

# 2018/19 Campbell Island (Motu Ihupuku) New Zealand Sea lion Research Trip Report



Photo by: Dahlia Foo

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## 1 Executive summary

A survey of New Zealand sea lions (*Phocarctos hookeri*, NZSL) at Campbell Island/Motu Ihupuku was undertaken during the 2018/19 breeding season as part of a 5-year NZSL Threat Management Plan. This was the second consecutive season the survey has been undertaken. The research team arrived on Campbell Island on 29 December 2018 and left on 6 March 2019. The main aims of the work were to estimate total pup production for the season and assess factors contributing to early pup mortality. Other work included the study of pup behaviour around terrain traps and to trial solutions for mitigating pups dying in these terrain traps. The methodology of the work was similar to previous surveys to ensure consistency in the data. The analysis and report of the study on pup behaviour is part of a separate contract with researchers from the University of Tasmania and full details regarding that work will be reported separately.

In summary:

- Shoal Point colony has continued to shift westward.
- Paradise East colony did not appear to exist this season.
- 422 pups were flipper tagged and 395 of these were microchipped on Campbell Island between 30 December 2018 and 26 January 2019.
- The overall sex ratio of tagged pups was 1.02 (males = 213, females = 209)
- The overall pup production estimate for Campbell Island for the 2018/19 season was 705, with an overall pup mortality of 54%.
  - At Davis Point, estimated pup production was 447 where 77% of them died by 26 January
    - Lower pup production than previous 3 surveys
    - Highest number of pup deaths and highest pup mortality rate recorded at this site
    - 43% of pups that underwent post-mortem had blubber depth of 2 mm or less
  - At Shoal Point, estimated pup production was 342 where 15% of them died by 20 January
    - Higher pup production than previous 4 seasons
    - Second lowest mortality rate after last year
- Extreme weather events early in the breeding season were likely a major contributing factor to the high pup mortality at Davis Point. The differences in pup mortality rates between Davis and Shoal Point suggest that the latter is a better site to raise pups, likely because it is more sheltered.
- Exposure and starvation were the primary factors contributing to pup mortality at Davis Point.

- Mean estimates ( $\pm$ SE) for pup mass, length, and girth were measured at Davis and Shoal Point
  - Davis Point
    - Mass: females = 9.7 kg (0.2); males = 12.4 kg (0.3)
    - Length: females = 72.4 cm (0.5); males = 75 cm (0.4)
    - Girth: females = 50.1 cm (0.5); males = 52 cm (0.4)
  - Shoal Point
    - Mass: females = 10.8 kg (0.2); males = 12.4 kg (0.3)
    - Length: females = 84.9 cm (0.8); males = 87.4 cm (0.7)
    - Girth: females = 54.6 cm (0.5); males = 56.5 cm (0.5)
  - Female and male pups at Davis Point were 1.1 kg and 1.6 kg lighter than at Shoal Point, respectively
  - At both sites, both male and female pups averaged ~2 kg lighter in 2018/19 than in 2017/18 season
- The comparison of pup mass this season across Campbell Island and the Auckland Islands colonies are:
  - Females: Sandy Bay > Dundas Island > Shoal Point > Davis Point
  - Males: Dundas Island > Sandy Bay > Shoal Point > Davis Point
- A total of 36 different adult tags were resighted
- Mitigation solutions for pup mortality in terrain traps were trialed =. When traps proved to be useful and did not pose as a hazard to the pups, they were left in place at Bog colony (Davis Point)

## 2 Introduction

Campbell Island is home to the second largest breeding population of NZ sea lions (NZSL). Previously, there has been limited, and sporadic monitoring of the Campbell Island sea lion population. However, commitments made through the New Zealand sea lion/Rāpoka Threat Management Plan include increasing the frequency of monitoring of this population, understanding the causes of pup mortality, and looking for practical solutions to reduce it.

The two known NZSL breeding colonies on Campbell Island are situated at Shoal Point and Davis Point on either side of Perseverance Harbour. The location of Shoal Point colony on the southern side of Perseverance Harbour has been progressively shifting westwards from Paradise Point (towards Mt Beeman). This population, despite apparent growth in pup numbers, typically experiences high levels of pup mortality (e.g. 40-60%) in the first two months after birth with the exception of last season (2017/18) where the overall pup mortality was much lower (29%) (Boren 2018). That season happened to be unusually dry which was hypothesised as the main reason for low pup mortality.

The 2017/18 summer season was the first since the Minister of Conservation and Minister for Primary Industries approved the Threat Management Plan. During this breeding season, a team of four people conducted pup tagging and post-mortem work on Campbell Island from 18 December 2017 to 24 January 2018, splitting their time between the two primary colonies (Davis Point and Shoal/Paradise Point). One disadvantage of this work schedule (and how previous teams have operated on the island) is that when the team is monitoring at one site, they are missing what is happening at the other site. For the 2018/19 season, to gain a full understanding of the similarities and differences between the two colonies, two teams of three people each conducted pup tagging and post-mortems simultaneously at the two colonies.

Previous surveys on Campbell Island identified starvation and trauma to be the two leading causes of early pup mortality (Childerhouse et al. 2015). The major contributor to trauma was pups falling into natural terrain traps that can result in them either drowning or starving (Childerhouse et al. 2015, Lea et al. 2018). A study to better understand pup behaviour around terrain traps was initiated in 2017/18 (Lea et al. 2018) and was proposed to be repeated this season to obtain a second year of data. Additionally, an engineer was brought to the colony sites at Campbell Island in March 2018 to assess the terrain and identify potential solutions to mitigate pup mortality in terrain traps. Some of his solutions were trialled in this season.

*Klebsiella pneumoniae* is a bacterial infection that seems to be one of the primary causes of early pup mortality at Enderby Island (Childerhouse et al. 2014). On Campbell Island, it has been identified as a minor cause of pup mortality (Childerhouse et al. 2015). However, this may be due to the lack of research effort as symptoms of this disease typically occur during the later stages of the breeding season (mid February) (Wilkinson et al. 2012) and survey teams have usually left Campbell Island by that time. Hence, researchers were present on the island until 6 March this season to continue with the post-mortem work and address this concern.

### 3 Objectives

Broadly, the aims of this research trip are to:

- 1) Flipper tag and microchip as many pups at Davis and Shoal Point as possible;
- 2) Describe the distribution of sea lions at the two colonies (including counts);
- 3) Estimate pup production at both locations for the 2018-2019 season;
- 4) Quantify early pup mortality;
- 5) Investigate factors that might contribute to early pup mortality;
- 6) Do a cross-sectional measure of weight, length and girth of pups at both sites on specific dates that are consistent with previous work;
- 7) Record any sightings of sea lions tagged in previous seasons;



- 8) Study the behaviour of pups at Davis Point around terrain traps by using camera traps and GPS loggers and;
- 9) Trial mitigation of solutions for pup mortality in terrain traps

Results from the analysis of data collected under objective 8 will be provided by researchers from the University of Tasmania in a separate report. The procedures in the field will be briefly explained here.

