworm and 2% stillbirth/peripartum death (Figure 8). Although five pups were found to have severe haemorrhagic enteritis caused by hookworms, all but one of these animals also had lesions suggestive of *K. pneumoniae* infection, which would have caused the death of the pup acutely. It is important to note that these diagnoses are provisional and will be refined and/or confirmed once histopathology and microbiology analysis has been completed at Massey University (funding dependent). Figure 9 shows the temporal distribution of deaths by provisional cause. As seen in previous seasons (Childerhouse et al. 2014; Roe et al. 2015) there was a “spike” in deaths with a presumptive diagnosis of *K. pneumoniae* infection. This season the spike was centred at week 11 (17-23 February 2015), approximately two weeks later than the 2013/14 season.

Of pups originating from Sandy Bay that died after marking (n=42), 24 had been flipper tagged and microchipped for identification, compared to 18 that had only been microchipped. Unlike the 2013/14 season however, no overt signs of flipper tag wound infection were identified on dead pups.

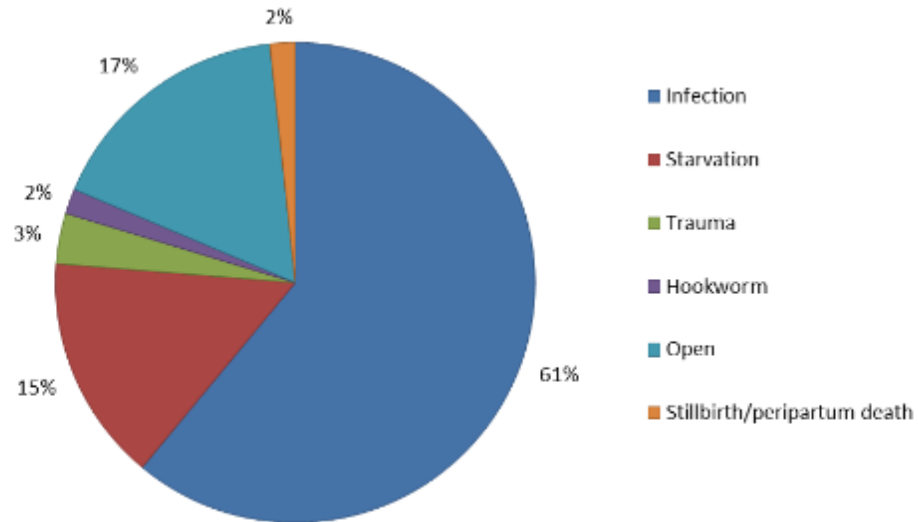


Figure 8: Preliminary and provisional diagnosis (%) of cause of death of New Zealand sea lion pups at Sandy Bay, Enderby Island 2014/15 (n=59) to 25 March 2015.

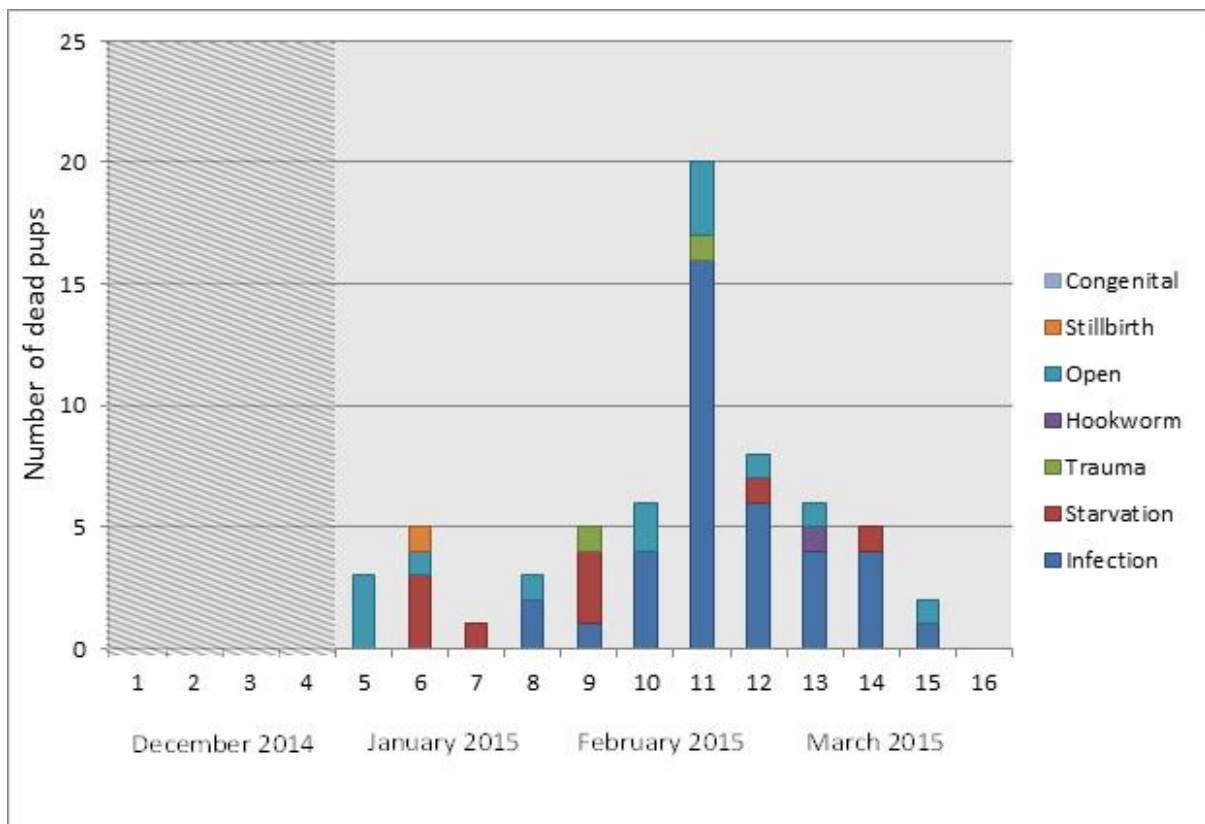


Figure 9: Preliminary provisional diagnosis of cause of death of New Zealand sea lion pups at Enderby Island by week.

