



New Zealand Sea Lion Monitoring and Pup Production at The Auckland Islands 2018/2019 Research Report



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Executive Summary

This report outlines components of the New Zealand sea lion (*Phocarctos hookeri*, 'sea lion') population monitoring work on the Auckland Islands as a part of the wider New Zealand sea lion Threat Management Plan. This work consists of two major components:

- The population monitoring (i.e. pup production) work funded by the Conservation Services Programme (CSP), and
- The population demographics and pup mortality work funded by the New Zealand sea lion Threat Management Plan (TMP).

During the 2018/19 field season, a total pup production estimate of 1,679 was acquired for sea lion colonies at Enderby Island (Sandy Bay 319, South East Point 0), Dundas Island (1,295) and Figure of Eight Island (65). This estimate is 6% lower than the 2017/18 estimate of 1,792; 44% lower than the peak pup count of 3,021 in 1997/98, and 12% higher than the lowest recorded pup count of 1,501 in 2008/09. The 2018/19 estimate appears to continue a relatively stable trend over the past 11 years following steady declines since the 1990s.

Flipper tags and microchips were used to permanently mark 767 pups (312 at Enderby, 400 at Dundas, and 55 at Figure of Eight). One hundred pups on each of Enderby and Dundas Islands were weighed and measured.

The population monitoring conducted in 2018/19 also included 44 daily counts of sealions at Sandy Bay, six whole-island sea lion counts of Enderby Island, and 3,296 total tag resightings acquired from the Auckland Islands (once matching occurred to remove any resights that were not comparable to an existing tag). Sea lion pup mortality investigations for 2018/19 will be reported separately. The project outputs contribute to the ongoing study to inform management decisions for the species in the future.

1. Introduction

The New Zealand sea lion (*Phocarctos hookeri*, 'sea lion') is considered to be the world's most endangered sea lion (Geschke & Chilvers, 2009). Due to the 50% drop in the number of pups born annually between 1998 and 2009 at the Auckland Islands, and the third lowest pup count in the history of monitoring in 2014, the New Zealand sea lion Threat Management Plan (TMP) was commissioned. The TMP's vision is to "*promote recovery and ensure the long-term viability of New Zealand sea lions*". This includes, but is not limited to, the long-term monitoring of demographic parameters, with the use of tag resights, and mortality investigations.

As a project delivered under the Conservation Service Programme (CSP), measuring pup production was continued through counting, tagging, and microchipping pups. This paper reports on the field work undertaken by researchers from 10 January to 9 March 2019 on the Auckland Islands (note: the field work conducted on Figure of Eight Island was undertaken by a separate team but is included in the document for completeness). This information is valuable for monitoring whether the TMP is on track to protect and recover this species, or whether actions need to be reviewed.

2. Objectives

1. Conduct direct counts and mark-recapture estimates of pup production at Enderby Island (Sandy Bay and South-East Point), Dundas Island, and Figure of Eight Island (only direct count);

2. Double flipper tag and microchip all pups at Sandy Bay and Figure of 8, and 400 pups at Dundas (300 females and 100 males);
3. Weigh and measure, (dorsal straight length and axillary girth) a sample of 100 pups (50 males and 50 females) at Sandy Bay and Dundas;
4. Daily counts of dead and live animals at Sandy Bay and weekly around Enderby Island;
5. Improve understanding of population dynamics:
 - Resight tagged animals including recording of PIT tags;
 - Acquire photos of animals with shark scars or distinct scarring to develop a library for identifying individuals;
6. Post-mortems (briefly summarised but reported on separately); and
7. Monitoring “Planks for Pups” and establishing new ramps as needed.

Note: Points 1-4 are the core part of the CSP pup monitoring programme and that points 5-7 are part of the wider TMP.

3. Logistics

The field season was largely split into two components as the priorities transitioned from the CSP portion of the project to the TMP portion. There was a change in personnel between phases of field work, with one team member remaining throughout the season to allow for cross-over and consistency.

3.1. Summary of Key dates:

- 8 January – Five researchers (Don Neale, Mike Morrissey, Karen Ismay, Eleanor Cooper, and Helena Dodge) departed Bluff aboard RV *Evohe* for the Auckland Islands.
- 10 January – Team arrived at Enderby Island.
- 10-14 January – Hut set up, familiarisation with site, animals, and tasks, resighting, and counts.
- 15-16 January – Sea lion counts, pup marking, and mark-recapture count, and weighing/tagging at Sandy Bay.
- 17- 21 January – Team of three (Neale, Morrissey, and Dodge) were transported via Helicopter to Dundas for counts, pup marking, mark-recapture counts, and tagging/weighing. Additional researchers (Ismay and Cooper) were transported over via helicopter for the day on the two days the weather permitted.
- 17 January – 10 February- Research continued towards acquiring daily counts, looking for dead pups to necropsy, and resighting tags.
- 27 January – Two researchers (Morrissey and Ismay) depart Enderby Island aboard RV *Evohe*.
- 7-8 February – A separate team undertakes the Figure of 8 tagging and pup production estimate (dropped off by RV *Evohe*).
- 10 February – RV *Evohe* arrives for a personnel change. Neale and Cooper depart from Enderby, Dodge remains and is joined by Aditi Sriram, and Andrew Eastwood for focused mortality investigation and resighting.
- 9 March – Three researchers depart Enderby on RV *Evohe*, concluding the sea lion 2018/19 field season.

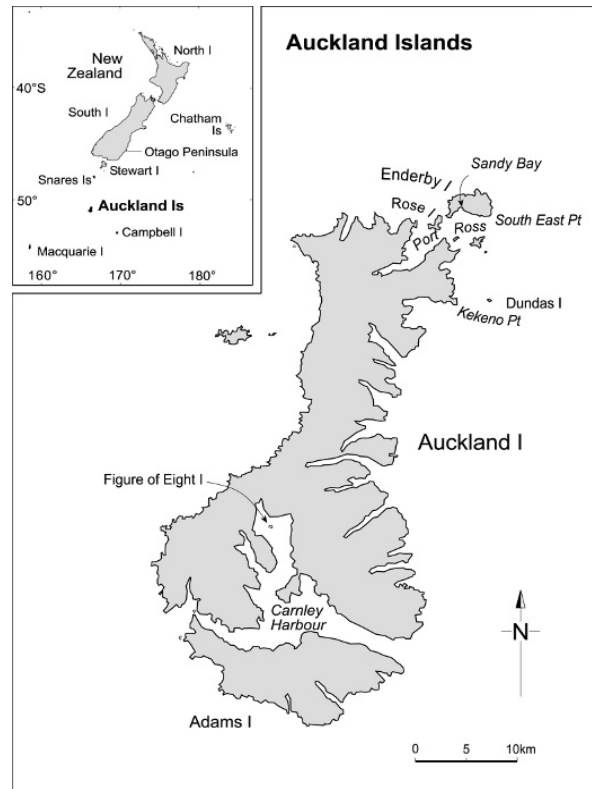


Figure 1. Map of the Auckland Islands as a reference for sites mentioned in the text: Figure of Eight, Dundas, Enderby, and Auckland Islands.

4. Methods

4.1. Pup production estimates on Enderby, Dundas and Figure of Eight

Direct counts of pups, direct tagging counts, or mark-recapture techniques were used to estimate pup production for the three islands. The live count/estimate is added to the dead count for a total pup production estimate. The dead count is performed first as to not miscount a pup as live that may be dead, then direct counts, then the M-R count. On Enderby Island the three types of counts were undertaken at Sandy Bay. Direct counting methods were also performed at South East Point (SEP) on Enderby, but no pups have been recorded there since the 2011/12 field season. Direct counts and mark-recapture counts were performed at Dundas, and a direct count of tagged pups was done at Figure of 8.

4.1.1. Dead counts

The total count of dead pups was performed first on the date that pup production estimates are counted.

At Enderby, in order to investigate mortality, from the team's time of arrival, dead pups were counted and collected daily, as they were found, prior to the live count. The carcass was spray-painted and disposed of far from the colony as to not be recounted as an additional dead pup in the days to come.