## 4 Methods

### 4.1 Logistics

The research trip was split into two parts which included changes in personnel: 29 December 2018 – 6 February 2019, and 6 February – 6 March 2019.

During the first part of the trip, two teams of three people were based at either Shoal or Davis Point. The Davis Point team included Kelly Buckle (veterinary pathologist), Dahlia Foo (University of Tasmania) and Dr Jody Weir. The team at Shoal Point (previously Paradise Point but renamed due to shifting of the colony) included Nathaniel Scott (Ngāi Tahu), Marti Alegre (DOC) and Jim Campbell (DOC) (Fig. 1).

Work at Davis Point was undertaken 30 December 2018 – 26 January 2019 and work at Shoal Point was undertaken 1 – 25 January 2019. Both teams moved to Beeman's Base from 26 January to 6 February 2019 for changeover. The changeover of team members was scheduled to be on 3 February 2019; however, this was delayed due to unfavourable weather conditions. On 6 February, four original field personnel left the island and a new person, Catherine Lea joined J. Campbell and M. Alegre to continue the second part of the fieldwork (Fig. 2). Transport during the field season was aboard the RV Evohe. Temporary campsites were set up at Shoal and Davis Point where field personnel slept in individual tents.



Figure 1 Research team in the first phase of the trip (up till 6 Feb 2019). From left to right: Jim Campbell, Nathaniel Scott, Marti Alegre, Kelly Buckle, Jody Weir and Dahlia Foo. The boys made up the Shoal Point team and the girls made up the Davis Point team.



Figure 2 Research team for phase two of the trip (from 6 February onwards). From left to right: Marti Alegre, Jim Campbell and Catherine Lea.

Summary of key dates:

Date	Activity
19-21 December	Pre-Quarantine Invercargill
27 December	Personal quarantine and depart for Campbell Island
29 December	Arrive Campbell Island
13 – 14 January	Pup weigh day
16 – 19 January	Beeman's Base
20 – 21 January	Pup weigh day (for Shoal Point only)
26 January	Pack up camp
27 January – 5 February	Beeman's Base
6 February	Four researchers leave Campbell Island, one new researcher joins the remaining team, new team gets dropped at Davis Point
	Pack Davis Point camp
	Beeman's Base
	Shoal point
	Pack Shoal Point Camp
	Beeman's Base
3 March	Evohe arrival
4 – 6 March	pick up gear from camps, leave Campbell Is
	Auckland Islands – pickup gear and staff

	Leave Auckland Islands
8 March	Arrive Bluff

## 4.2 Breeding colonies

The two main breeding colonies on Campbell Island are located Shoal Point and Davis Point. The boundaries of the breeding colonies were recorded using a handheld GPS unit and described according to landscape features. The boundaries are defined based on where the harems and the surrounding adults were.

### 4.2.1 Davis point

At Davis Point, there are two sub-colonies called Bog and Rock that are next to each other and their boundaries have been mostly the same since they were discovered. Detailed descriptions of the Davis Point colony can be found in a previous report (Childerhouse et al. 2015). Briefly, the main substrate of Bog colony is peat bog. The site tends to get muddy and boggy when wet. Several terrain traps exist at Bog colony (mud channels, deep boggy holes) which pose a threat to pups when they fall in as it can be difficult for them to climb out. Rock colony is mainly rock substrate with several rock pools of various shapes and sizes. It is also much less vegetated than Bog colony.

### 4.2.2 Shoal Point

Historically, each season's research team has observed a shift in the boundaries of the Shoal/Paradise Point colony. Before the breeding site shifted from Paradise to Shoal Point (2017/18), there used to be two sub-colonies at Paradise Point as well called Paradise Point East and West. Following the 2017/18 field season, Paradise Point West was renamed to Shoal Point. During this season (2018/19), the colony at Shoal Point had shifted closer towards Beeman Base (westwards). The western and eastern side of the Shoal Point colony were bounded by steep rock cliffs and a steep forested slope, respectively. The bulk of the Shoal Point colony occupied the ridgeline plateau which was heavily vegetated with tussocks (Fig. 2).

### 4.2.3 Paradise Point East

The Shoal Point team also made treks to Paradise Point East but reported that they did not find any sea lion colony there.





Figure 3 Map of Davis Point colony indicating key site features, terrain traps, campsite, and boat drop-off points.

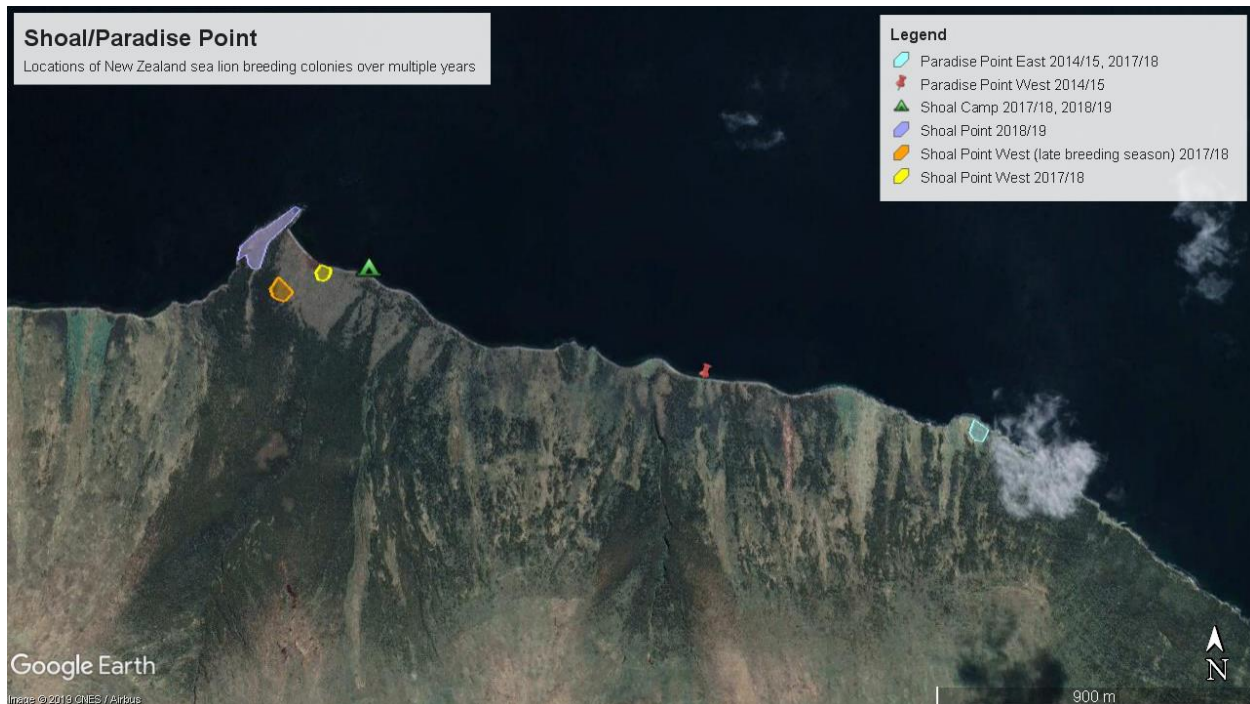


Figure 4 Map of Shoal/Paradise Points indicating the movement of the breeding colonies over multiple years and the campsite.

