Final Report:

NZ sea lion research at Campbell Island-Motu Ihupuku, 2014/15

BPM-15-Final report-NZ sea lion research at Campbell Island 2014-15 v1.2

24/04/2015

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Date: 24/04/2015

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Document Revision Record

Rev.	Date	Description	Prepared	Reviewed	Approved
1.0	26/03/2015	Draft for internal review	SC	LD	SC
1.1	09/04/2015	Draft for external review	SC	LD	SC
1.2	24/04/2015	Final	SC	LD	SC

Document Reference Number: BPM-15-Final report-NZ sea lion research at Campbell Island 2014-15 v1.2

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Last updated: 24/04/2015

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1. Executive Summary

Blue Planet Marine (BPM) was contracted by the Deepwater Group Ltd (with co-funding from the Ministry of Primary Industries) to undertake a survey of New Zealand sea lions (NZSL) at Campbell Island (also known as Motu Ihupuku) during the 2014/15 breeding season. The research team arrived on Campbell Island on 18 December 2014 and left on 29 January 2015. The main aims of the work were to estimate total pup production for the season and to ensure compatibility with previous population surveys in 2007/08 and 2009/10. Other work included the characterisation of pup mortality and attempting to mitigate pup mortality from dying in holes. This report is the final report for this project.

In summary:

- Pup production (i.e. total number of pups born) was estimated for NZSL colonies at Davis Point (n=515), Paradise Point West (n=106) and Paradise Point East (n= 67) with a further 8 pups being found outside of the colonies for a total pup production for 2014/15 of **696** pups. This total represents an increase of twelve pups from the most recent survey of Campbell Island in 2009/10. Pup production at Campbell Island represents 31% (696) of the total estimated pup production (2271) for Auckland and Campbell Islands combined in 2014/15;
- The overall estimate of pup mortality for the season was 58% (i.e. 403 dead of 696 born) to the end of January and is broadly comparable to previous estimate from 2009/10 of 55%. Pup mortality estimates by colony are: Davis Point 62%, Paradise Point West 56% and Paradise Point East 28%. By comparison, the estimate for Sandy Bay at the Auckland Islands for the same period in 2015 (e.g. to the end of January), is only 4% but noting that this total is an underestimate given that it doesn't represent full season surveys;
- This year was the first time that live pups have been weighed at Campbell Island. Mean estimates (±SE) were measured for Davis Point (female = 9.9 kg (0.2); male = 11.7 kg (0.3)) and Paradise Point (female = 10.7 kg (0.3); male = 12.0 kg (0.3)). Ranking of mean weights by colony from Campbell and the Auckland Islands are:
    - Females: Davis Point < Sandy Bay < Paradise Point < Dundas Island
    - Males: Sandy Bay < Davis Point < Paradise Point < Dundas Island
- Four hundred and eighty one pups were double flipper tagged at Campbell Island including: Davis Point Bay – 360; Paradise Point West – 61; Paradise Point East – 55 and five pups tagged at other locations only;
- Of the 73 dead pups autopsied, it has been possible to provide a provisional cause of death for 60 (82%). Of these 60, preliminary provisional diagnosis for cause of death includes 62% starvation, 30% trauma (comprising general 13%; drowning 12%; aspiration 3%; and bite 2%); 7% bacterial infection, and 2% stillbirth/peripartum death. Of the autopsies where infection was the principle cause of death, dead pups had wounds with a purulent discharge but which were not the typical K. pneumoniae like signs that are regularly seen in at Enderby Island in the Auckland Islands group. The only way to confirm the presence of K. pneumoniae will be to run the cultures on some of the samples collected. It is important to note that these diagnoses are provisional and will be refined and/or confirmed once full histopathology analysis has been completed at Massey University;
- During the trip, a total of 131 resights of tagged adult sea lions were collected. Most (88%) of resights were from Davis Point. All resights will be entered into the New Zealand sea lion database; and

- In response to previous examples of pup mortality in holes at Sandy Bay, 3 new wooden ramps have been installed at Davis Point (in addition to the two ramps installed in 2009/10) to allow pups to climb out of places where they otherwise wouldn't be able to. Prior to the introduction of ramps, over 60 pups were physically rescued by researchers before ramp installation. Overall this programme of work has been very successful and has led to a direct reduction in NZSL pup mortality as a result. This was a core part of the project but with additional mitigation work (e.g. building ramps to allow pups to get out of holes) funded separately by WWF.