This count is acquired differently at Dundas, due to teams only being able to be present at Dundas for a limited number of days. On the morning of 18 January, prior to the direct live count, a single count of dead pups was performed by the five team members. The whole team of five walked around the island in a line transect and counted the number of dead pups with one person recording

cumulative counts. To ensure individual pups were not recounted, once a carcass was called out to the other team members and to the recorder, the carcasses were sprayed with a fluorescent stock spray paint. Due to the land layout and distribution of pups on Dundas, the count was divided into two main areas as indicated by the approximate areas within the yellow and green borders depicted in Figure 2. First, the team members were spread out in a straight line width-wise across the vegetation and rocky shore areas, and moving forward together as a team performed a full circumference sweep of that portion of the island (indicated within the yellow border seen in Figure 2). Second, the south eastern sandy beach where the largest aggregation of sea lions and pups were located was surveyed in a similar matter (approximately within the green border seen in Figure 2 below). The five researchers were spread out in a line across the beach covering the area from the start of the sandy beach to the exposed tide line (pups in the immediate shallow water/rocky shelf were considered). The count was conducted between 8-9am, so it was approximately halfway through the tidal cycle (low tide 5:22am, high tide 11:39am). The team members slightly adjusted as needed to maneuver around the harems. When possible, carcasses were removed and placed in a group, away from the harems. On certain occasions where highly decomposed carcasses were unable to be retrieved, they were returned to and collected once it was safe to approach.



Figure 2. Image of Dundas Island with the approximate surveyed areas indicated within the bordered colours.

For Figure of 8, the dead pups were counted at the same time the two-day island survey was done on 7 – 8 February. Dead pups were easily reidentified, due to a low number of deaths, and a smaller area of coverage, so once they were made known to the team members, they were left in place.

4.1.2. Direct counts

A direct count of all the live pups was conducted at Sandy Bay on Enderby Island on 16 January. At this time, the colony was restricted to the beach, as with majority of previous years; therefore, direct counts of pups are considered complete. Counts of all live pups were conducted walking along the beach/sward (grassy areas spanning between beach and forest) margin and on the beach amongst the colony when necessary to view pups, typically staying within close proximity to other counters to ensure safety. Each team member performed two individual counts of the total number of pups with tally counters, giving a total of ten counts.

Direct counts of all animals were conducted at South East Point (SEP) when performing around the island surveys of Enderby. Counts took place every 4-7 days between 12 January to 5 March. SEP is a smaller rocky coastal area that is manageable and straightforward to survey. Counts were conducted at the rocky beach edge with hand tally counters, or verbally when applicable, and counts were recorded. In surrounding areas where there was a grassy sward inland from the shore, team members (typically 3-4 people) would spread out along the sward/tussocks/forest edge 20-40 meters apart (or closer depending on the size of the area that needed to be covered) to survey the area within their line transect. The team members remained in visual and verbal communication and pointed out/indicated which animals they were recording if there were any sea lions near the border of the researchers transects that could have otherwise possibly been counted twice. These numbers were recorded by each researcher and were reported to one person at the end for a total. At SEP there were no pups to be directly counted, but methods to perform the direct count were always performed when completing an around island survey to ensure appropriate monitoring of potential presence of pups.

As with direct counts on Enderby, on Dundas (on 18 January) each team member used a tally counter as they walked around the island to take a count of all the pups, for a total of five counts. As the sandy beach is an area with such a large amount of sea lions, counters largely separated the survey into two sections for a more manageable approach, as indicated in the Dead Count Methods and in Figure 2 above. This was done within the same survey time frame, but counters seemed to find it helpful to have the sandy boarder (indicated within the green outline) as a clear indication of an area that hadn't been counted yet. The three counts on Dundas were overall performed with this as a search pattern. While Mark-Recapture (M-R) counts were the primary method for estimating pup production at Dundas, direct counts of pups were undertaken prior as a comparative reference.

At Figure of 8, direct pup counts were conducted on the 7 and 8 February. The pup production estimate comes from the sum of the direct number of pups that were tagged over the period of two days, the number of pups unable to be tagged, and the number of dead pups found. A team of four spread out in a straight line covering the top half of the island width-wise and moved around the island starting from one end and moving to the other end. Once at the other end, the team shifted down and covered the bottom half of the island as before, until all areas were covered and as many pups as were possible to access were tagged or otherwise counted. This was performed twice over two days.

4.1.3. Mark-recapture estimates

Mark-recapture experiments were performed on 16 January at Sandy Bay, and on 18 January at Dundas. Pups were marked with circular ~5cm diameter flexible and flat caps (yellow at Enderby, red at Dundas) glued squarely on top of their heads using fast-setting Loctite glue. When marking,

caps are spread as evenly as possible amongst pups based on the current distribution. Whenever possible, capping occurs the night prior to the M-R count to allow for redistribution of marked and unmarked pups. At Sandy Bay, capping occurred on 15 January, and at Dundas, on the evening of 17 January and some on the morning of 18 January (due to logistics and timing). For Dundas, after the last remaining caps were applied the morning of 18 January, a little over two hours was given prior to starting the M-R count to allow for some additional movement and mixing of the pups within the colony.

On Enderby, three counters (the two other researchers observing the environment to ensure safety of counters) walked through the colony with two tally counters each (one labelled for marked and one for unmarked pups). Only the pups that counters could see the entire head of were counted to ensure proportions were not skewed or pups were not incorrectly indicated as capped or uncapped. Counters did not talk during the count unless to confirm that all areas had been covered. This was continued on rotation until each of the five team members completed two counts, for a total of ten counts. On Dundas, M-R counts were performed similarly (and each of the 5 researchers performing 2 counts each) with the only difference being, all researchers performed counts at the same time but remained close to other counters for safety.

M-R estimates of pup production were calculated using the Petersons estimate (described in Chapman (1952)) as indicated in Chilvers (2012). Assumptions of the M-R model remained consistent with those mentioned in Chilvers (2012). For example, all pups are: assumed born by M-R dates, accessible for marking, mobile/mixed well after marking. In addition, caps were not lost prior to M-R counts, and mortality was negligible/assumed to be zero in the time between marking and recapturing.

4.2. Methods used to tag animals

Pups at Enderby, Dundas, and Figure of 8 were tagged in both trailing edges of the foreflippers with Dalton Superflexi (Allflex group Germany). The tags used are laser marked coffin shaped tags with a unique alphanumerical combination. Each island was allocated a different colour or alphanumerical series (pink tags for Enderby and Figure of 8, and blue tags for Dundas). During handling for the tagging, the ventral surface of each animal was observed to determine and record the pup's sex. At Dundas and Enderby, the pup would then be lifted onto a padded "tagging table" to measure, flipper tag, and PIT tag. At Figure of 8, pups were flipper tagged (did not have a tagging table, performed tagging on the ground) and PIT tagged.

All of the pups tagged were implanted with a passive integrated transponder (Trovan Unique ID100, Microchips Australia). This is a subcutaneous microchip injected into the hind quarters of the pups (dorsal surface) to provide an alphanumerical code unique to each animal. Prior to inserting the microchip, the surface of the injection site was sprayed with a betadine solution to ensure the area was clean prior to PIT tagging. If pups were too muddy or couldn't be cleaned adequately, they weren't microchipped in order to reduce the likelihood of infection.

4.3. Methods to weigh and measure pups

The first 50 of each sex at each island (Dundas and Enderby) were weighed and measured. Standard length (tip of nose to tip of tail on a table), and axillary girth of the pups were taken with a measuring tape. After the tagging and measuring was complete the animal was put into a canvas bag to weigh. To remain consistent, weights and measurements were obtained on or closest to the day as possible

as weights taken in years past. Weights and measurements were taken on Enderby on 15 January, and 18 and 19 of January on Dundas. Pups on Figure or 8 were not weighed or measured.

4.4. Daily counts of dead and live animals at Sandy Bay and weekly around Enderby

4.4.1. Daily counts at Sandy Bay

Daily counts of live and dead pups, females, juvenile/sub-adult males (SAMs), and adult males were conducted from 11 January to 5 February at Sandy Bay on Enderby. Typically, two people did a count in the mornings covering sub-areas of the beach, sward, and up into the forest. Counts of pups, females, SAMs, and adult males, are recorded within each sub-area and combined to provide a total for each age/sex class observed for the day. For more detail on the methods performed when a dead was found during the daily count, see section 4.6 below. As the animals shifted up/north from Sandy Bay and then along the sward/forest from the west to east, the counters shifted with the location of the colony for the count. Figure 3 indicates an approximation of the area covered within the daily counts which would vary some based on current sea lion distribution. As the sea lions started spreading out amongst the sward and into the forest, the researchers found it helpful to have two counters, to allow for discussion and confirmation of particular areas that had or had not been counted yet. In these instances, there was some collaboration in the count as one researcher would indicate the number and what type of individual was seen in a hidden spot, and both would record these animals.