### 4.3 Pup production estimates

Total pup production was estimated by either,

- 1) adding the total number of tagged pups and untagged dead pups,
- 2) adding the total number of live pups on a specific date and the total number of dead pups counted cumulatively to that date, or
- 3) using a mark-recapture method (proposed as a method but not undertaken, see section 5.4.1).

Whichever method gave the higher number was the selected as the final estimate.

Pup tagging took place at both Davis and Shoal Points (see section 4.4). Additionally, a direct count of live pups was only done at Davis Point which took place on 11<sup>th</sup> January – when the number of adults at the colony was noticeably lower. Team members were able to walk safely through the colony, as opposed to just around the edges. The colony was concentrated enough such that two people walking along parallel transects, one along higher ground and the other along lower ground, were enough to cover the entire colony area when counting live pups.

#### 4.3.1 Mark-recapture

Briefly, the mark-recapture (M-R) method involves marking a proportion of the total pups produced at the colony by gluing round canvas caps to the heads of pups. Pups are then allowed 24 hours to move around and mix back into the colony. Resighting surveys are done where each surveyor takes turns to walk through the colony with two tally counters to count the number of marked and un-marked pups. The total pup production is then estimated using the same calculations as in Chilvers (2012).

Mark-recapture is typically only done at Davis Point. Due to extreme bad weather this season, early pup mortality was very high and not many pups were left in the colony for M-R to be particularly useful. Hence, after discussions with the trip managers at DOC, it was agreed that doing M-R was not necessary.

### 4.4 Flipper tagging and microchipping pups

One of the core objectives of the trip was to tag all live pups or as many as possible at both colonies. Pups were tagged on the trailing edge (web) of both fore flippers with identification tags (Superflexitag®, Dalton ID systems, Oxon, UK), following the DOC Standard Operational Procedures (SOP). The color of the tags was pink this breeding season and they had a unique alpha-numeric identification code. The flipper tags were inserted with the male pin facing outwards from the pup's body (i.e. the male part was inserted from the underside of the flipper).

Microchipping of pups in addition to flipper tagging has been done for multiple years on the Auckland Islands but this is not the case on Campbell Island due its harsher and dirtier working conditions. Nonetheless for the first time on Campbell Island, pups were also implanted with subcutaneous microchips (Unique ID-100B. Trovan Ltd, UK; also known as Passive Integrated Transponder, PIT tags) on their dorsal side near the rump area. When microchipping, the applicator needle was inserted into the skin in the direction facing the rump. Next, the rump was scanned with a chip reader to ensure that the microchip was properly inserted. Microchipping counteracts the limitations of flipper tags where the printed IDs can fade after several years making it difficult or impossible to read. The tags can also rip through the flipper skin and fall off. Microchips can provide a long-lasting solution for identifying individuals.

All surfaces of the skin that were punctured during flipper tagging or microchipping were spayed with a diluted Betadine solution prior to the procedure to reduce the likelihood of infection at these sites. This procedure was only done at Davis Point, because of the muddy conditions. Following guidelines in the sea lion SOP created by DOC (unpublished), pups that were deemed to be too muddy/dirty for flipper tagging and/or microchipping were not tagged (usually flipper tagged but not microchipped). The sex of each pup tagged and/or microchipping was also recorded.

#### 4.5 Pup morphometrics

Cross-sectional sampling for pup mass, standard length (from nose to tip of tail without following the curvature of the pup's body) and axillary girth (under the armpits) was done on 100 (50 males, 50 females) randomly-caught live pups on 13 – 14 January at both sites. These dates are consistent with the cross-sectional sampling dates in previous field seasons at Davis Point and the Auckland Islands. In the past, cross-sectional sampling was usually done around 19 – 20 January at Shoal/Paradise Point since there was never a team simultaneously there during the earlier measuring dates. Hence, the same cross-sectional sampling procedure was repeated at Shoal Point on 19 – 20 January to ensure that the measurements for both weighing occasions were comparable. A two-sided t-test was used to compare the differences in measurements on the different sampling occasions at Shoal Point. Upon capture, pups were first sexed, then placed in a canvas bag and weighed using a hanging scale (Salter, Victoria, Australia). They were then measured for length and girth using a measuring tape. The mass of the canvas bag was measured after the release of the pup and recorded. During calculations the mass of the canvas bag was subtracted from the overall reading of the bag and pup.

#### 4.6 Direct counts

Direct counts of adult females, males and sub-adult males were aimed to be undertaken every 2 – 3 days at both colonies in the morning (~8 – 10 am). This was done with the aid of tally counter and binoculars (whenever useful).

At Davis Point, sea lions were counted from an elevated position, transects were not necessary as the whole colony could be seen from the viewpoint. At least two counts were made every time and both counts had to be  $\pm 10\%$  of each other, or they were repeated until this happened.

Direct counts at Shoal Point were more challenging due to the topography, the terrain doesn't provide a good vantage point and has a large amount of tussock cover. The team did direct counts by circling the colony and trying to section areas off. Each person targeted either sub-adult males, adult females or adult males. Counts were undertaken only once. Counts were not done on days where visibility of animals was particularly poor.

The number of dead pups were counted every morning unless field work is put on hold due for rest days or unfavourable weather conditions. The count was done by walking along the edges of the colony or through the colony whenever possible, which depended on the movements and number of adults present at the time. Dead pups counted were either removed from the main colony area, dragged into piles, and/or marked with a brightly coloured spray paint whenever it was safe to do so. For each dead pup, the location where it was found, including the type of substrate was also noted.

#### 4.7 Tag re-sighting

Pup tagging has been undertaken on Campbell Island inconsistently since 1998. DOC maintains a database of tags (<http://data.dragonfly.co.nz/nzsl-demographics/>), that includes the date and location where the animal was tagged as a pup. Tag resights on subadult and adult sea lions were done opportunistically by either reading directly from the flipper tag on sea lions or zooming in on photos taken by a camera with a telephoto lens. The colour, shape and identification number on flipper tags were recorded.

#### 4.8 Pup post-mortem

Full post-mortems with tissue collection were performed at each site to determine causes of early pup mortality. A total of 70 necropsies of freshly dead pups were undertaken this season. Since the main goal of the second part of the fieldwork (after 6 Feb) was to detect evidence of *Klebsiella*, 40 out of 70 necropsies were allocated to this. The remaining 30 necropsies were split

between Davis and Shoal Point, meaning up to 15 necropsies at each site was undertaken between 29 Dec and 6 Feb. The goal was to spread the number of necropsies as evenly as possible over the period that teams were at the colonies. Selection of carcasses to necropsy was based on freshness (fresher carcasses were selected) and ease of access (e.g. it is more difficult to get a carcass in the middle of the colony due to territorial males and aggressive females). followed the protocol established during Sarah Michael's PhD work (unpublished).