Hatched area indicates early season when no research team was present.

Additionally, eight pup necropsies were performed opportunistically on Dundas Island between 13 and 18 February 2015. Preliminary provisional diagnosis based on gross necropsy examination alone includes 50% bacterial infection (suspected with *Klebsiella pneumoniae*), 26% open diagnosis (scavenged or inconclusive findings), 12% starvation and 12% trauma. Samples were collected for analysis at Massey University (funding dependent).

The extended length of field season this year was undertaken in order to evaluate pup mortality beyond the standard departure date for the research team of mid-February. As illustrated in Figure 7 and 8, the data compiled this year demonstrates that pup mortality continues well beyond February, with over 20% of pup deaths at Sandy Bay this year occurring beyond the normal CSP departure date of approximately 20 February. These late season cases were comprised predominantly of suspected *K. pneumoniae* infection. Although pup mortality appears to wane in March, this is likely biased by movement of adult females and their pups away from Sandy Bay to sites elsewhere on Enderby Island (particularly Teal Lake) and other islands in the Port Ross area where monitoring is intermittent or impossible. The survey of Port Ross islands undertaken prior to departure (26-27 March 2015) identified a freshly dead pup on Ewing Island and many dead pups in various states of decomposition at Dundas Island. Further, a pup with clinical signs of *Klebsiella* septic arthritis (lame with severely swollen forelimb) was seen at Ewing Island. Pups at Sandy Bay in this condition anecdotally are dead within several days. In addition to the pup necropsies, one adult female and one juvenile female were found dead at Sandy Bay and had gross post mortems and samples collected.

3.10 Dundas Island follow-up trips

Given additional available helicopter transport, two researchers were able to spend some extra and unprogrammed time on Dundas Island. They were based on Dundas Island from 13 to 18 February with the primary objectives of undertaking resighting, counting live and dead pups and autopsies. A total of 93 dead pups were counted, which excludes previously marked (i.e. all dead pups recorded on 19 January were spray painted to avoid double counting) and old/mummified carcasses assumed to have been counted on the previous January visit. The estimate of dead pups on 19 January was 67 pups, which would provide an overall estimate of pup mortality at Dundas Island of 160 dead pups (i.e. 13% of total pup production) to 19 February.

Autopsies were performed on eight fresh carcasses, five of which showed lesions consistent with *Klebsiella* infection, one of starvation, one drowned, and one no diagnosis. Samples were taken for analysis at Massey University.

A brief follow-up survey was also undertaken at Dundas Island on 27 March 2015 prior to the team returning back home. This was in order to investigate whether there was likely to have been an unusual mortality event there also. Overall, there were only 3 pups present on the Island but a further 40 dead pups were seen over and above those previously recorded at Dundas Island (e.g. all previously dead pups were marked with spray paint). There was no evidence of an unusually high level of pup mortality. Of the 40 newly dead pups recorded on 27 March, 9 were found in the muddy moat around the centre of the Island. The previous visit to Dundas Island on 19 January 2015 had a live pup count of 1,051 and a dead pup count of 67. The numbers of dead pups between the two surveys should not be directly compared as it is likely that not all of the pups that had died after 19 January 2015 would have been available for counting on 27 March 2014, as over time they would have been scavenged, decomposed and/or washed away.

3.11 Mitigation of pup mortality in holes

Inability to escape from holes and undercut streams has been recognised as a potential contributor to pup mortality at the Auckland Islands and as a target for active management to improve survival. Pups that fall into these holes and cannot escape may die due to drowning or starvation. This season a program (funded by DOC and WWF) was implemented in order to identify and respond to problem

holes at Sandy Bay by installing wooden ramps to allow pup escape, with efficacy monitored on cameras.

At the beginning of the season, surveys of Sandy Bay and Dundas Island were undertaken to identify existing wooden ramps and potential problem holes (Appendix 8 and Appendix 9). Throughout the 2014/15 season, 12 wooden ramps were installed on streams and mud holes around the Sandy Bay sward in order to allow pups to climb out of deep channels and undercut holes. The GPS coordinates, direct and aerial photos of the installed ramps are included in Appendix 10.

Daily monitoring was crucial in order to identify and respond to changes occurring due to weather conditions (e.g. rising of water levels in holes) and dispersal of NZSLs across the sward (e.g. new problem holes requiring ramps Figure 10). GoPro HD cameras monitored the various ramps (i.e. one photo per minute protocol, set up as shown in Figure 11) for over 122 hours, as well as 25 hours on streams without ramps. Additionally, over 304 hours of motion-activated trail camera monitoring of ramps was undertaken. The trail cameras had the benefit of significantly longer battery life (over a week) and ability to take day and night (with infrared flash) photos without changing modes. Examples of images depicting pup escape are presented in Figure 12 and Figure 13. Two pups were found dead in mud holes and on necropsy were believed to have drowned, however 65 were physically rescued by the NZSL team before ramp installation and at least 45 were seen exiting on ramps on review of GoPro and trail camera photos. Of pups identified by flipper tag or microchip on rescue, (n=54) the median number of rescue events was one, however one pup required rescue seven times (this pup later was found dead in a hole without an installed ramp).