As the pups spread further into the forest collaboration was needed between the two counters to cover larger sections of the forest, and they would report the number seen in their search section to the other counter, who would add that to their total. For example, researchers would discuss and decide on a location to search such as to the north of the stream and to the south of the stream (including pups in the stream), they would each perform their count and give those numbers to the other counter for their total. The researchers continued to keep in contact either visually or verbally as they undertook that portion of the count. This year there was potentially a deeper investigation into the forest for daily counts. Therefore, the counts after the animals moved off the beach and into the sward/forest (on the 20 January), may not be comparable to the counts in past years, but may serve as some supplemental information. In the future it would be beneficial to have a clear boarder in which the daily count should be contained in, for consistency over the years.



Figure 3. Image indicating the approximate search boarder for the daily counts, and also for the daily dead runs. Note: these boarders are not exact and team members would shift as needed, deeper into areas if a presence of sea lions was detected.

4.4.2. Around the island counts

Throughout the season an “Around Island” walk would be undertaken. Figure 4 shows the track (indicated by a dashed line) that is taken for the walk which encompasses about 75% of the island’s perimeter. This typically occurred every 4-7 days and included 2-5 people (typically 3 or 4). Like daily counts at Sandy Bay, any pups, adult females, SAM’s, and adult males are counted and recorded. The researchers would spread out in transects along the tack from the beach line and up into the sward/forest edge and count the animals in their direct transect (further description of this transect survey approach is mentioned above in the direct count of SEP methods section). These were reported to one person who recorded the total numbers. There was always a search for pups but with additional focus and interest at South East Point which has not been identified as a breeding colony since the 2011/12 breeding season.

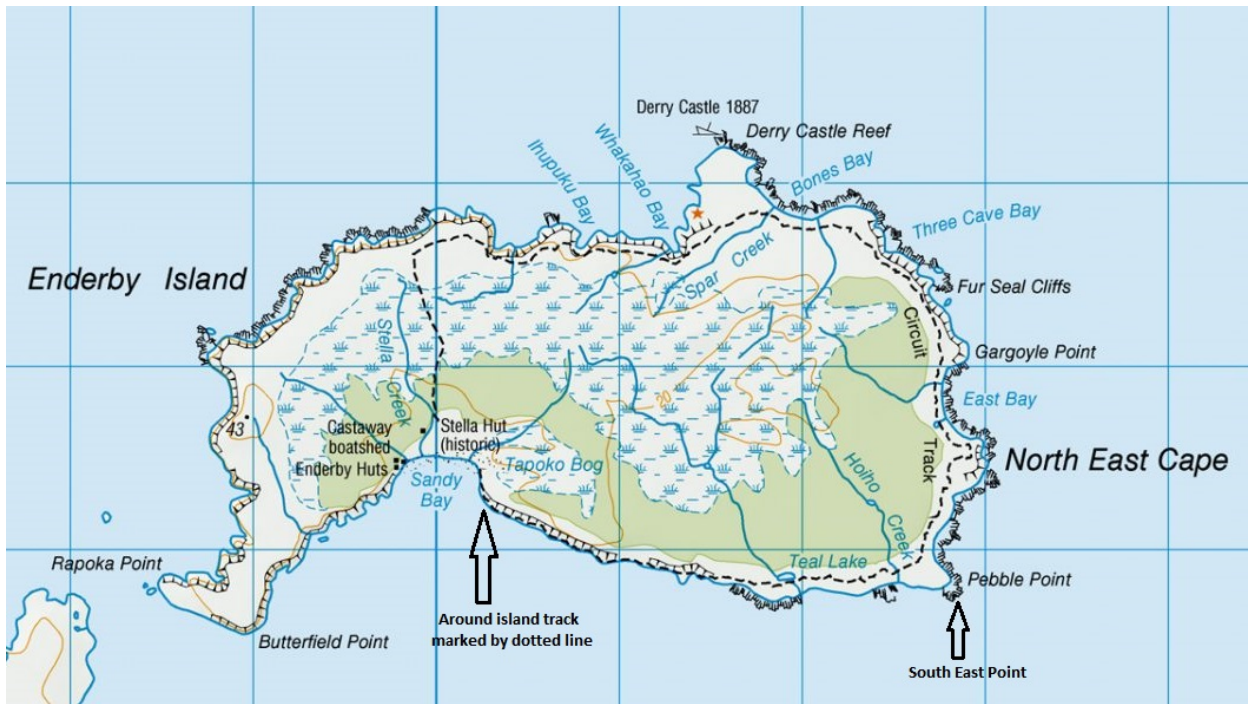


Figure 4. Map of Enderby Island for an indication of the track taken for the Around the island count.

4.5. Improve understanding of population dynamics

4.5.1. Resighting of tagged animals

Resights of tags were taken daily on Enderby throughout the season starting from 11 January to 5 March. The tag ID (four digits alphanumeric) was recorded along with tag colour, shape, presence or absence of tags in each flipper, sex, the sub area of the animal (beach, sward, or bush) and the behaviour of the animal. The behaviour descriptions included: A-Alone, IH-in harem, NP-Nursing Pup (Female nursing a pup, and when possible the pups tag number is also recorded in association to the nursing mother), CP-female calling pup, and WP-female with pup, PM-peripheral male, TM-Territorial male, D-dead, P- pup, NF-pup nursing from female (plus female tag number if possible). Often SLR cameras are used with telephoto lenses to assist in capturing the tag number. Typically, resights were done with one person in the morning and two or three people in the afternoon, making their way through the whole colony taking anywhere from two-three hours for each person. When undertaking the round island counts on a weekly basis, resighting tags was also a priority, in these instances the location on the island was also recorded.

Recordings of PIT tags was also undertaken which requires a close approach to scan a sleeping or distracted animal's hind quarters. A higher number of PIT tag reading occurred in the second half of the season. While some were scanned prior, from late January onwards, with harems breaking up, the sea lions are easier to approach which allows for more success in chip reading.

Resights occurred at Dundas as well, however due to logistics and time frames, the M-R counts and the tagging consumed the majority of the time on island. There was minimal spare time on Dundas for tag resights compared with Enderby resulting in fewer successful tag resights. For multiple reasons tag resightings are more difficult at Dundas; a smaller proportion of the population is tagged, the tags are well worn making them harder to read, and the animals are more densely packed into harems. As a result, in the time available only five tag resightings were collected at

Dundas. Due to power restrictions on Dundas, the PIT tag scanner was prioritized for using to scan chips while PIT tagging rather than for resighting PIT tags.

Two opportunistic tag resights occurred on Figure of 8.

4.5.2 Acquire photos of animals with shark scars or distinct scarring

Opportunistically throughout the field season, series of photos were taken (with SLR camera lenses) of animals that had shark scars or distinct scarring. These were taken in order to develop a library to identify unique animals in the future, and to potentially use the images to assess frequency of shark scarring, severity, and survival. Ideally a set of eight photos was taken whenever possible including: left front flipper, right front flipper (including tags when present), left hind flipper, right hind flipper, overall dorsal view, right side, left side, and overall ventral view. The photos were taken when the animal was asleep or otherwise distracted and were not disturbed by the photo taking. While it is not always realistic to acquire photos of every desired view of the animal at one time, over time, photos of different views of that animal will be taken to start to develop a library for specific animals. Once overall shots are obtained, a closer zoomed in view of the unique scar is taken (with a frame of reference to maintain an awareness of which portion of the animal the scar is on). These are then uploaded onto the computer with each individual having a separate folder under known and unknowns and filed based on the date they were taken. This work was conducted once a week, generally when the weather was better for quality images. Also, the focus was on building the library of unique individuals rather than attempting to get multiple resights of known animals.

4.6. Post-mortems

Pup mortality investigations were a large portion of the efforts for this field season (with an additional focused effort from the 10 February to the 9 March). These methods, efforts, and results will be reported in a separate report, however a short summary will be included here for completeness.

Starting from the team's first walk through of Sandy Bay on the 11 January 2019 through to the end of the season the 5 March Daily walks ("dead runs") were performed to look for pup carcasses. In the first portion of the season this was conducted as part of the Daily counts which occurred almost every morning (typically starting between 8-9:30am). If there was no count performed that day at least one person would survey the area where the sea lions were currently distributed in, to look for the presence of any carcasses. When a carcass was found, photos of the animal and its environment were taken along with a GPS point using a handheld Garmin (logged with an individual ascending post-mortem identification number). Depending on staffing and how far along the daily count or dead run was, the animal was either temporarily covered until completion of the survey (to prevent scavenging) or was transported back to camp at that time to have a necropsy performed.