Additionally, in response to high pup-mortality experienced at Davis Point, gross post-mortem was undertaken on freshly dead pups where five basic variables such as blubber depth, volume of milk in stomach, ulceration severity on flippers, presence of mud in trachea, and presence of trauma (carcass not flensed) were collected. These health markers were chosen based on the recommendations of the 2017/18 field season vet, Micah Jensen, as they measured potential factors contributing to death (unpublished 2017/18 post-mortem reports).

#### 4.9 Behaviour of pups at Davis Point

The study of pup behaviour and movements around terrain traps was repeated for a second time this field season. Methods were similar to what was undertaken previously (details in Lea et al. (2018)). Camera traps (n = 4) were placed around terrain traps with high traffic and moved accordingly to the dynamic nature of the colony's movements. Miniature GPS loggers were deployed on 20 randomly caught live pups from Bog colony from 1 January until the pup's death or 21 January. Pups were sexed, flipper tagged and microchipped when first captured, and morphometrics (weight, standard length, and axillary girth) were also recorded.

Additionally, ad-hoc observations and videos (recorded on a mobile phone) of pup behaviour around terrain traps were recorded. More thorough details on the methods will be provided in a separate report by researchers from the University of Tasmania.

#### 4.10 Mitigation of pup mortality in terrain traps

Another task this season was to trial mitigation solutions suggested by an engineer from Fulton Hogan. The engineer visited both colony sites in 2018 to survey the terrain and come up with solutions. The mitigation measures trialled were 1) filling up hessian bags with dirt/rocks as blockades or to fill holes, 2) using local dirt/rocks to fill holes, and 3) coir logs to fill holes/mud channels. We also moved existing ladders to address current problem areas.

## 5 Results

### 5.1 Overall environmental conditions

The overall weather conditions experienced during the 2018/19 field season were particularly wet and windy. There most extreme weather events occurred earlier in the breeding season. At



Davis Point, there were days where frost was found on tents, in the crevices between tree-bark and on the faces of dead pups in the early morning.

The local climate and living conditions experienced at both breeding sites were notably different. Davis Point is more exposed, located closer to the mouth of Perseverance Harbour whereas Shoal Point is located at a more sheltered bay. Additionally, the terrain at Davis Point occupied by the sea lions is primarily rocky and muddy substrate with much less vegetation than at Shoal Point.

The combination of an early extreme weather event when pups were still young and more vulnerable, and the exposed nature of Davis Point, likely led to the high pup mortality experienced at that site early in the breeding season (more details will be discussed at later sections of the report). Because of this, certain procedures were adapted or put on hold to minimise pup handling due to ethical reasons.

## 5.2 Colony movements and direct counts

Similar to previous years, females at Davis Point gradually occupied more inland areas as the breeding season progressed and eventually took their pups into the *Dracophyllum spp.* forest by the end of January. A similar pattern was observed at Shoal Point: the colony gradually moved further up the ridgeline and into drier tussock as the breeding season progressed. By the end of January, the entire colony was contained within the *Dracophyllum spp.* forest. The movement of both colonies is reflected in the counts of the adults and sub-adults where their numbers declined at both sites throughout January (Figures 3 and 4). Between 14 – 20 January, both teams were focused on doing the cross-sectional sampling of pup morphometrics and subsequently went to Beeman's Base to recuperate hence no counts were undertaken on those dates. Records of counts conducted at Davis and Shoal Points are included in Appendix 1. There were fewer direct counts undertaken at Shoal Point due to poor visibility of animals caused by the terrain (high vegetation and lack of vantage points) and the distribution of the animals.

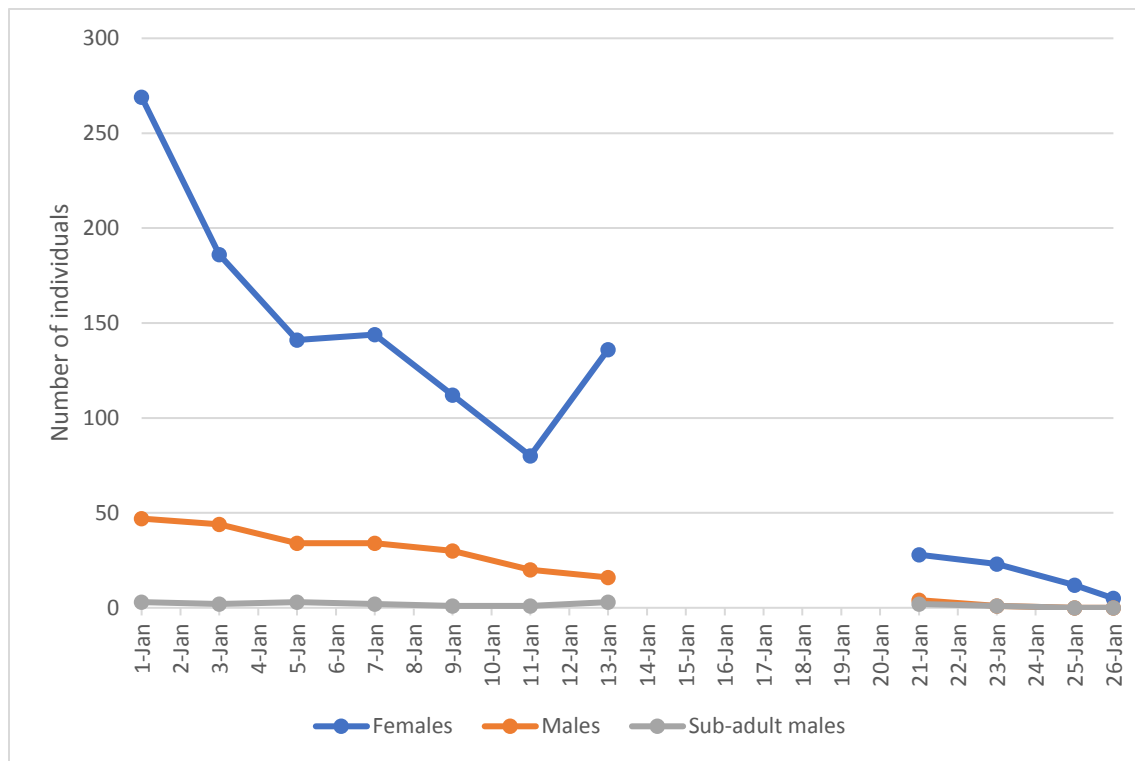


Figure 5. Numbers of adult females (blue), adult males (orange) and sub-adult males (grey) at Davis Point January 1 – 26, 2019 as obtained from direct counts. Note that no counts were conducted from 14 – 20 January.