The 3-4 m deep holes identified in the 2013/14 season were regularly checked but did not pose a problem this year due to the dispersal of NZSLs around the holes to the southwest of the area. Although the sea lions dispersed in a similar pattern in 2014/15 to the 2013/14 season, detailed information about their route in other seasons is not available, apart from Auge et al. (2009) which shows a broadly similar pattern of movements also occurred in 2002/03 and 2003/04.

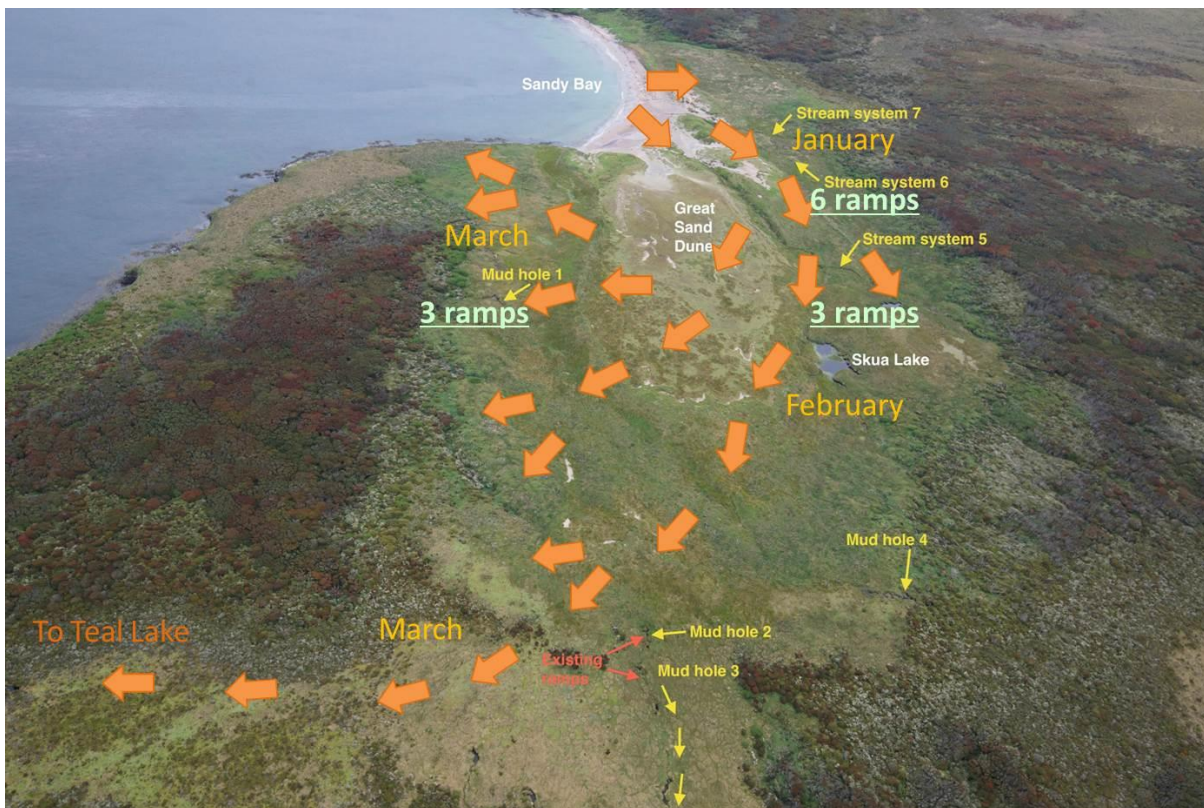


Figure 10: Figure of Sandy Bay showing locations of holes, ramps and movements of pups from the beach across the sward.



Figure 11: Overview of GoPro and trail camera set up at ramp 10B.

The cameras were mounted on a wooden post (left) overlooking the ramp.



Figure 12: Trail camera with infrared flash at night image of pup escape on ramp 10B.



Figure 13: GoPro daytime image of pup escape on ramp 10B.

3.12 Summary of other work

A range of other work has been undertaken alongside the normal NZSL CSP work programme including:

- Further investigation of *Klebsiella pneumoniae*. Throughout the season 60 yellow-eyed penguins and 33 brown skua around the Sandy Bay area were captured for cloacal swabbing. Further serial samples of substrate including mud, water and sand were collected. These samples will be processed at Massey University to analyse *K. pneumoniae* burden in potential carrier avian species and environmental reservoirs; and
- Fifty-seven southern royal albatross nests were identified around Enderby Island.

4. Issues for Future Consideration

Based on the experience of the 2014/15 team, we would recommend the following issues be reviewed for any 2015/16 field season:

- Autopsy – At present the project does not include any requirement for undertaking autopsy of pups or adults. This work has been undertaken in the past but was funded separately to the CSP component of work. Given the importance of understanding the causes of mortality to the decline in pup production, consideration should be given to incorporating this work into the existing project;
- If a vet is present on the Island, consideration should be given to prior approval for injectable humane euthanasia of moribund pups. When performed correctly, this would not significantly impact on post mortem findings and would prevent prolonged suffering of pups. These pups would need to be buried in order to prevent scavenging;