A gross post-mortem was performed which included acquiring morphometrics, photos, and various samples. These samples were fixed in formalin and or liquid nitrogen for further histology/investigation (the Dewar containing Liquid Nitrogen arrived with the team on 10 February and was used for the post-mortems after that date). Upon completion of the necropsy, a post-mortem report was written for each individual case. On some of the days at the beginning of the season where the team was unable to conduct a full necropsy for various reasons (team tagging on Dundas, etc.) as much information on the carcass as possible was taken (photos, GPS location,

measurements, and blubber depth), and the carcass was marked with spray paint and removed from the colony to not be mistaken as an additional carcass in the future.

4.7. Monitoring “Planks for Pups” and establishing new ramps as needed

This season’s focus regarding ramps was operational to ensure pups could self-rescue from recognized terrain traps. From the start of the team’s arrival on Enderby, pre-existing ramps were identified, and new ramps were constructed for placement. Early on, two ramps were added to areas that appeared to be of high risk. Then throughout the season, as the pups distributed and spread from the beach out into the sward and forest, and new problem areas developed (with changes in weather and pup exploration), new ramps were added as needed. Close monitoring occurred typically two times a day, a quantitative recording of interactions was not considered necessary.

During daily counts or dead runs, streams, holes, and any pre-existing areas of known higher risk were checked for the presence of pups. In the afternoon, problematic areas were rechecked during tag resighting efforts. The team rescued pups as and when needed. The pre-existing ramps, that were still thought to be necessary by the end of the field season, were left in place. Photos and GPS points were taken of the ramps that remained in place.

5. Results and Discussion

5.1. NZSL pup production on the Auckland Islands (Enderby, Dundas, and Figure of Eight).

5.1.1. Enderby pup production including direct and M-R counts

Table 1: Summary of pup production estimates for Sandy Bay, 2018/19.

Method	Date	Number counts	Start end time	Estimate (SE)
Mean direct live count	16/1/19	10	0900-1050 (Earliest start to latest finish)	286 (2.4)
Cumulative dead count to the day of mark recapture	16/1/19	N/A	N/A	7
Mean mark recapture estimate	16/1/19	10	1145-1650	315 (3.2)
Total number of pups individually tagged	From 15/1/19	N/A	N/A	312 tagged

The total pup production for Sandy Bay in 2018/19 is estimated at 319 (312 live and 7 dead). This number reflects the total number of live pups tagged plus the number of dead pups cumulative to the day of pup production counts (from Table 1). With the tagging goal at Enderby being to tag as many pups as possible, a physical count of all the pups tagged is a more accurate representation of the population and remains consistent with the methods used to determine pup production at Sandy Bay in past years. The M-R is still undertaken for comparability in numbers but is not as necessary for accuracy in a smaller population of pups at Enderby. This year’s estimate is ~4% lower

than the 2017/18 season (332). Figure 5 shows annual estimates at Sandy Bay over time and a list of these annual estimates can be found in Appendix 1. There was a 2% mortality rate seen up to the day of the M-R. However, it is important to note that in the 2018/19 field season, carcass counting/daily retrieval only started on 11 January, compared with some other seasons where a field team was there from late November/early December. It is highly likely that some early season deaths were not captured due to events such as scavenging where the carcass would no longer be present in early January. Raw counts for Enderby Island are found in Appendix 2.

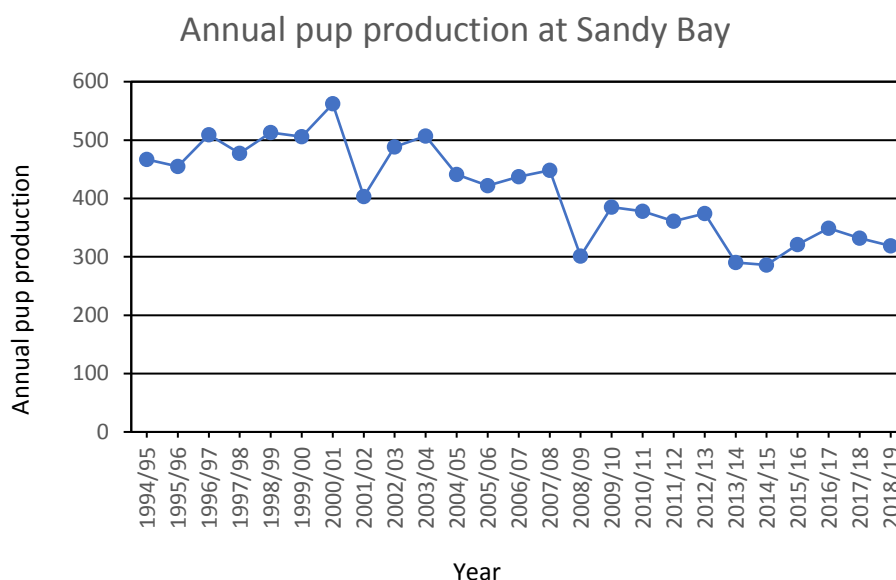


Figure 5. Total estimated pup production for New Zealand Sea Lions at Sandy Bay. 1994/95-2018/19. (Data prior to 2012/13 from Chilvers (2012) and data prior to 2018/19 from Childerhouse et al. (2018)).

5.1.2. Dundas pup production including direct and M-R counts

Table 2: Summary of pup production estimates for Dundas Island, in 2018/19.

Method	Date	Number counts	Start end time	Estimate (SE)
Mean direct live count	18/1/19	5	1130-1230	1310 (64.8)
Cumulative dead count to the day of mark- recapture	18/1/19	1 (plus recovered others as they became accessible)	0800-0905	55
Mean mark- recapture estimate	18/1/19	10	1250-1950 (Earliest start/latest finish) ¹	1240 (14.6)
Total number of pups individually tagged	17 & 18/1/19	N/A	N/A	400

¹ Majority of the counts were undertaken from 12:50pm – 14:30pm but upon looking at the raw data, the team lead decided that another pair of counts should be performed to improve precision, these were conducted between 1850-1950 hours.

The total pup production for Dundas Island in 2018/19 is estimated at 1,295 (1,240 live and 55 dead). This number reflects the mean of the mark-recapture estimate plus the dead count (Table 2). Historically, the mean of the M-R counts has been higher than the mean of the direct live count. However, for the 2018/19 Dundas count, the mean of the direct live count was found to be higher. This could be due to the complexity of the Dundas pup counts as they can prove difficult to count due to dynamics like continual mixing/movement and sheer abundance. This can result in a large range in direct counts which was seen this season (raw count data can be found in Appendix 3). The M-R method using a ratio of marked to unmarked pups helps to address the difficulties of counting many animals in a complex environment and is typically more accurate than a direct count.

In addition to complexities associated with the direct count, the standard error for the M-R count is typically found to be lower than that of the direct counts, which remains true for 2018/19 data. For these reasons, The M-R has been continually recognized as the more accurate representation of pup production estimates, and to remain consistent, was used to determine Dundas pup production estimates for 2018/19. This estimate of 1,295 is 7% lower than in 2017/18.

The number of dead pups found up to the 18 January is 4% lower than the 2017/18 season. Eight additional dead pups were found after the day of the M-R count (and up to the team departure from Dundas on 21 January 2019) but were not incorporated into the dead count for purposes of the pup production estimate. Figure 6 shows annual estimates of Dundas over time and in a table found in Appendix 1. Raw count data for Dundas Island this season can be found in Appendix 3.