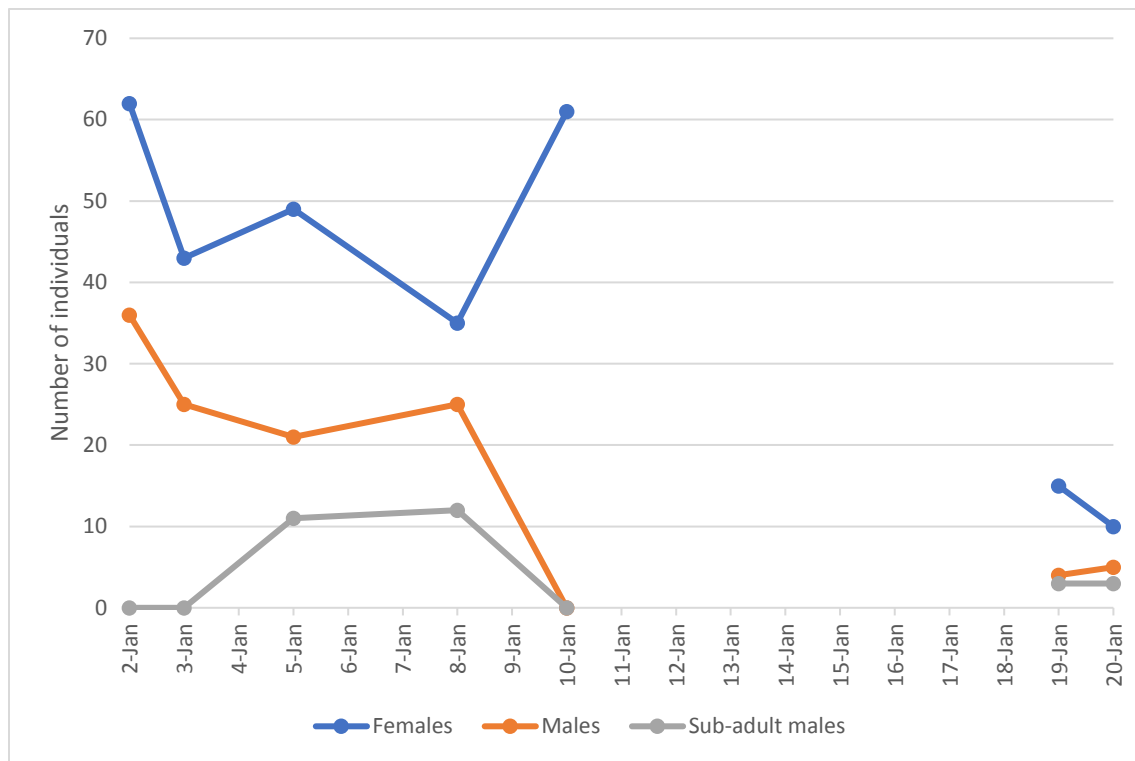


Figure 6 Numbers of adult females (blue), adult males (orange) and sub-adult males (grey) at Shoal Point 2 – 20 January 2019 as obtained from direct counts. Note that no counts were conducted from 11 – 18 January.

### 5.3 Tagging and microchipping

In total, 422 pups were flipper tagged and 395 of these were microchipped on Campbell Island between 30 December 2018 and 26 January 2019. The overall sex ratio of tagged pups was 1.02 (males = 213, females = 209). Breakdown of numbers for each colony are shown in Table 1. Records of all pups tagged and microchipped at Davis and Shoal Points are included in Appendix 2.

Pup tagging was more challenging earlier in the breeding season due to adults being very territorial and aggressive which makes access to pups in the middle of the colony difficult. Additionally, there were more adults present at the colony earlier in the season (Fig. 3 and 4). Hence, teams began tagging more accessible pups near the edges of the colonies first and eventually pups in the middle of the colony later in the breeding season when adults were more relaxed. At Davis Point, due to the large numbers of pups dying, tagging and microchipping was put on hold from 12 – 20 January in the hope of tagging the stronger and healthier pups that manage to survive till later in the field season.

Table 1. Number of live pups flipper tagged and microchipped at each colony.

Colony	Subcolony	Flipper tagged	Microchipped	Males	Females	Male:Female ratio
Davis Point	Bog	96	94	50	46	1.09
	Rock	109	84	58	51	1.14
	Subtotal	205	178	108	97	1.11
Shoal Point		217	217	105	112	0.94
Total		422	395	213	209	1.02

### 5.3.1 Tag and microchipping infections and loss

Infections at the flipper tagging sites were noted for 17 % (n=37) of pups at Shoal Point. No tag infections were noted at Davis Point, although this could have been an artefact of the high pup mortality rates which markedly reduced the number of pups surviving to a point where infection might have been noted. At Davis Point, two pups had each lost one of their two flipper tags by January 26. One of the full post-mortems undertaken at Davis Point also revealed a small amount of purulent exudate (pus) around the subcutaneous microchip (note this may have been a bacterial infection or the normal response to a foreign material– a swab was taken for bacterial culture).

## 5.4 Pup production estimates

A total of 705 pups were estimated to be produced in this season on Campbell Island. This consisted of 447 pups at Davis Point, 257 pups at Shoal Point, and one pup that was opportunistically sighted on the track descending towards the coast from Mount Lyall when the team was walking from Davis Point to Beeman Base. The pup production estimate for Davis Point was obtained by a direct count of live pups (tagged and untagged) done on 11<sup>th</sup> January where a total of 163 live pups were counted and the cumulative numbers of dead pups to that date was 284.

Mark-recapture was not undertaken this field season due to the high pup mortality at Davis Point and it was not done at Shoal Point as the team felt that the visibility at the site was too poor for the method to be effective. However, the Shoal Point team spent a considerable amount of effort searching for pups even outside the main colony area and was confident that they had tagged almost every live pup at Shoal Point.

Pup production at Campbell Island has never been estimated through mark-recapture. The established protocol recommends flipper tagging as many pups as possible and to undertake direct counts, and one of these methods is generally used to estimate the pup production. There is a growing interest in testing the accuracy of M-R methods to estimate pup production in

Campbell Island as this would reduce fieldwork effort. A trial period has been proposed for the coming years.

No pups were found at Beeman Base during the times that either teams were there.

Table 2 Location and number of pups counted at Davis and Shoal Points, Campbell Island, 30 December 2018 – 26 January 2019.

Colony	Sub-colony	Start date	End date	Live pups tagged (A)	Live pups not tagged (B)	Tagged pups later found dead (C)	Dead pups not tagged (D)	Total estimate of pup production (E=A+B+D-C)	Total dead tagged and untagged (F=C+D)	Mortality rate (G=F/E)
Davis Point	Rock	30/12/18	26/1/19	109	5	28	120	206	148	0.72
	Bog			96	3	26	168	241	194	0.80
	Subtotal			205	8	54	288	447	342	0.77
Shoal Point	Subtotal	1/1/19	25/1/19	217	2	17	21	257	38	0.15
Total				422	10	71	309	704	380	0.54

Estimated pup production for Davis Point was lower than the previous three breeding seasons. However, it is still within the range of values observed in the past (Table 2). For Shoal Point, estimated pup production was the highest on record. However, this may have been influenced by the length of the survey at Shoal Point (the longest to date), resulting in a more accurate survey.

## 5.5 Pup mortality

Table 3 Pup production, early mortality and timing of surveys at Davis Point and Shoal Point for seasons with available data.