2. Introduction

New Zealand (NZ) sea lions (*Phocarctos hookeri*, hereafter NZSL) are NZ's only endemic seal species and historically bred all around NZ, though were extirpated from the mainland by early human settlers. The current population is estimated at fewer than 10,000 individuals, with more than 98% of breeding occurring at a small number of breeding sites at the Auckland Islands and Campbell Island (also known as Motu Ihupuku) of the NZ Subantarctic. Much smaller breeding sites are slowly increasing at Otago and Stewart Island.

Pup production is recognised as the best indicator of population status, and since the peak in pup production in 1998, there has been an approximate 48% decrease in pup production at the Auckland Islands, resulting in the species being classified as 'nationally critical' as of 2010 (**Figure 1**). Adult female mortality was initially believed to be the driver for the decline and therefore management has focussed on minimising adult/sub-adult mortality, but more recent analyses suggest that low fecundity and pup survival may also be important contributing factors. In addition, the bacteria *Klebsiella pneumoniae* has also been recognised as an additional (and potentially new) source of pup mortality. This disease is responsible for significantly increasing early pup mortality to at least two or three times average levels in some years.

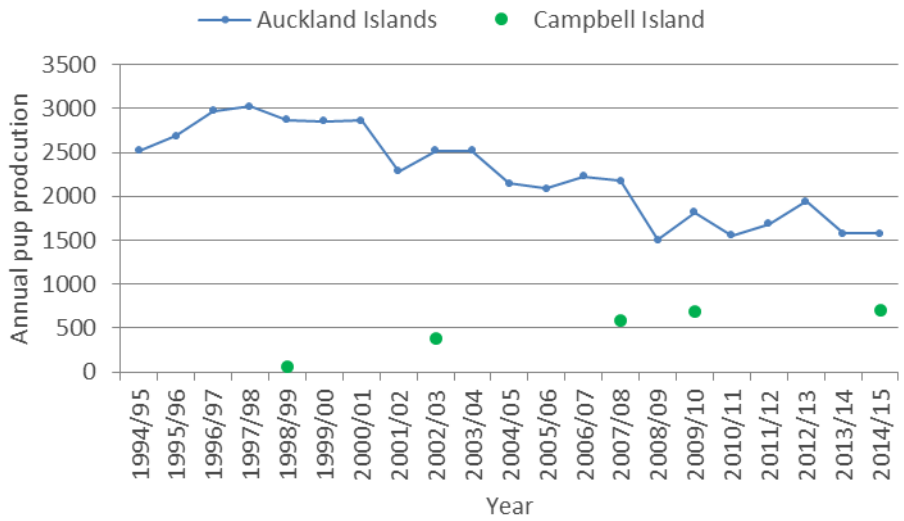

Figure 1: Estimates of previous pup production at Auckland and Campbell Islands

Campbell Island is the only significant breeding site outside of the Auckland Islands. Given its significance to the species, the NZSL population at Campbell Island has been surveyed several times over the last decade (Childerhouse et al. 2005; Maloney et al. 2009, 2012). In 2010, it was estimated to comprise approximately 27% of the total pup production for the species (Maloney et al. 2012). These surveys have pointed to increasing total pup production despite high levels of pup mortality within the first two months of the breeding season. This positive trend contrasts with that observed at the Auckland Islands. To confirm this reported trend in pup production and to further explore levels and causes of pup mortality, a population monitoring project (i.e. monitoring of pup production) was proposed for the summer of 2014/15. Furthermore, given some observed incidental captures of NZSL in some Campbell Island fisheries and the development of an indicative PBR (i.e. Potential Biological Removal – level of sustainable human induced mortality) for the local sea lion population (Roberts et al. 2014), this research can directly contribute to the improved monitoring and management of NZSLs at Campbell Island.

The project is was primarily funded by Deepwater Group Ltd. with support from the Ministry of Primary Industries (MPI). WWF provided funding towards the building of ramps to help mitigate pups dying in holes.

3. Objectives

The aims of the research are broadly to:

1. Estimate total pup production for Campbell Island in 2014/15;
2. Ensure comparability with previous surveys in 2008 and 2010 to allow for direct comparisons;
3. Identify and estimate causes and magnitude of pup mortality; and
4. Install mitigation measures (e.g. ramps) to prevent and reduce the number of pups dying in holes including monitoring the effectiveness of such mitigation.

4. Methodology

A description of methods used in this field study are available in Childerhouse (2014), which is available from the CSP website[1] and the author upon request. The research outlined here follows comparable methods as undertaken previously at Campbell Island as described in Maloney et al. (2009, 2012[2]) and Childerhouse et al. (2005[3]).