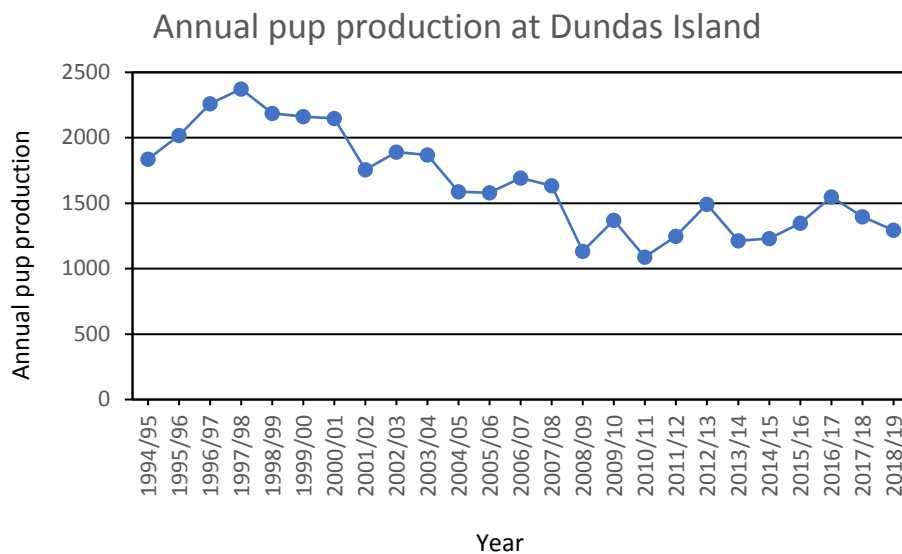


Figure 6. Total estimated pup production for New Zealand Sea Lions at Dundas Island. 1994/95-2018/19. (Data prior to 2012/13 from Chilvers (2012) and data prior to 2018/19 from Childerhouse et al. (2018)).

5.1.3. South East Point pup production with direct counts

For the 2018/2019 breeding season, the pup production at SEP is estimated at 0 (0 live and 0 dead). This remains consistent from what has been seen, as no pup production has been recorded at SEP since 2011/12 (Childerhouse et al., 2017). Annual estimates for SEP colony are shown in Appendix 1.

5.1.4. Figure of Eight total pup production and total pup estimate for 2018/19

Table 3. Summary of pup production estimates for Figure of Eight Island in 2018/19.

Method	Date	Estimate (Total estimate= # tagged+ # untagged+ # of dead)
Total number of tagged pups	7-8 February 2019	55
Total number of untagged pups	7-8 February 2019	5
Direct Dead Count	7-8 February 2019	5
Total Pup Production Estimate	7-8 February 2019	65

The total pup production for Figure of Eight Island is estimated at 65 (60 live and 5 dead). This represents a 3% increase from the 2017/18 field seasons estimate (63). The mortality rate for 2018/19 is 8% compared to 12% in 2017/18. This indicates a 4% decrease in mortality from 2017/18. Figure 7 shows pup production estimates at Figure of Eight over time. Annual estimates for Figure of Eight can be found in Appendix 1.

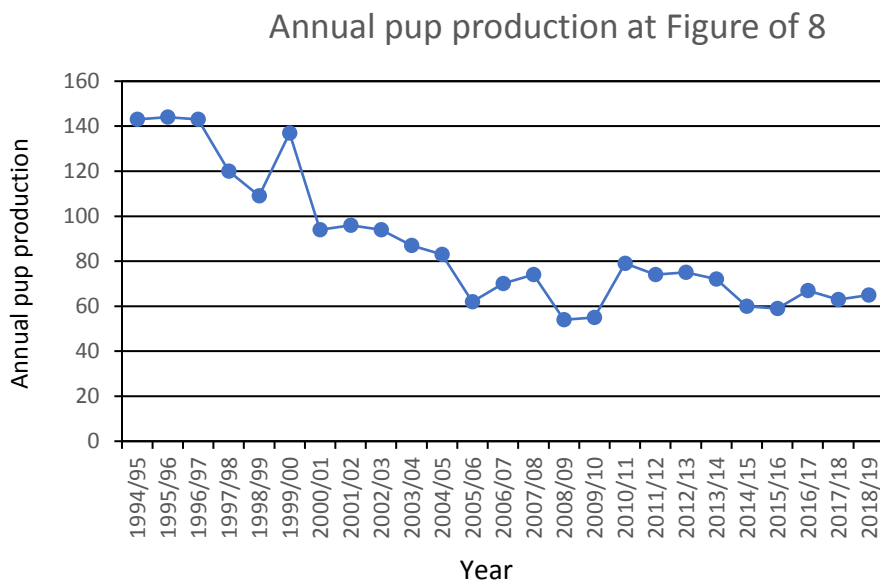


Figure 7. Total estimated pup production for New Zealand Sea Lions at Figure of Eight Island. 1994/95-2018/19 (Data prior to 2012/13 from Chilvers (2012) and data prior to 2018/19 from Childerhouse et al. (2018)).

5.1.5. Auckland Island total pup production

Table 4. Summary of Pup Production Estimates for The Auckland Islands in 2018/19.

Location	Total	Live	Dead
Sandy Bay	319	312	7
South East Point	0	0	0
Dundas	1295	1240	55
Figure of Eight	65	60	5
Total Auckland Islands	1679	1612	67

The overall pup production for The Auckland Islands for 2018/19 is estimated at 1,679 (1,612 live, 67 dead). This is a 6% decrease from 2017/18 Auckland Island pup production estimates. While this represents a 12 % increase from the lowest estimate in 2008/09 it's notable to indicate that this is a 44% decrease from the highest recorded estimate in 1997/98. Figure 8 shows annual pup production at the Auckland Islands over the years. Annual estimates for the Auckland Islands can be found in Appendix 1.

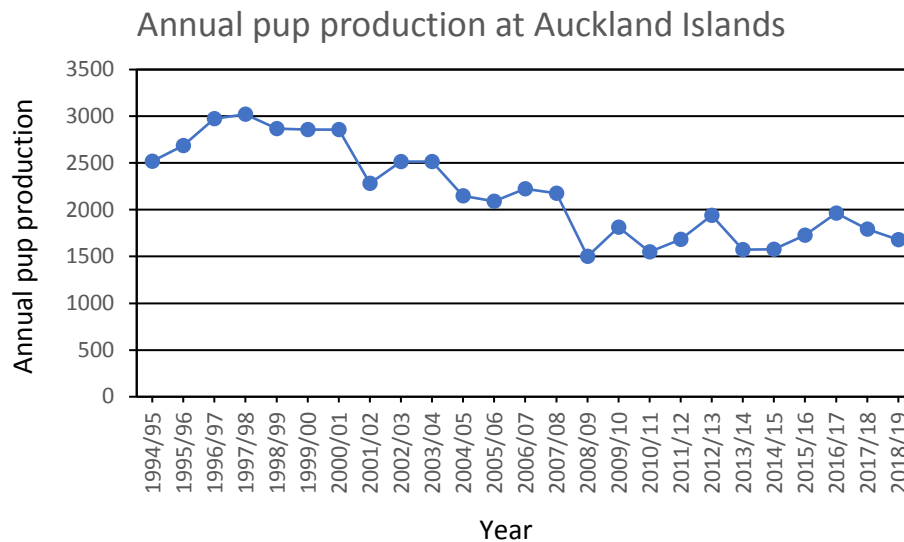


Figure 8. Total estimated pup production for New Zealand Sea Lions at the Auckland Islands 1994/95-2018/19 (Data prior to 2012/13 from Chilvers (2012), and data prior to 2018/19 from Childerhouse et al. (2018)).

5.2 Tagging

Starting on 15 January, as many pups as possible were tagged. A total of 312 pups were double flipper and PIT tagged. In order to decrease the chances of tagging newly arrived pups that may have swam over with their mother from a different island, the majority of tagging happened by 18 January on Enderby and stopped on 28 January. Of the 312 pups tagged, 151 were females and 161 were males, for a ratio of nearly 1:1 respectively (with .94 females to every 1 male).

On Dundas a total of 400 pups were tagged in both pectoral flippers and PIT tagged. Overall, 100 males and 300 females were tagged with no applicable sex ratio found because pups were chosen for tagging based on sex.

While Figure of 8 tagging was undertaken by a different team, the results are indicated here for completeness. Fifty-five pups were flipper tagged, four of which were not microchipped as they were deemed to be too muddy. Five pups were not tagged as two had swollen flippers and three were inaccessible in a harem. Of the 55 pups tagged, 29 were females and 26 were males for a ratio of nearly 1:1 respectively (with 1.12 females to every 1 male).

5.3. Weighing and measuring pups

5.3.1 Pup weights

Table 5. Mean pup weights for Enderby and Dundas Islands in 2018/19.

Location	Mean female weight			Mean male weight		
	n	Kg (SD)	Change from 2017/18	n	Kg (SD)	Change from 2017/18
Enderby	50	12.24 (1.82)	+3.7%	50	13.82 (2.44)	+12.4%
Dundas Is	50	12.11 (1.82)	+12.1%	50	13.87 (2.45)	+11.9%

Table 5 above represents the results for pup weights on Enderby and Dundas. On both islands, 100 randomly selected pups (50 male and 50 female) were weighed and measured. Pup weights were not recorded on Figure of 8.