- Pup flipper tagging at Sandy Bay – in 2014/15, the number of pups flipper tagged at Sandy Bay was reduced from 100% to 50% although all of them were still microchipped. It would be worth reviewing this decision as 85% of all individual resight records each year are from flipper tags and reducing the number of tags in the population is likely to impact on resighting rates and perhaps on the estimation of vital life history rates;
- Confidence intervals for total pup production estimates – confidence intervals for estimates of total pup production have never been provided. A total pup production estimate is comprised of several different estimates generated from different techniques, some of which have no estimates of variance associated with them. It would be useful to develop a standardised method for the estimation of confidence intervals for pup production and one that could also be used for all previous data;
- Pup and adult body condition have been implicated in the decline of pup production at the Auckland Islands. It would be useful to assess how this information could be collected in future in order to provide an insight into future trends. For example, it would be possible to catch and measure adult females (as was done in 1999-2001) to provide a comparative data set on both adult body condition and also age structure;
- Active management – some sources of pup mortality could be mitigated through active management. This includes such things as:
 - The number of pups dying in holes could be reduced by filling in holes or building ramps so they could get out;
 - Veterinary treatment of sources of mortality such as injury (e.g. relocation of dislocated flippers);
 - Hookworm or disease (e.g. immunisation drug treatment); and/or
 - Supplementary feeding (e.g. in cases a pup may not be getting sufficient food from its mother).

This is a very complex issue and would require careful consideration before any actions are agreed. Active management may offer the most promising avenue for active conservation management to make a positive contribution to survivorship of individual pups and potentially yield positive flow-on benefits for the species as a whole. Elements of active management such as those identified here should be reviewed as a minimum, as part of the development of a Threat Management Plan, but also perhaps as a wider issue that could lead to immediate changes to the research programme for the 2015/16 season.

- This was the first year for several years that surveys have been undertaken in known sea lion areas away from the main colonies. These were generally undertaken late in the season (e.g. March) when pups were assumed to have dispersed from Dundas Island and Sandy Bay. It would be useful to survey these Islands early in the season (e.g. early January) to confirm that there are in fact no pups being born there and help confirm that the pups seen later in the season are actually immigrants. Other possible sea lion breeding areas could also be surveyed including North Harbour, Ranui Cove and Kekeno Point. This would aid in confirming that pup production is still limited to the existing breeding colonies.

5. Acknowledgements

This project is funded by the Department of Conservation's Conservation Services Programme through levies on the commercial fishing industry. This research would not have been possible without the support of many people, and for which we are very grateful. We'd like to specifically mention:

- Henk Haazen, master of the *RV Tiama*, and his crew were extremely professional and accommodating and the *RV Tiama* was an excellent vessel for the work;
- DOC staff including Ian Angus, Paul Crozier, Katie Clemens-Seely, Igor Debski, Kris Ramm, Sharon Trainor, Janice Kevern, and Doug Veint;
- Southern Lakes Helicopters and pilots Mark Deaker and Richard Hayes for helicopter support;
- The Auckland Islands helicopter team of Barry Baker, Mark Holdsworth, Louise Chilvers and Mark Deaker for excellent company and support;
- Members of the CSP Technical Working Group who provided useful feedback on this project; and
- DOC, WWF and Deepwater Group for funding research and mitigation on pup mortality.

6. References

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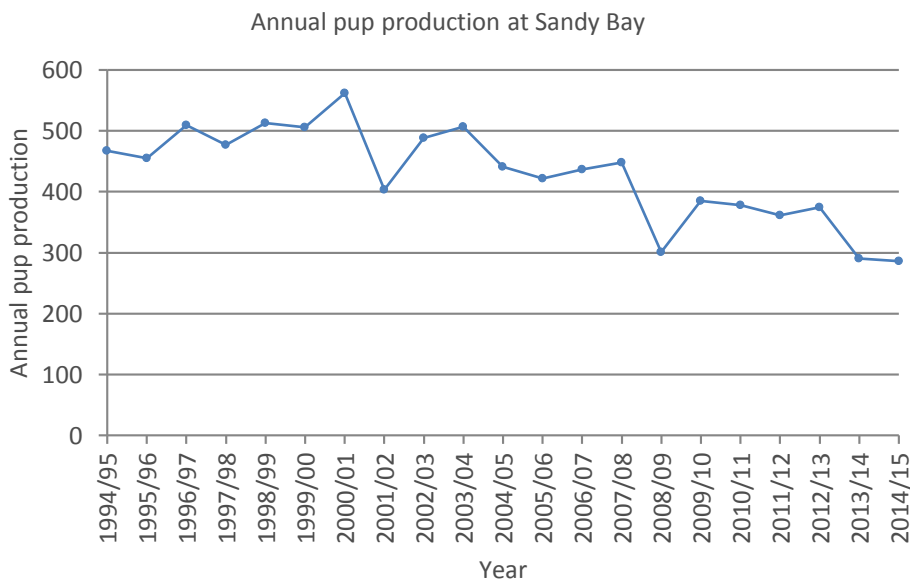
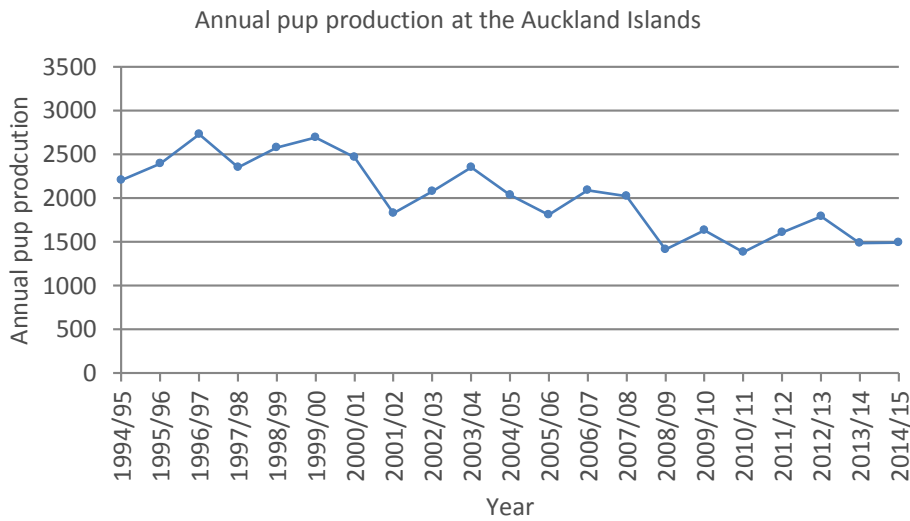
Appendix 1: Annual estimates of live, dead and total pup production for each colony and for total Auckland Islands pup production 1994/95 – 2014/15