The area of operation was Campbell Island (53°S, 168°E), NZ with a particular focus on breeding colonies at Davis Point and Paradise Point in Perserverance Harbour but also including surveys over the whole island later in the season (**Figure 2**). A team of four researchers was present on the Island from approximately 18 December 2014 until 29 January 2015. The field team included a Massey

[1] http://www.doc.govt.nz/Documents/conservation/native-animals/marine-mammals/nz-sea-lion-tmp/nzsl-methodology-for-campbell-island-project-2014-15.pdf

[2] Maloney et al. (2009). Distribution, pup production and mortality of New Zealand sea lion *Phocarctos hookeri* on Campbell Island / Motu Ihupuku, 2008. New Zealand Journal of Ecology 33; Maloney et al (2012). Increasing pup production of New Zealand sea lions at Campbell Island/ Motu Ihupuku: can it continue? New Zealand Journal of Zoology 39: 19-29.

[3] Childerhouse et al (2005). Distribution, abundance and growth of New Zealand sea lion *Phocarctos hookeri* pups on Campbell Island. NZ Journal of Marine and Freshwater Research 39: 889-898.

University veterinarian (for undertaking autopsies) and a researcher who previously worked on the 2008 and 2010 NZSL surveys to suppport consistency with previous surveys.

General methods will include:

- All live pups found double flipper tagged;
- All tag resightings recorded;
- Davis Point and Paradise Point visited at approximately one week intervals;
- The remainder of suitable habitat at Campbell Island was surveyed during the last two weeks in January;
- Live pup counts:
    - One-off direct counts and daily direct counts;
    - All pups found were tagged;
- Dead pup counts:
    - Direct dead counts (single or multiple counters);
    - Dead pups counted and discarded at sea to prevent recounting;
- Tag and brand resighting as per previous survey work at Auckland Islands by Childerhouse (2013[4]); and
- Data were collected in an accurate and robust fashion and these data are provided in an electronic format suitable for upload into the New Zealand sea lion database.

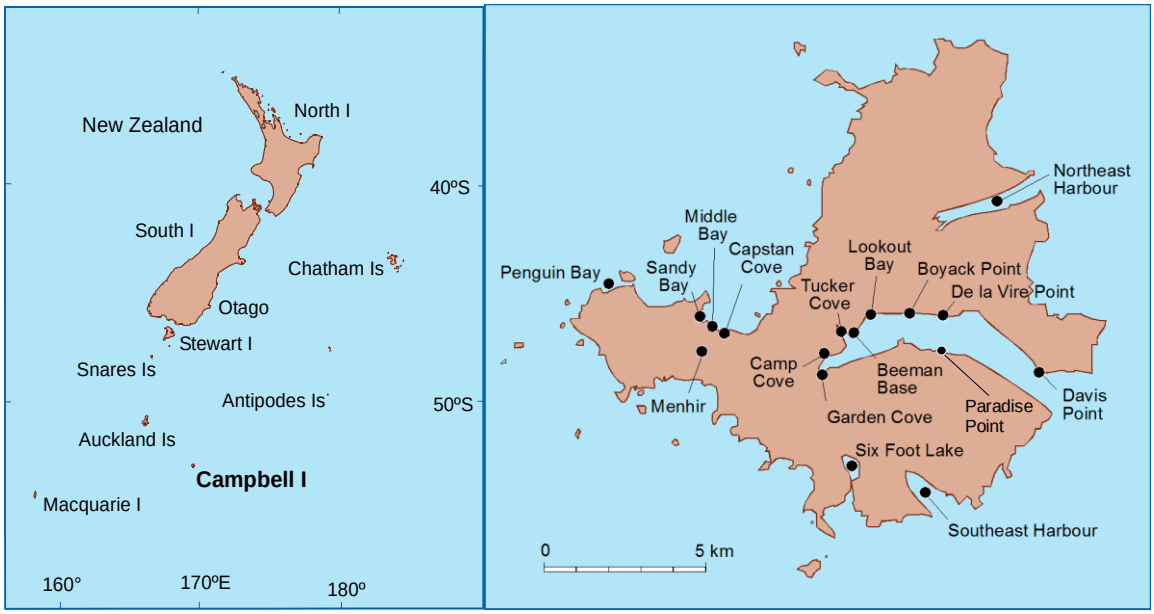

Figure 2: Figure of Campbell Island

[4] Childerhouse SJ (2013) Methodology for CSP Project 4522 New Zealand sea lion ground component 2013/14. Unpublished paper presented to the Conservation Services Programme, Department of Conservation, New Zealand. 18th November 2012. BPM document number: BPM-13-Methodology for CSP project 4522 NZ sea lion ground component 2013-14 v1.0. 9 p.