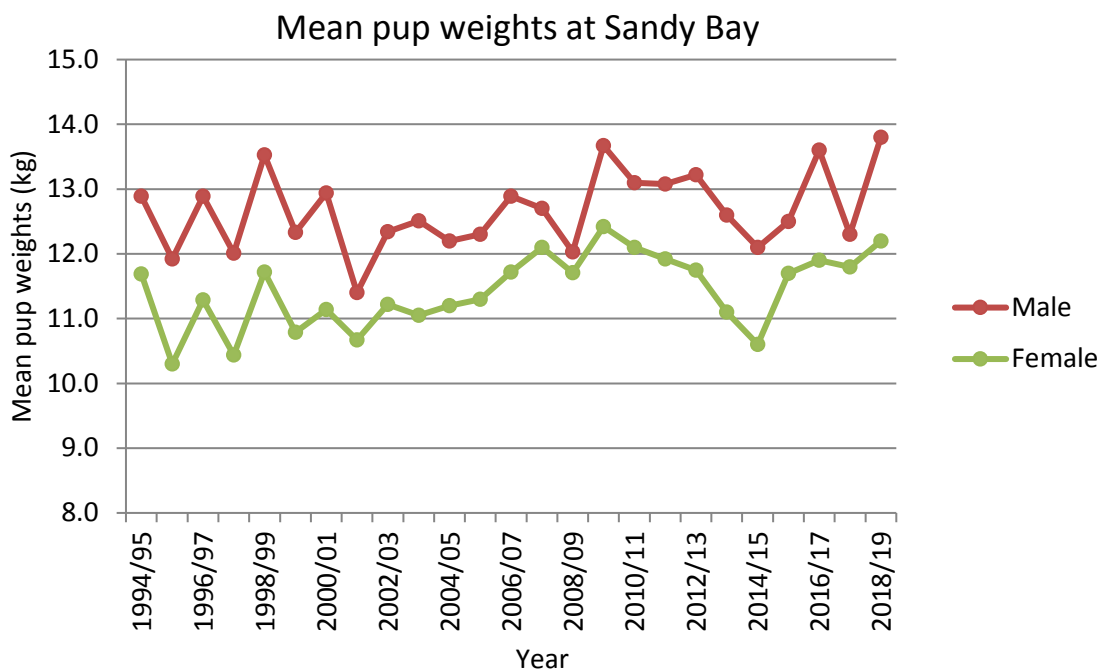


Figure 9. Mean pup weights for Sandy Bay (Enderby Island) by sex from 1994-95-2018/19. Data prior to 2012/13 from Chilvers (2012), and data prior to 2018/19 from Childerhouse et al. (2018). Despite a slightly lower pup count this season, pup weights were higher than last season, with the mean male pup weight being the highest recorded since 1994/95. For female pups the mean weight this year was the second highest recorded.

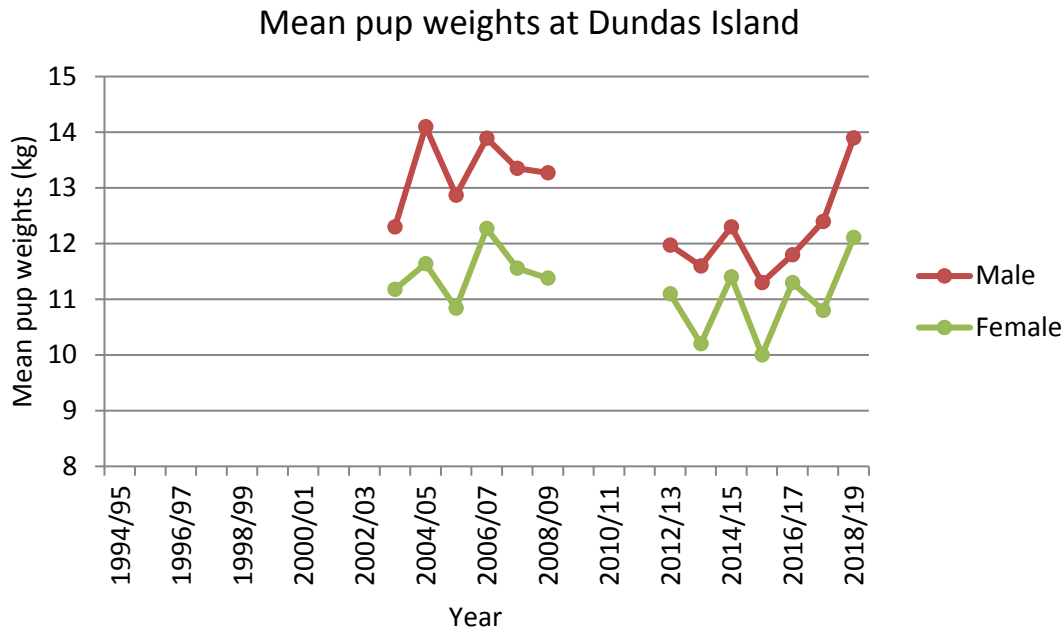


Figure 10. Mean pup weights for Dundas Island by sex from 1994-95-2018/19. Data prior to 2012/13 from Chilvers (2012), and data prior to 2018/19 from Childerhouse et al. (2018). At Dundas in 2018/19, the mean male pup weight is the 3rd highest recorded, and the mean female pup weight is the 2nd highest. As seen in a combination of Table 5 and Figure 9 and 10, in 2018/19 Dundas and Enderby pup weights represents an overall increase from 2017/18.

5.3.2 Pup Measurements

Table 6. Summary of Average Pup measurements for males and females on Enderby and Dundas in 2018/19.

	Average of Length in cm (SD)	Average of Girth in cm (SD)	Average of Weight in Kg. (SD)
Dundas	79.15 (4.52)	56.49 (4.08)	12.99 (2.32)
F	77.36 (3.59)	55.32 (3.35)	12.11 (1.82)
M	80.94 (4.67)	57.66 (4.44)	13.87 (2.45)
Enderby	80.73 (3.66)	56.94 (4.21)	13.02 (2.28)
F	79.90 (3.03)	55.65 (3.78)	12.24 (1.81)
M	81.55 (4.06)	58.24 (4.25)	13.82 (2.44)
Grand Total	79.95 (4.17)	56.72 (4.14)	13.01 (2.30)

Of the 50 females and 50 males measured at both Enderby and Dundas, overall the males had a larger length and girth over the females. Averages of these measurements and weights along with a total average of these items can be found in Table 6 above.

5.4 Daily counts of dead and live animals at Sandy Bay and weekly around Enderby

5.4.1 Daily counts at Sandy Bay

As seen in Figure 11, during the daily counts a big shift is seen on the 20 January. This is when the sea lions largely made a shift up into the upper sward and forest. Thus, making it more difficult to capture the full counts (particularly of pups) from this point until daily counts were completed on 7 February. Days in which two daily counts were performed will be represented on the graph. Any gaps seen in the daily count in Figure 6 would be as a result of team members having different

assigned tasks such as work on Dundas from 15-17 January (however dead counts were performed even if the full daily count was not performed). Dead pups are represented cumulatively. Information from after 7 February regarding dead pups will be found in the separate necropsy report. The highest number of females on a daily count was 359, juvenile males 126, adult males 79. The highest number of pups recorded on a daily count was 292 (note: the direct counts of pups provided a higher count (300) this was not included as part of the daily count as it did not include a count of any of the other ages/sexes).