(NB. Data prior to 2012/13 from Chilvers (2012))

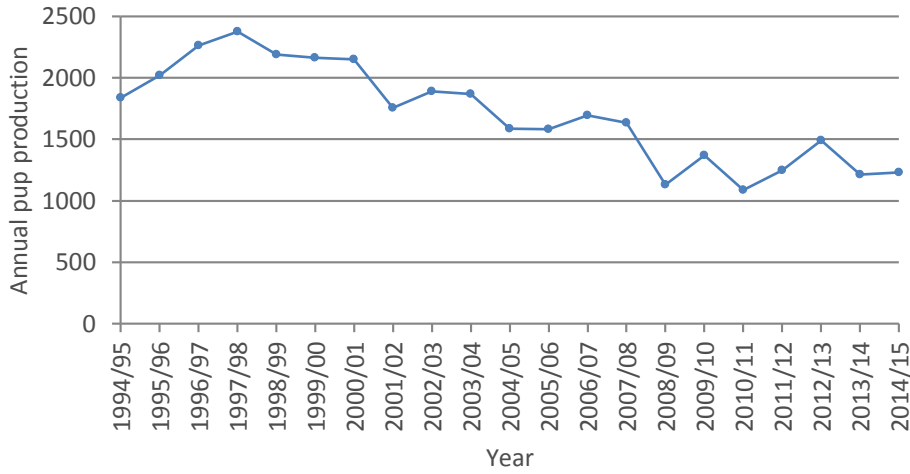
Year	Sandy Bay			Dundas Island			Figure of Eight Island			South East Point			Total Auckland Islands		
	Total	Live	Dead	Total	Live	Dead	Total	Live	Dead	Total	Live	Dead	Total	Live	Dead
1994/95	467	421	46	1837	1603	234	143	123	20	71	59	12	2518	2206	312
1995/96	455	417	38	2017	1810	207	144	113	31	69	49	20	2685	2389	296
1996/97	509	473	36	2260	2083	177	143	134	9	63	39	24	2975	2729	246
1997/98	477	468	9	2373	1748	625	120	97	23	51	37	14	3021	2350	671
1998/99	513	473	40	2186	1957	229	109	100	9	59	42	17	2867	2572	295
1999/00	506	482	24	2163	2039	124	137	131	6	50	37	13	2856	2689	167
2000/01	562	527	35	2148	1802	346	94	92	2	55	47	8	2859	2468	391
2001/02	403	320	83	1756	1395	361	96	90	6	27	21	6	2282	1826	456
2002/03	488	408	80	1891	1555	336	94	89	5	43	26	17	2516	2078	438
2003/04	507	473	34	1869	1749	120	87	86	1	52	39	13	2515	2347	168
2004/05	441	411	30	1587	1513	74	83	79	4	37	31	6	2148	2034	114
2005/06	422	383	39	1581	1349	232	62	55	7	24	20	4	2089	1807	282
2006/07	437	414	23	1693	1587	106	70	67	3	24	19	5	2224	2087	137
2007/08	448	425	23	1635	1512	123	74	72	2	18	13	5	2175	2022	153
2008/09	301	289	12	1132	1065	67	54	48	6	14	8	6	1501	1410	91
2009/10	385	364	21	1369	1218	151	55	48	7	5	1	4	1814	1631	183
2010/11	378	359	19	1089	952	137	79	71	8	4	2	2	1550	1384	166
2011/12	361	343	18	1248	1189	59	74	72	2	1	0	1	1684	1604	80
2012/13	374	357	17	1491	1364	127	75	70	5	0	0	0	1940	1791	149
2013/14	290	284	6	1213	1141	72	72	62	10	0	0	0	1575	1487	88
2014/15	286	279	7	1230	1163	67	60	47	13	0	0	0	1576	1489	87

Appendix 2: Annual estimates of total pup production for each colony and for total Auckland Islands pup production