In general the research team spent approximately 4-6 days at each colony, 3-4 days walking between the colonies and taking a break at base, and then approximately 4-6 days at the other colony. This schedule was weather dependent and also influenced by access to transport as some of the tour companies kindly transported the team between sites by boat.

The team of reseachers undertaking the work were: Jim Fyfe, Chris Muller, Karina Gonzalez-Argandona and Rebecca French. The work in this report is a credit to the hard work, dedication and expertise of these people in trying conditions.

5. Results

5.1 Estimates of pup production

Estimates of pup production and mortality are shown in **Table 1**. Estimates from 2014/15 are compared with those from the last survey undertaken at Campbell Island in 2009/10. The key features are:

- Over 99% of the pups were recorded at three breeding colonies at Davis Point (74%), Paradise Point West (15%) and Paradise Point East (10%) with very few pups found outside of these locations during January (i.e. Norwest Bay, Beeman Base, Tucker Cove);
- Pup production from 2014/15 is 2% higher than the directly comparable estimate from 2009/10;
- Pup mortality from 2014/15 is 3% higher than the directly comparable estimate from 2009/10;
- Pup production at Campbell Island represents 31% (696) of the total estimated pup production (2271) for Auckland and Campbell Islands combined in 2014/15.

Figure 1 shows previous pup production estimates from Campbell Island including annual estimates from the Auckland Islands. It is important to note that the estimates from Campbell Island from 2007/08, 2009/10 and 2014/15 all used identical methods including one team member who was present for all three of the surveys ensuing continuity between the three surveys. The total of 696 pups is slightly higher than previous estimates from preliminary reports as it reflects an extra 3 dead pups that were not included in previous estimates.

Table 1: Estimates of pup production and mortality for NZSLs at Campbell Island 2014/15

	A	B	C	D	E	F	G	
Location	**No. live pups tagged**	**No. tagged pups later found dead**	**No. pups dead and not tagged**	**Total estimated pup production (A+C)**		**Total dead: tagged + untagged (B+C)**	**Mortality rate (F/D)**	
	2014/15	**2014/15**	**2014/15**	**2014/15**	**2009/10**	**2014/15**	**2014/15**	**2009/10**
Davis Point	360	166	155	515	503	321	62%	63%
Paradise Point East	55	7	12	67	54	19	28%	61%
Paradise Point West	61	15	45	106	114	60	56%	18%
6 Foot Lake	1	0	1	2	0	1	50%	N/A
Northwest Bay	2	0	2	4	2	2	50%	0%
Other Locations	2	0	0	2	8	0	0%	N/A
TOTAL	**481**	**188**	**215**	**696**	**681**	**403**	**58%**	**55%**

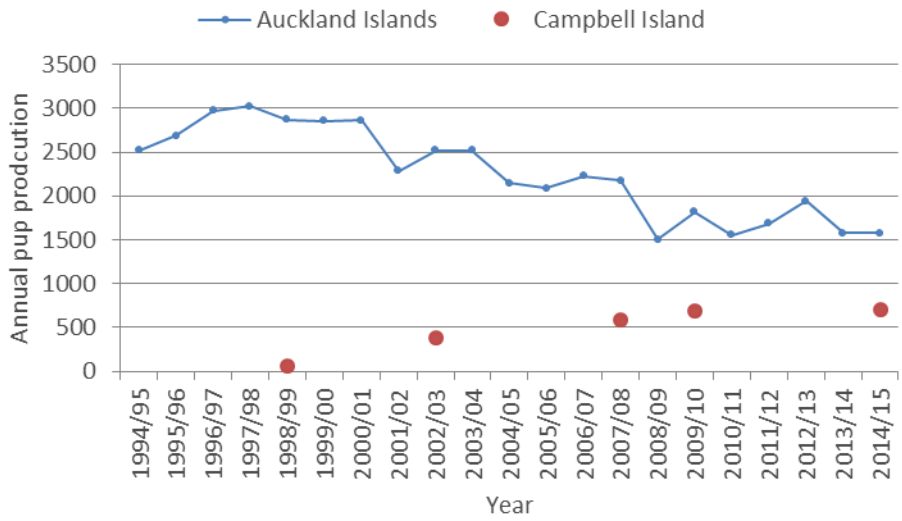

Figure 3: Total estimated pup production for New Zealand sea lions at the Auckland Islands and Campbell Island 1994/95 – 2014/15