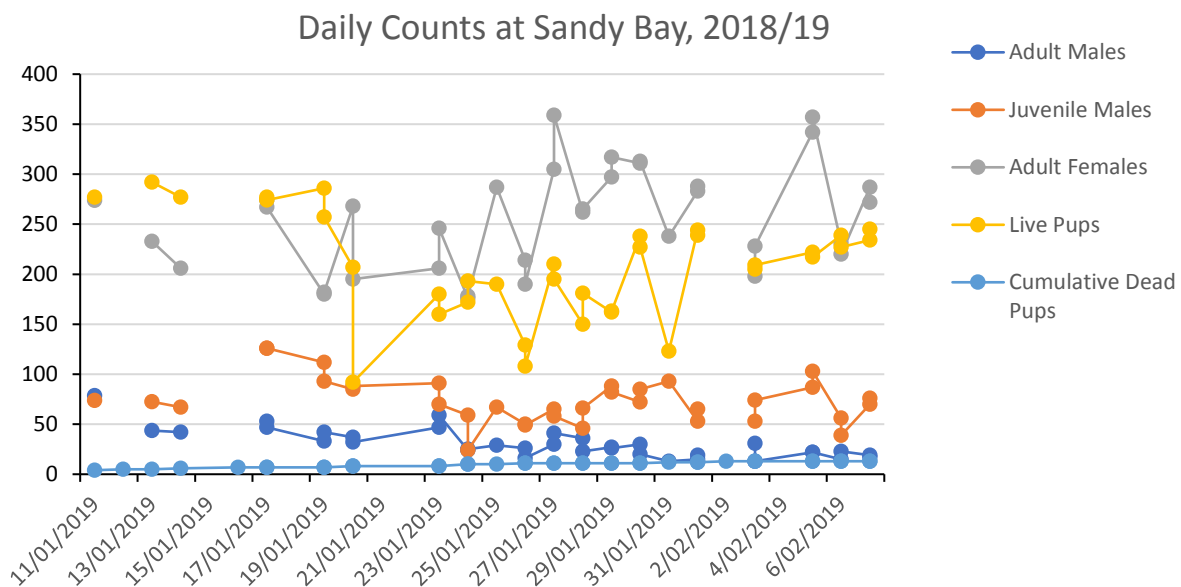


Figure 11. NZSL Daily counts at Sandy Bay on Enderby Island in 2018/19 Dead pups are represented as a cumulative count.

5.4.2 Around the island counts

Throughout the season, six around the island counts were conducted. On these counts no pups were seen during the breeding season. On average, the total number of sea lions seen (of different ages/sexes) on the count was ~175. The first pup seen in East Bay and SEP was on 18 February 2019 when there had been apparent dispersal of adult females and pups from Sandy Bay, and arrivals of Dundas mother and pup pairs to the Island.

5.5 Improve understanding of population dynamics

5.5.1 Resighting of tagged animals

Throughout the season on Enderby, a total number of 3286 tag resights were acquired (once matching had occurred to remove any resights that were not comparable to an existing tag). The resights include 69 PIT tag scans. These were collected over about ~155 hours of resighting time on Enderby. On Dundas, as mentioned prior, with less time to put into resighting effort, only five tags were resighted over two hours of effort put into resighting. Additional tags were seen there, however, most of them were highly worn/not readable. At Figure of 8, two tag resights were acquired opportunistically. This represents a total of 3296 tag resights acquired for the Auckland Islands. These resights are uploaded into the NZSL demographic database and have been checked to ensure they are comparable to an existing tag.

5.5.2 Acquire photos of animals with shark scars or distinct scarring

Throughout the season, 84 sets of photos were taken of animals on separate occasions. The 84 sets do not represent 84 individuals, photographic matching is still underway for some sets, as some scarred individuals will have been photographed on multiple occasions. Once matched, it will form the start of a photo ID library for which the data can be used for ID purposes and in the future for assessing shark scar prevalence (note: specific methodology will be required for specific questions). Additionally, a series of photos were also taken of 3 individuals with brands.

5.6 Mortality investigations

Postmortems were performed on pups whenever possible to collect samples to determine causes of mortality. A separate report is being produced to address the effort and findings of this portion of the work. However, in summary, from 10 January to 5 March, upon performing daily dead runs (searches for pup carcasses), 44 pups were found dead, of those, 35 necropsies were performed. For Enderby this is ~14% mortality rate, however it's important to realise this is not a complete count due to the potential to miss deaths that occur from Mid-November to staff arrival on the 10 January. Of the 35 necropsies performed, 22 cases contained gross pathology suggestive of *Klebsiella pneumoniae* (still needs to be confirmed through histology). While more detail will be found in the additional report, some of the other provisional diagnosis included, infection, congenital disorders, starvation (with circumstantial indicators), and more.

5.7 Monitoring "Planks for Pups" and establishing new ramps as needed

Starting around 2 February when pups moved further into the sward at Sandy Bay, where there are more streams and ditches present, the first pup was pulled out of a stream. Note that this date would likely differ every year based on slight variations in distribution patterns of the sea lions. Starting around this day, as pups were pulled out and problem areas became evident ramps were put into place (aside from two being put in within the first two weeks of the season in areas that appeared high risk). On 7 February, four pups were removed from the same hole (one earlier in the day, three later in the day) a ramp was installed that day, and a pup was later observed using the ramp to exit. There were no more pups found in that particular hole after placement of the ramp. This placing/rearranging of ramps as needed occurred at a higher frequency around this this week as pups were exploring new areas and weather increased the flow and erosion of streams. However, this monitoring and placing of ramps continued to occur throughout the remainder of the season. The rate at which pups got stuck in streams seemed to decrease as pups got larger/stronger, however deep holes still remained high-risk areas.

Once ramps were placed, there was often no additional rescues needed in those terrain traps. There were some terrain traps which were difficult to install ramps (e.g. narrow streams or streams with dense vegetation covering large sections), these areas were monitored closely to ensure pups could be rescued if they became trapped. Overall, seven new ramps were installed during the season, sometimes rearranged if the previous terrain no longer remained a current issue. All but one of these ramps were removed at the end of the season as they were no longer needed. Eleven old ramps were monitored and left in place at the end of the season as they were determined to still be of need. Need was determined based on pups still making use of the space around these locations, or the depth of the holes made it evident that self-rescues would be nearly impossible without the assistance of a ramp. It was also considered whether leaving in these ramps would pose any additional threat, and only those which were thought to not pose additional risk were left.

Five pups were found dead in streams. All of these streams were very shallow or had accessible exits as other pups were seen coming in and out of these streams with ease. Three of the total five were suspected *Klebsiella* cases two of which were unable to be sampled due to decomposition. It is possible that neurological compromise as a result of the infection impeded the pup's ability to manoeuvre out of these otherwise typically accessible streams. Otherwise, no pup carcasses were found in "typically inescapable" streams.

Approximately 15 pups were removed from streams/terrain traps by researchers with the assistance of a noose pole or when appropriate/possible by carefully handling their hind flippers to extract them with gloved hands. Photos and GPS locations as seen in Figure 12 were taken as an indicator of ramps left in place at the end of the 2018/19 season.

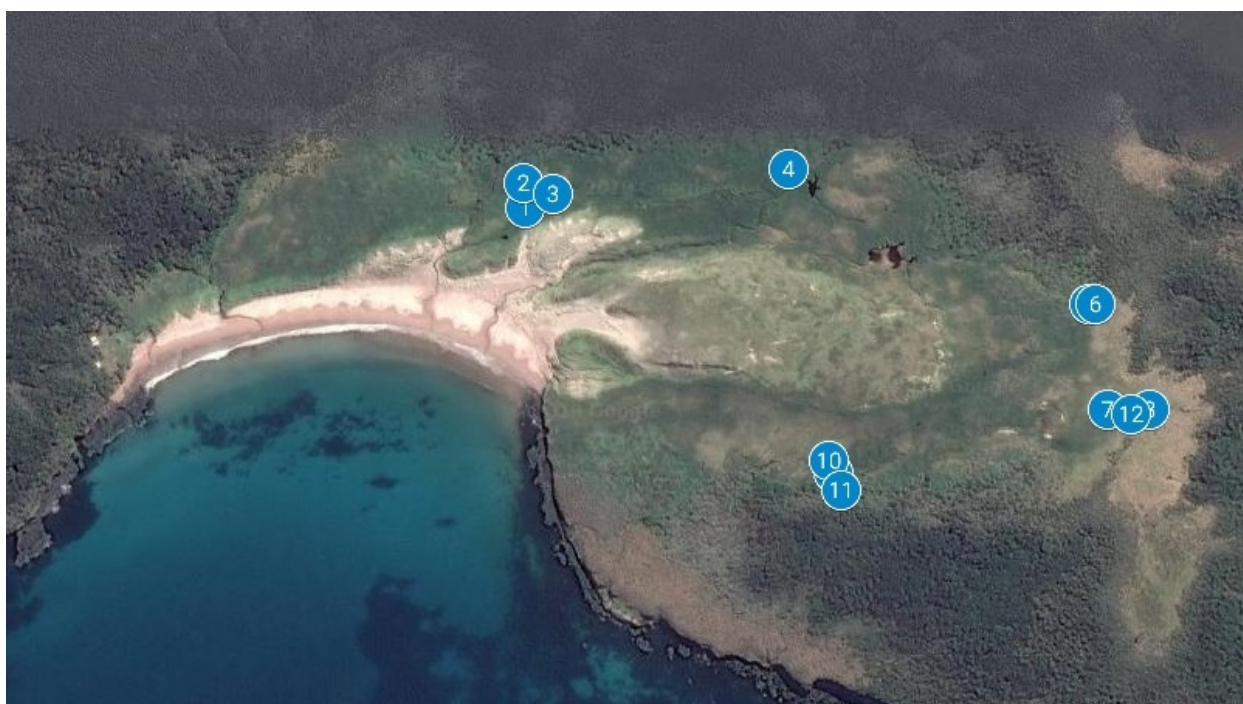


Figure 12. Image indicating the pre-existing ramps that were monitored throughout the season and were left in place. Ramp #7 is the location in which an old ramp was moved to a new location (the trap it was taken from received a replacement ramp).