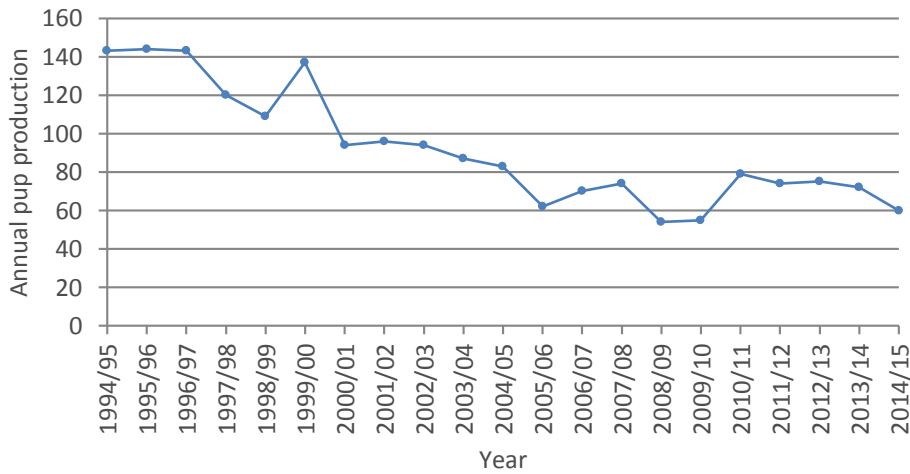
(NB. Data prior to 2012/13 from Chilvers (2012))



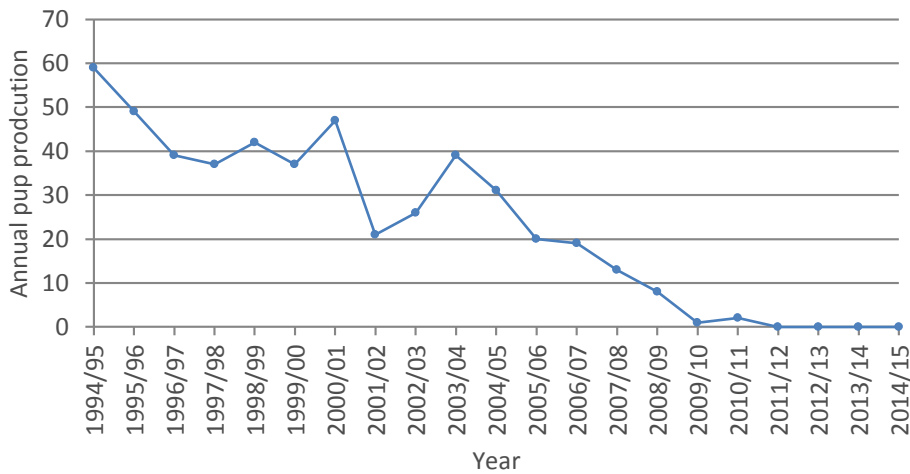
Annual pup production at Dundas Island



Annual pup production at Figure of Eight Island



Annual pup production at South East Point



Appendix 3: Raw data for pup production estimates for Sandy Bay, Dundas Island and Figure of Eight Island³

Mark recapture individual counts for Sandy Bay, 16 January 2015		
No. of animals marked = 139 (i.e. 1 cap found (i.e. fell off) before MR)		
	Number marked counted	Number unmarked counted
Counter 1-1	124	122
Counter 1-2	128	137
Counter 1-3	131	135
Counter 2-1	82	79
Counter 2-2	102	101
Counter 3-1	130	147
Counter 3-2	115	120
Counter 4-1	93	88
Counter 4-2	124	113
Direct live pups counts for Sandy Bay, 16 January 2015		
	Number counted	
Counter 4-1	280	
Counter 5-1	263	
Counter 5-2	284	
Counter 5-3	279	
Counter 5-4	293	
Counter 5-5	276	
Counter 6-1	271	
Counter 6-2	264	
Counter 6-3	283	
Counter 3-1	272	
Cumulative dead pup counts for Sandy Bay to 16 January 2015		
	Cumulative number counted	
Cumulative count	7	
Mark recapture estimates for Dundas Island, 19 January 2015		
No. of animals marked = 395 (i.e. 5 caps found (i.e. fell off) before MR)		

³ The identity of the individual counters is indicated by “Counter 1-“ being the first person, “Counter 2-“ being the second, etc. This identifier is used throughout all the counts in this Appendix but is not consistent with previous years. Details of counters is available from DOC.

	Number marked counted	Number unmarked counted
Counter 1-1	284	657
Counter 1-2	299	606
Counter 1-3	291	547
Counter 2-1	238	459
Counter 2-2	248	432
Counter 2-3	262	495
Counter 3-1	302	589
Counter 3-2	303	560
Counter 3-3	319	618
Direct counts for number of live pups for Dundas Island, 19 January 2015		
Number counted		
Counter 1-1	1027	
Counter 1-2	1054	
Counter 2-1	1073	
Direct counts for number of dead pups for Dundas Island, 19 January 2015		
Number counted		
Count 1	67	
Count 2	67	
Count 3	67	
Direct counts for number of live pups for Figure of Eight Island, 10 January 2015		
Number counted		
Counter 2-1	46	
Counter 3-1	44	
Counter 1-1	48	
Direct counts for number of dead pups for Figure of Eight Island, 10 January 2014		
Number counted		
Counter 4-1	13	
Counter 1-1	13	
Counter 5-1	13	

Appendix 4: Description of breeding area searched during pup counts at Sandy Bay, Enderby Island

The following figure provides a graphical presentation of the “entire breeding area” searched during pup counts at Sandy Bay, Enderby Island. All of the beach and surrounding sward (e.g. green, grassy area adjacent to the beach) constitutes the “entire breeding area” but the forested area is excluded. On 16 January, when the mark-recapture counts are undertaken, pups are almost exclusively restricted to the beach area, although sometimes a few pups have moved up onto the sward but no more than 20-30 m from the beach itself.

This image is taken from Baker B, Jenz J and Chilvers L (November 2012). Aerial survey of New Zealand sea lions – Auckland Islands 2011/12. Report prepared for Ministry of Agriculture and Forestry, Deepwater Group Limited and Department of Conservation. 11 p.