		2007/2008 <sup>1</sup>	2009/2010 <sup>2</sup>	2014/2015 <sup>3</sup>	2017/2018 <sup>4</sup>	2018/2019 <sup>5</sup>
<b>Davis Point</b>	Pup production	442	503	515	503	447
	Dead total	196	319	321	144	342
	Timing of survey	4 – 31 Jan	20 Dec – 26 Jan	20 Dec – 27 Jan	27 Dec – 14 Jan	30 Dec – 26 Jan
	Number of days	27	37	39	19	28
	Early pup mortality	44%	63%	62%	29%	77%
<b>Shoal Point and Paradise Points (East and West)</b>	Pup production	122	168	173	227	257
	Dead total	32	54	79	28	38
	Timing of survey	3 visits between 28 Jan and 13 Feb	17 – 21 Jan and 10 Feb	28 – 30 Dec and 16 – 20 Jan	19 – 24 Dec and 18 – 24 Jan	1 – 20 Jan
	Number of days	?	6	9	11	20
	Early pup mortality	26%	32%	46%	12%	15%
<b>Total</b>	Pup production	564	671	688	730	704
	Dead total	228	373	400	172	380
	Early pup mortality	40%	56%	58%	24%	54%
<sup>1</sup> Maloney et al. (2009) <sup>2</sup> Maloney et al. (2012) <sup>3</sup> Childerhouse et al. (2015) <sup>4</sup> Unpublished data, retrieved from Micah's mortality assessment draft report <sup>5</sup> This study						

The overall pup mortality at Campbell Island in 2018/19 was 54%, which is well within previous years' ranges. Pup mortality at Davis Point however was 77% by 26 January, the highest on record among trips with similar survey timings, and a marked increase of 48% from last season. At Shoal Point the mortality rate was 15 % by 25 January (Table 3). Shoal Point also experienced a slight increase (3%) in pup mortality from last season. Even though both Davis and Shoal Point experienced difficult climatic conditions (but perhaps different micro-climates), the stark contrast between the early pup mortality rates provides evidence that Shoal Point is a better location for raising pups.

Data for the cumulative pup deaths was only available for Davis Point (Fig. 5; Appendix 3). At Shoal Point, while daily counts of dead pups were undertaken (where carcasses were sprayed and/or moved into a pile), the dates were not recorded hence we are not confident in the daily count data.

At both Davis Point sub-colonies, the rate of pup deaths was high early in the breeding season and levelled off later. The cumulative number of pup deaths was consistently higher at Bog colony than at Rock colony. This is consistent with its higher estimated pup production and pup mortality rate (Table 2).

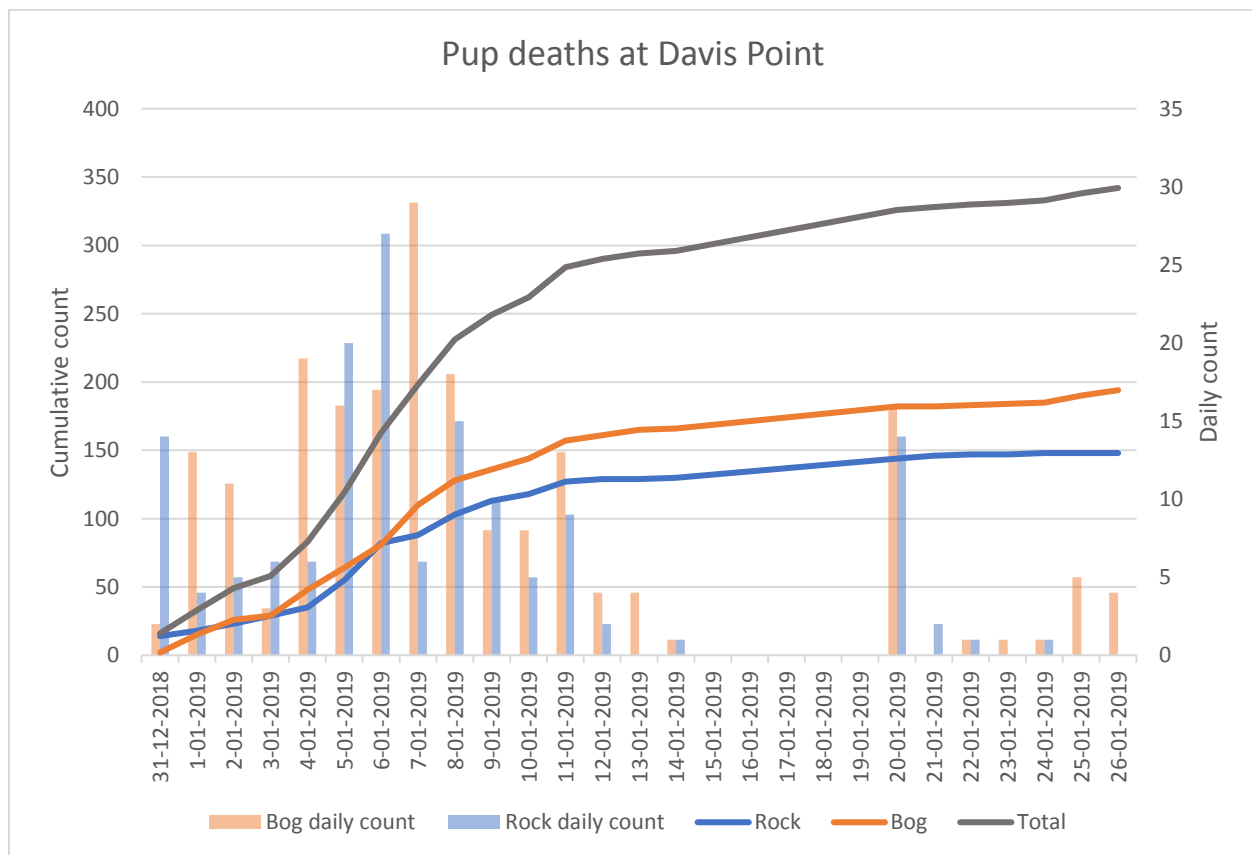


Figure 7 Daily (bars) and cumulative (lines) pup deaths at the Davis Point colony from 31 December 2018 – 26 January 2019. Note that pup deaths were not recorded from 15 – 19 January. The number recorded on 20 January may thus underestimate the number of pups that died over those 4 days.

## 5.6 Results of pup morphometrics

Pup mass, girth and length for each site are outlined in Tables 4, 5, and 6 alongside results for 2015 and 2018 for comparison.

Table 4 Mean ( $\pm$  SE) pup mass for females and males recorded at Davis and Paradise/Shoal Point for 2015, 2018 and 2019. Pup mass for the Auckland Islands (Sandy Bay and Dundas Island) in 2019 are also included.

Location	Date	Female mass (kg)	n	Male mass (kg)	n
Davis Point	13-Jan-15	9.9 $\pm$ 0.2	50	11.7 $\pm$ 0.3	50
	13 – 14 January 2018	11.7 $\pm$ 0.2	50	12.8 $\pm$ 0.2	50
	13 – 14 January 2019	9.7 $\pm$ 0.2	51	10.9 $\pm$ 0.3	49
Paradise/Shoal Point	15 – 20 January 2015	10.7 $\pm$ 0.3	33	12 $\pm$ 0.3	47
	20 – 21 January 2018	13.1 $\pm$ 0.3	50	14.7 $\pm$ 0.3	50
	13-Jan-19	10.8 $\pm$ 0.2	49	12.4 $\pm$ 0.3	51
	19 – 20 January 2019	11.0 $\pm$ 0.3	49	12.8 $\pm$ 0.4	51
Sandy Bay	2019	12.2 $\pm$ 0.3	50	13.8 $\pm$ 0.3	50
Dundas Island	2019	12.1 $\pm$ 0.3	50	13.9 $\pm$ 0.3	50

Table 5 Mean ( $\pm$ SE) pup girth for females and males recorded at Davis and Paradise/Shoal Point for 2018 and 2019.