6. Summary of other work undertaken

6.1.1 Albatross survey

As an additional project, when time allowed at Enderby, royal albatross (*Diomedea epomophora*) nest monitoring occurred. The aim was to perform an island census to determine an annual nest estimate. The methodology in this survey followed Childerhouse et al. (2003) as a guideline. This included two-three researchers walking in transect 20-40 meters apart, while maintaining visual and voice contact. The cushion/herb field and along the edge of the rata forests were the areas of focus (there may be some difference in the amount of area that was able to be surveyed in comparison to that reported in Childerhouse et al. (2003)). Excluding areas of dense rata forest with a canopy height of 4-5 meters. When an albatross, and or suspected nest was seen from afar it was visited to confirm the presence of a nest. After carefully and quietly approaching with a low profile (crouched down), if on a nest, the albatross was gently encouraged to stand by grazing an extended stick (walking pole) just below the adults' chest. This would often result in the adult temporarily standing,

which revealed if the nest was active or abandoned. It was recorded as active if there was an egg or a chick present (and the coinciding activity was recorded) or was recorded as abandoned which was indicated by crushed egg shells or a dead chick present. Each nest was marked with flagging tape with 19-ALB-nest # (and coinciding number of the active nest we were on) and a GPS point was taken with a handheld Garmin.

The results found after four days of effort into surveying the aforementioned areas were as follows; 28 active nests were found, 27 of which contained a chick, and one of which contained an egg. Additionally, one abandoned nest was found that contained fresh egg shell remains. All nests (active and inactive) were recorded and were mapped to give an indication of location and distribution as seen in Figure 13 and 14 below on a google map satellite image of Enderby.



Figure 13. Overall map of Enderby to give frame of reference for the areas searched for the Albatross surveys.



Figure 14. The light blue GPS locations indicate all of the active nests with a chick present. The tan GPS location of number 11 indicates an active nest with an egg present, and the dark blue #29 indicates an abandoned nest that contained fresh egg shell remains. The yellow boxed in area indicates the approximate area that was searched to find the royal albatross nests.

6.1.2 Acquiring Giant Petrel Chick/Nest Locations on Dundas

Upon request from researchers with Parker Conservation GPS Locations of Northern giant petrel chicks/nests were acquired while on Dundas. On the evening of 20 January, a survey (done alongside of some sea lion tag resighting) was performed to acquire the GPS locations. One researcher went around the island with a focus on the vegetation area looking for giant petrel chicks. When one was found, a GPS location was taken ~5 meters downhill/towards the ocean from the chick. A total of 13 Northern giant petrel chicks and associated GPS locations were acquired which can be seen in Figure 15.



Figure 15. This image indicates the Northern Giant Petrel Chicks/Nest Locations found on Dundas Island.

7. Acknowledgements

An abundant thank you to Don Neale, Mike Morrissey, Eleanor Cooper, Karen Ismay, Aditi Sriram, and Andrew Eastwood for all of the tremendous hard work and effort put into this year's field research. Also, a Thank you to all of the hard work by researchers and teams that have been a part of this research present and past. A special thanks to Louise Chilvers, Simon Childerhouse, and those with Blue Planet Marine, this project would not be the long-standing program that it is without all of your hard work and dedication. Sincere thanks to Sarah Michael, Wendi Roe, and Massey University Staff who have either performed a tremendous amount of work on the ground at Enderby towards mortality investigation or have put the effort into processing samples to acquire valuable information on sea lion mortality and future steps. Steve and Evohe crew deserve a huge thanks for their large role in transportation and logistical support that was always preformed with excellency and professionalism. As does Stephen Horn and the crew that assisted in helicopter operations and transportation for the team. None of this work could be completed without the abundance of effort and coordination put in by Laura Boren, Ian Angus, Enrique Pardo, Katie Clemens-Seely supporting staff. DOC quarantine staff remains an asset to this project in their abundant contribution to logistics and ensuring gear makes it to the Islands in a manner that is highly considerate of the sensitive environments in which the work is carried out. A big thank you to those at the Murihiku office with whom we daily scheded with, and their watch ensured our safety. Gratitude goes to members of the TMP and CSP Technical Working Group that provided feedback which will allow us to continue to make improvements to the protection of this species in the future.

8. Recommendations

- A suggested earlier start date/longer field season in order to be present for births and to acquire a complete season count of dead pups (and thus a more accurate pup production estimate).Development of clear goals and guidelines on the areas in which to search for animals in the daily count and in the dead run to allow for consistency over the years.
- Determine and take additional action steps to move forward with *Klebsiella pneumonia* research (i.e.: ivermectin controls/ trials, etc.)
- Perform more precise recording on “planks for pups” such as on ramp additions, rescues before and after placement etc.
- Further advancement in the development of the shark/distinct scaring photo ID library if specific shark predation type data is desired to be derived from it.
- Additional time spent on Dundas to allow for effort into resighting there.
- Ensure continued use of the M-R as the estimate method for Dundas.
- Potentially change to different PIT tags for Dundas, and if so, change to one that would have options of a fixed scanner.

9. References

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Appendix 1: Annual estimates of the total Auckland Island pup production and total pup production estimates for each colony (including live and dead) 1994/95-2018/19.

(NB. Data prior to 2012/13 from Chilvers (2012), and data prior to 2018/19 from Childerhouse et al. (2018)).

Year	Sandy Bay			Dundas Island			Figure of Eight			Southeast Point			Auckland Islands		
	Total	Live	Dead	Annual pup production	Live	Dead	Annual pup production	Live	Dead	Annual pup production	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
2015/16	321	308	13	1347	1221	126	59	53	6	0	0	0	1727	1582	145
2016/17	349	328	21	1549	1415	134	67	52	15	0	0	0	1965	1795	170
2017/18	332	309	23	1397	1340	57	63	55	8	0	0	0	1792	1704	88
2018/19	319	312	7	1295	1240	55	65	60	5	0	0	0	1679	1612	67

Appendix 2. Raw data for direct and M-R counts at Sandy Bay

Mark- Recapture counts for Sandy Bay on 16, January 2019.		
<i>200 pups capped/marked</i>		
Sandy Bay	Marked Counted	Unmarked Counted
Counter 1-1	181	96
Counter 1-2	177	98
Counter 2-1	188	107
Counter 2-2	174	119
Counter 3-1	202	107
Counter 3-2	187	114
Counter 4-1	176	104
Counter 4-2	191	103
Counter 5-1	189	97
Counter 5-2	192	102
Direct Live Pup Counts for Sandy Bay on 16, January 2019		
	Direct Count	
Counter 1-1	283	
Counter 1-2	293	
Counter 2-1	278	
Counter 2-2	286	
Counter 3-1	300	
Counter 3-2	283	
Counter 4-1	286	
Counter 4-2	292	
Counter 5-1	275	
Counter 5-2	280	
Cumulative dead pup count for Sandy Bay to 16, January 2019		
	Dead Count	
Cumulative count	7	

Appendix 3. Raw data for direct and M-R counts at Dundas Island

Mark- Recapture counts for Dundas on 18, January 2019.		
<i>400 pups capped/marked</i>		
Sandy Bay	Marked Counted	Unmarked Counted
Counter 1-1	245	486
Counter 1-2	261	578
Counter 2-1	290	607
Counter 2-2	368	751
Counter 3-1	354	802
Counter 3-2	278	638
Counter 4-1	375	769
Counter 4-2	313	649
Counter 5-1	309	607
Counter 5-2	225	459
Direct Live Pup Counts for Dundas Island on 18 January 2019		
	Direct Count	
Counter 1	1151	
Counter 2	1459	
Counter 3	1252	
Counter 4	1221	
Counter 5	1469	
Cumulative dead pup count for Dundas Island, 18 January 2019		
	Dead Count	
Cumulative count	55	