Appendix 5: Direct counts made at Sandy Bay, Enderby Island.

Date	Live pups			Cumulative dead pups			Adult females			Adult males			Sub-adult males		
	Beach	Sward	Total	Beach	Sward	Total	Beach	Sward	Total	Beach	Sward	Total	Beach	Sward	Total
08/01/2015	282	0	282	2	0	2	242	0	242	61	34	95	17	16	33
09/01/2015	No count as team at Figure of Eight Island														
10/01/2015	No count as team at Figure of Eight Island														
11/01/2015	282	0	282	3	0	3	158	17	175	60	23	83	15	37	52
12/01/2015	289	0	289	4	0	4	212	7	219	46	20	66	14	29	43
13/01/2015	294	0	294	5	0	5	159	0	159	44	19	63	25	16	41
14/01/2015	285	0	285	6	0	6	219	0	219	35	29	64	58	21	79
15/01/2015	272	0	272	7	0	7	219	0	219	49	18	67	49	31	80
16/01/2015	271	3	274	7	0	7	215	0	215	51	19	70	31	19	50
17/01/2015	281	3	284	9	0	9	190	61	251	26	39	65	29	42	71
18/01/2015	277	2	279	9	0	9	175	23	198	25	29	54	27	31	58
19/01/2015	276	6	282	9	0	9	139	36	175	22	22	44	24	24	48
20/01/2015	270	6	276	9	0	9	157	38	195	28	7	35	30	22	52
21/01/2015	278	3	281	10	0	10	149	26	175	23	13	36	29	38	67
22/01/2015	276	5	281	10	0	10	171	39	210	20	9	29	36	36	72

Appendix 6: Approximate location of where mark-recapture caps were put out on pups on Dundas Island

The following figure identifies the approximate number and location of where 400 mark-recapture caps were put out on Dundas Island for the mark phase of the mark-recapture. Please note that this aerial image of Dundas Island was provided by Barry Baker (Latitude 42) but is from 2011/12 and therefore the location of pups shown on this image does not reflect the location of pups in 2014/15 but has been used here for illustrative purposes.



Appendix 7: Recording of effort data for resightings

The following table provides a example of the effort data that were collected for all the resighting work during 2013/14.

Date	Location	Person	Start time	End time	Total effort	Wind	Cloud Cover	Weather	Notes
9/01/2014	F8	AM	10:30	11:30	1:00	SW20	8/8	Overcast	
9/01/2014	F8	DMD	10:02	11:30	1:28	SW20	8/8	Overcast	
9/01/2014	F8	NTS	10:30	11:30	1:00	SW20	8/8	Overcast	
9/01/2014	F8	SAM	10:30	11:30	1:00	SW20	8/8	Overcast	
9/01/2014	F8	SC	10:02	11:30	1:28	SW20	8/8	Overcast	
11/01/2014	SEP	AM	10:02	14:30	4:28	W25	8/8	Overcast	
11/01/2014	SB	DH	17:25	18:08	0:43	W15	8/8	Overcast	
11/01/2014	SB	DH	21:05	21:21	0:16	W15	8/8	Overcast	
11/01/2014	SB	DH	21:23	21:41	0:18	W15	8/8	Overcast	
11/01/2014	SB	SC	21:13	21:44	0:31	W15	8/8	Overcast	
12/01/2014	SB	AM	9:00	15:00	6:00	W20	5/8	Showers	
12/01/2014	SB	DH	9:00	9:34	0:34	W10	6/8	Overcast	
12/01/2014	SB	DMD	9:07	15:21	6:14	SW20	5/8	Overcast	
12/01/2014	SB	NTS	9:07	15:21	6:14	SW20	5/8	Overcast	
12/01/2014	SB	SAM	9:00	15:20	6:20	W10	6/8	Overcast	

Appendix 8: Survey of mud holes and existing ramps at Sandy Bay, Enderby Island

Prepared by Sarah Michael.

This survey was carried out on 20 January 2015, when the vast majority of NZSLs were in harem on the beach. Potential problem holes were described, but not necessarily all became dangerous for pups this season. Ramps that were installed this season to the described holes are listed below in bold text but further information is available in Appendix 10. Estimates of trapped and dead pups in mud holes at this early stage of the season are likely poor indicator of overall mortality and activity as most pups were only beginning to disperse to the areas of danger. An overview of the location of mud holes and existing ramps has been marked on an aerial photograph of the Sandy Bay sward at the end of this appendix. Descriptions of each hole are provided below.

Mud hole 1 (50°30.079'S, 166°17.357'E)

- Steep sided water-filled pool with long undercut channels, including several underground sections leading to lower pools (see images next page)
- No ramps present
- No visible dead pups
- No trapped live pups
- Nearest pups approximately 200 metres away
- **During 2014/15 season ramps 10 and 10B were constructed at this site. The lower section of this mud hole (ramp 10B) only became a problem late in the season following heavy rainfall, preventing escape through the underground channel. Ramp 11 was built close by on a potential tributary**





Mud hole 2 (50°30.048'S, 166°17.586'E)

- Deep (3-4 metres) mud hole with steep sides and overhanging vegetation
- Two staircases present at eastern and western end (constructed in 2013/14 season)
- No visible dead pups
- No trapped live pups
- Nearest pups over 600 metres away
- **This hole was a significant problem in the 2013/14 season but pups did not disperse to this area in 2015**



Mud hole 3 (50°30.054'S, 166°17.601'E)