Location	Date	Female girth (cm)	n	Male girth (cm)	n
Davis Point	13 January 2015	Not recorded		Not recorded	
	13 – 14 January 2018	51.7 $\pm$ 0.4	50	53.0 $\pm$ 0.4	50
	13 – 14 January 2019	50.1 $\pm$ 0.5	51	52.0 $\pm$ 0.4	49
Paradise/Shoal Point	15 – 20 January 2015	Not recorded		Not recorded	
	20 – 21 January 2018	53.5 $\pm$ 0.4	50	55.7 $\pm$ 0.5	50
	13 January 2019	54.6 $\pm$ 0.5	49	56.4 $\pm$ 0.5	51
	19 – 20 January 2019	55.4 $\pm$ 0.7	49	57.3 $\pm$ 0.7	51



Table 6 Mean ( $\pm$ SE) pup length for females and males recorded at Davis and Paradise/Shoal Point for 2018 and 2019.

Location	Date	Female length (cm)	n	Male length (cm)	n
Davis Point	13 January 2015	Not recorded		Not recorded	
	13 – 14 January 2018	77.9 $\pm$ 0.5	50	80.0 $\pm$ 0.5	50
	13 – 14 January 2019	72.4 $\pm$ 0.5	51	75.0 $\pm$ 3.1	49
Paradise/Shoal Point	15 – 20 January 2015	Not recorded		Not recorded	
	20 – 21 January 2018	82.7 $\pm$ 0.6	50	85.4 $\pm$ 0.6	50
	13 January 2019	84.9 $\pm$ 0.8	49	87.4 $\pm$ 0.7	51
	19 – 20 January 2019	86.0 $\pm$ 0.8	49	88.0 $\pm$ 1.8	51

The pup mass, girth, and length of each sex at Shoal Point were not significantly different between the two sampling periods (two-tailed t-test; Appendix 4). This increases our confidence that the pup measurements from the later sampling period (19 – 20 January) in are indeed comparable to those from the earlier sampling period (13 – 14 January). In the future, pup measuring days at Shoal Point need only be done on the earlier sampling period for better comparability with those taken for Davis Point and Auckland Islands, as well as to avoid unnecessary handling of pups.

The comparison of pup mass this season across Campbell Island and the Auckland Islands colonies are:

- Females: Sandy Bay > Dundas Island > Shoal Point > Davis Point
- Males: Dundas Island > Sandy Bay > Shoal Point > Davis Point

## 5.7 Re-sightings of sea lions tagged in previous seasons

A total of 36 adult tag resights (Davis Point = 29, Shoal Point = 5, Beeman's base = 2) were made opportunistically over the course of the field season (Table 7). All re-sighting data are included in Appendix 5. In future field seasons, tag re-sights of adult sea lions will be given more priority.

Table 7 Number of tag resights at each location by colour and sex. Breeding season in which sea lions were tagged as pups on Campbell Island is shown in brackets.

Location	Colour					Sex	
	Yellow (2007/08)	Lime/green (2009/10)	Orange (2014/15)	Pink (2014/15)	Blue (2017/18)	Male	Female
Davis Point	22	6		1		17	12
Shoal Point	1	1	1		2	3	2
Beeman's Base	2					2	

## 5.8 Preliminary assessments on factors contributing to early pup mortality

Specific studies to identify causes of pup mortality were another purpose of the fieldwork and these tasks assigned to specific team members. The assessment of the cause of pup mortality was undertaken primarily from necropsies, gross or full post-mortem. Tasks were allocated to K. Buckle at Davis Point and N. Scott at Shoal Point in the first part of the trip. During the second half of fieldwork a dedicated new team member, C. Lea, was responsible for undertaking necropsies with the specific goal of collecting samples to identify the presence of *Klebsiella pneumoniae*.

By the end of the first half of the fieldwork, 13 full post-mortem examinations were undertaken at Davis Point (see Appendix 6) and 67 gross post-mortems overall (63 at Davis Point and 4 at Shoal Point). During the second part of fieldwork (when most of the colony at both sites had dispersed into the forest), no post-mortems were done due to the lack of dead pups. Histology results and post-mortem reports for Shoal Point were not available at the time of writing. Results presented here are the overall initial diagnosis for pup mortality at Davis Point based on the available data from gross and full post-mortems.

### 5.8.1 Full post-mortems at Davis Point

Based on the diagnoses from the 13 full post-mortems, the relative contribution of different factors to pup mortality is indicated in Fig. 8. The majority of the pups likely died from exposure/starvation which are often inter-related factors, hence they are grouped together (W. Roe pers. comm.). Here, exposure is defined as a pup being found dead without other compromising gross lesions after a storm event or being found in the same time/place as other pups in a mass mortality that was not otherwise explainable. Starvation (i.e. extreme form of malnutrition) is defined as pups with a blubber depth of  $\leq 2$  mm (Maloney et al. 2009).

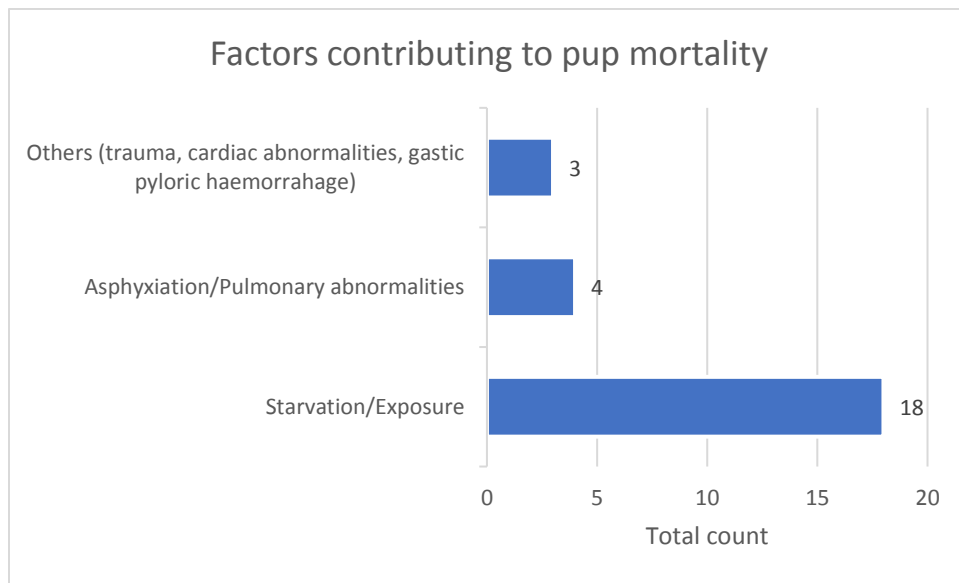


Figure 8 Factors that contributed to the pup mortality at Davis Point based on 13 full post-mortems. As there could be multiple factors that contributed to a pup's death, the relative influence of each factor was calculated by tallying up the number of times each factor was said to have contributed to pup mortality.