- Deep (3-4 metres) and long mud hole channel with steep sides and some land bridges over underground sections
- One staircase and one wooden ramp present at eastern end
- No visible dead pups
- No trapped live pups
- Nearest pups over 600 metres away
- **This hole was a significant problem in the 2013/14 season but pups did not disperse to this area in 2015**



Mud hole 4 (50°29.997'S, 166°17.568'E)

- Shallow water-filled channels
- No ramps present
- No visible dead pups
- No trapped live pups
- Nearest pups over 600 metres away



Stream system 5 (50°29.943'S, 166°17.290'E)

- Up to 1 metre deep series of undercut streams with overhanging vegetation. Grass mats completely cover some areas of stream through which pups could potentially fall
- No ramps present
- No visible dead pups
- No trapped live pups
- Nearest pups approximately 200 metres away
- **During 2014/15 season ramps 7, 8 and 9 were constructed at this site**



Stream system 6 (50°29.928'S, 166°17.133'E)

- Approximately 50 cm deep undercut streams with overhanging vegetation
- Two dug out ramps present
- No visible dead pups
- No trapped live pups
- Nearest pups approximately 100 metres away
- **During 2014/15 season ramps 1,2,4,5 and 6 were constructed at this site**



Stream system 7 (50°29.946'S, 166°17.058'E)

- Approximately 50 cm deep undercut streams with overhanging vegetation
- No ramps present
- No visible dead pups
- No trapped live pups
- Nearest pups approximately 100 metres away
- **During 2014/15 season ramp 4 was constructed at this site.**



Aerial photograph of Sandy Bay showing location of mud holes and stream systems



Aerial photograph (approx. 1000 m altitude) of Sandy Bay sward with locations of mud holes and existing ramps. Image courtesy of Barry Baker.

Appendix 9: Survey of mud holes and ramps at Dundas Island, Auckland Islands

Prepared by Sarah Michael.

This survey was carried out on 18 January 2015 when the vast majority of NZSLs were in harem on the beach (southern) end of the Island. Estimates of trapped and dead pups in mud holes at this early stage of the season are likely a poor indicator of overall mortality and activity as most pups were only beginning to disperse to the areas of danger. An overview of the location of mud holes and ramps have been marked on an aerial photograph of Dundas Island at the end of this appendix. Descriptions of each hole are provided below.

Mud hole 1 (50°34.603'S, 166°19.243'E)

- Small pool with thick mud
- No ramps present
- No visible dead pups
- No trapped live pups
- Nearest pups approximately 20 metres away



Mud hole 2 (Western extent: 50°34.605'S, 166°19.232'E, Southern extent: 50°34.626'S, 166°19.290'E, Eastern extent: 50°34.590'S, 166°19.290'E)

- Long convoluted channel with branches and islands encircling approximately half the Island
- 2 wooden ramps present on western side, 1 on the southern side. All overgrown with vegetation. Several ramps made of large submerged rocks present over length of mud hole
- 2 live pups retrieved (one flipper tagged red coffin M761, one untagged pup in below image)
- 4 untagged dead pups visible, all around extent closest to beach colony
- Nearest pups approximately 1 metre away at closest





Mud hole 3 (50°34.581'S, 166°19.197'E)

- Stellate pool with undercut sides and overhanging vegetation
- 1 ramp present
- No dead pups visible
- No trapped live pups
- Nearest pups approximately 15 metres away





Mud hole 4 (50°34.573'S, 166°19.193'E)

- Small pool with undercut sides and overhanging vegetation
- 1 ramp present
- No dead pups visible
- No trapped live pups
- Nearest pups approximately 20 metres away





Mud hole 5 (50°34.571'S, 166°19.200'E)

- Small pool with undercut sides and overhanging vegetation
- No ramps present
- No visible dead pups
- No trapped live pups
- Nearest pups approximately 30 metres away



Mud hole 6 (50°34.579'S, 166°19.265'E)

- Shallow pool with thick mud
- No ramps present
- No visible dead pups
- No trapped live pups
- Nearest pups approximately 10 metres away



Aerial photograph of Dundas Island showing location of mud holes and stream systems



Aerial photograph (approx. 1000 m altitude) of Dundas Island with locations of mud holes and existing ramps. Image courtesy of Barry Baker.

Appendix 10: Description and location of mud holes and ramps installed at Sandy Bay, Enderby Island 2015

The following provides a description and the location of mud holes and ramps installed at Sandy Bay, Enderby Island February and March 2015. Prepared by Sarah Michael.



The following table provides GPS coordinates of wooden ramps installed in 2014/15 season at Sandy Bay.

Ramp	Latitude	Longitude
1	50°29.941'S	166°17.095'E
2	50°29.936'S	166°17.120'E
3	50°29.943'S	166°17.058'E
4	50°29.935'S	166°17.093'E
5	50°29.929'S	166°17.091'E
6	50°29.961'S	166°17.075'E
7	50°29.963'S	166°17.254'E
8	50°29.935'S	166°17.294'E
9	50°29.944'S	166°17.292'E
10	50°30.079'S	166°17.352'E
10B	50°30.083'S	166°17.354'E
11	50°30.090'S	166°17.362'E

Aerial photographs of Sandy Bay sward showing location of installed ramps



Aerial photographs (approx. 1000 m altitude) of Sandy Bay sward with locations of installed ramps 1-6. Image courtesy of Barry Baker.



Aerial photographs (approx. 1000 m altitude) of Sandy Bay sward with locations of installed ramps 7-9. Image courtesy of Barry Baker.



Aerial photographs (approx. 1000 m altitude) of Sandy Bay sward with locations of installed ramps 10-11. Image courtesy of Barry Baker.