#### 5.8.2 Gross post-mortems at Davis Point

Of the 76 (13 full and 63 gross) post-mortem examinations at Davis Point, the average, median, maximum, and minimum blubber depth were  $3.9 \pm 3.1$  (SD) mm, 3 mm, 15 mm, and 1 mm respectively. Of these, 76 pups, 43 % ( $n = 33$ ) had a blubber depth of 2 mm or less (criteria for malnutrition in Maloney et al. (2009)), and the majority of pups with substantial blubber depth had evidence of serous atrophy (recent sudden depletion of fat stores). The quantity of milk in the stomachs of these pups ranged from 0 to 350 ml, with an average of  $12.3 \pm 55$  (SD) ml but a median of 0 ml. Of the 76 pups, 91% ( $n = 69$ ) had no milk in their stomach at all (a measure of 0 ml). It should be noted that the quantity of milk in the pups' stomachs does not necessarily provide evidence for starvation or malnutrition as this is also a common feature on extremely large pups that have been necropsied on Enderby Island (W. Roe, pers. comm.). It may simply be a matter of pups not being nursed within the few hours prior to their death.

Of the 76 pups, 34 % ( $n = 26$ ) had ulcerations on their flippers, including 2 minor, 12 mild, 10 moderate and 2 severe levels of ulcers. For the 20 pups where the number of affected flippers was recorded, 95 % ( $n = 19$ ) had ulcerations on all 4 flippers, 3 individuals had only 1 flipper affected, 2 individuals had 2 flippers and 1 individual had 1 flipper affected. Data for all gross post-mortems completed at Davis Point are included in Appendix 7.

Also, at Davis Point, a syndrome of sneezing, snotty-nosed pups with conjunctivitis was noted in live pups. This has been previously mentioned and was noted in M. Jensen's report (2017/18). Of

the live pups measured during weigh days, 16 % ( $n = 8$ ) of the 50 pups weighed and measured at Bog colony (Davis Point) had flipper ulcers and 62% ( $n = 31$ ) displayed clinical signs of conjunctivitis/rhinitis. Of the 50 pups weighed and measured at Rock colony at Davis Point, 74% ( $n = 37$ ) had flipper ulcers and 26 % ( $n = 13$ ) displayed symptoms of conjunctivitis.

The clinical syndrome of conjunctivitis and rhinitis is consistent with a viral (most likely) or bacterial infection but has no known cause. It is suggested that samples taken this year and last be investigated to rule out agents such as Influenza virus and others which cause similar disease in other species.

### 5.9 Mitigation of pup mortality in terrain traps at Davis Point

Coir logs were used to raise the floor of a giant bog and one of the mud channels (Foo et al. 2019). The coir log was lightweight which was excellent for easy transportation around the uneven terrain. The coir log was also used along the edges of the giant bog from where pups frequently enter. Wooden stakes were initially used to hold it in place as it was expected that the coir log would float on the surface and be relatively mobile. However, this was not the case. The coir log soaked up mud and liquid in the bogs/mud channels which made it heavy and rigid, allowing it to hold its position without the need for wooden stakes. In other words, the coir log provided a more stable than expected platform for pups (and even humans) to walk on when soaked in mud. Additionally, the dimensions and flexibility of the coir log allowed it to fit the shape and width of the mud channel snugly without requiring stakes to hold it in place (Fig. 9).



Figure 9. Mud channel (white outline) with coir log in place.



Pups were observed using the existing ramp installed by previous survey teams to self-rescue. The ramp was overall in good condition apart from the layer of mud and dirt that had built up on it which reduces its grip under wet conditions (Fig. 10). With the addition of the coir log, it helped provide extra purchase for pups that fall into the bog to pull themselves out.



Figure 10. Giant bog showing the condition of the existing ramp installed by previous teams and the new addition of the coir log (white outline; half of it underwater as indicated by the dashed lines)

Rocks were also used to fill some of the smaller mud holes. However, if rocks are to be used more frequently, more manpower or tools are likely to be needed. While there were loose rocks available at Davis Point, they are not typically within the main colony area. It was difficult to find reasonably sized rocks around the edges of the colony that were not too heavy to carry. Furthermore, carrying heavy rocks over uneven terrain can be a health and safety issue.

The hessian bags were not used for their original purpose; as bunkers to block pups from falling off cliffs (i.e. cliff between Bog and Rock colony). This was because no pups were observed to have fallen off the cliff while the team was there. While four dead pups were found at the bottom of the cliff when the team first arrived, no new dead pups were subsequently found there while the team was in place. Additionally, from personal observations by D. Foo who has been part of the survey team for two consecutive years, not as many pups were found sleeping next to the edge of cliffs compared to the previous season. This may be an effect of the weaker body condition of pups this season which reduced their movements around the colony.

Instead, the hessian bag was stuffed with dirt and rocks and was used to fill up a small shelter at the top end of a sloping mud channel where dead pups were found. Pups would fall into this particular mud channel from the top end and be tempted to hideout in this shelter instead of

exploring downstream where they would have greater chances of exiting the channel. Hence, by blocking the small shelter it discouraged pups that fall into the mud channel to hang around for too long in there (see Foo et al. (2019)).

## 6 Recommendations and future considerations

- Continue with two teams operating at the same time. Strive for consistency in the types of data collected and methods used between the two teams.
  - Have a clearer work plan and protocol for each objective
  - Have a pre-trip team training exercise for pup handling, tagging, and microchipping if possible.
- If microchipping is to continue at Campbell, ensure appropriate microchip readers (small and portable) are brought and used by both teams consistently.
- Include an objective to measure tag loss rates
- Consider starting tagging and microchipping one week later in the season to minimise tagging young pups – teams could use the first week to familiarise with the colony or do work for any objectives do not require handling of live pups
- Continue conducting gross post-mortems when and where possible to get a larger sample size and hence better representation of dead pups
- Collect climate data onsite at each location, including temperatures and wind chill
- Consider developing a barrier to stop sea lions from hauling out at Davis Point or other solutions that may attract sea lions to better breeding locations
  - Alternatively, explore solutions that may provide more shelter and windbreak for pups at Davis Point
- Finding pups after the colony disperses into the forest is more challenging on Campbell Island than on the Auckland Islands due to the nature of the terrain. DOC might want to reconsider the usefulness of having a second team in the later stage of the breeding season if the sole purpose is to do post-mortems. Alternatively, DOC may want to consider reducing the duration of the second phase in future surveys since the high early-pup mortality at Davis Point reduced the chances of the pup to live long enough to show symptoms of *Klebsiella*.
- Explore methods for evaluating female body condition (perhaps using ultrasound)
- More emphasis on tag resighting and keeping a daily record of the tags resighted

## 7 References

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## 8 Appendix

Please see separate document for appendices.