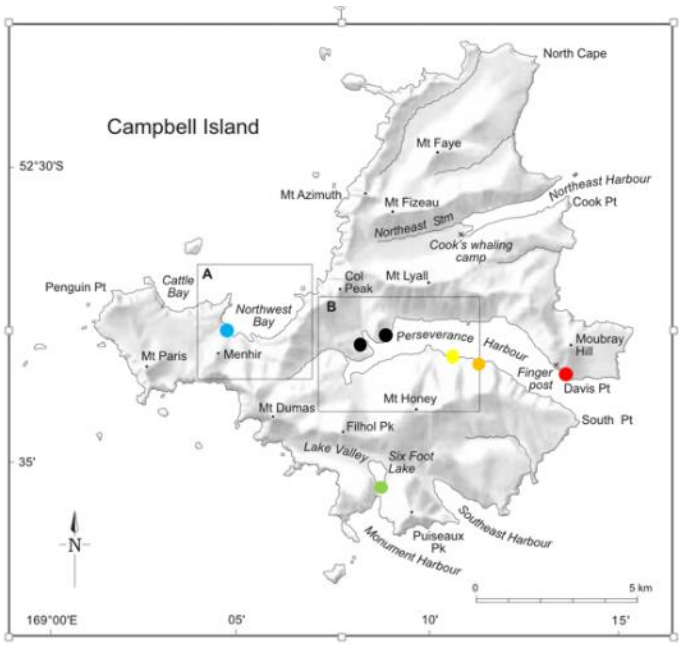

Figure 4: Locations of pups found during surveys of Campbell Island. Key: Red – Davis Point; Orange – Paradise Point East; Yellow – Paradise Point West; Green – 6 Foot Lake; Blue – Norwest Bay; Black – Beeman Base or Tucker Cove

5.2 General colony descriptions

5.2.1 Davis Point

Davis Point (52°33”46.6’S 169°14”13.4’E) is the largest colony on Campbell Island and is comprised of two sub-areas with different characteristics – Rock Platform and Mud Bog areas. Additional pictures and descriptions are shown in Appendix 1.

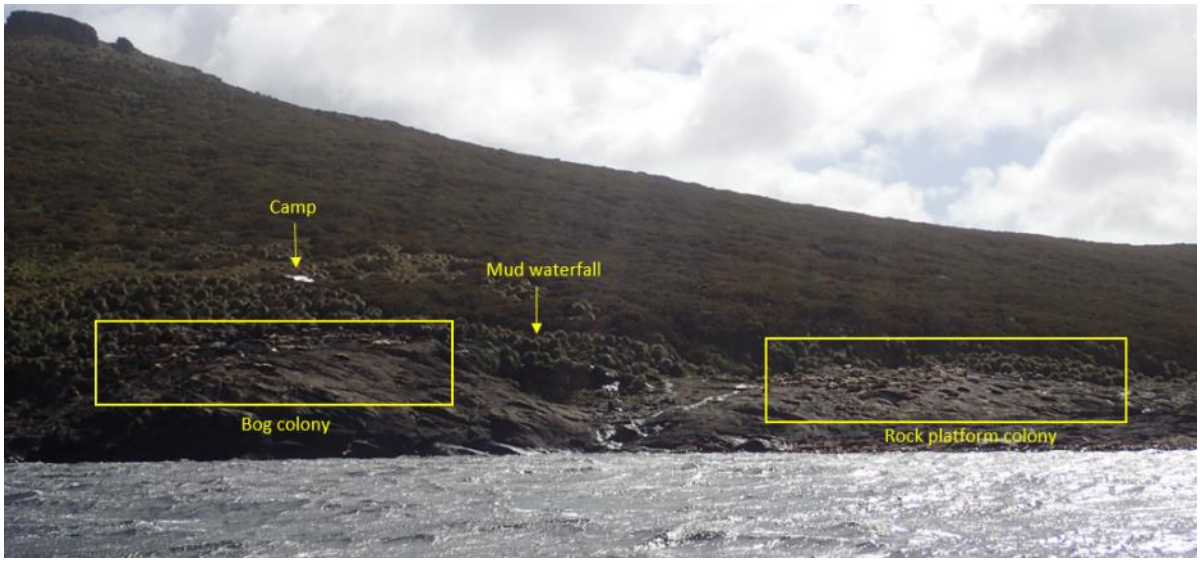

Figure 5: Visual description of Davis Point NZSL breeding colony showing component parts.

Rock Platform area: During December and January approximately two thirds of breeding harems at Davis Point are located here, next to several large rock pools. This breeding area is separated from the Mud Bog area by about 50 m with the Mud Waterfall in between. Some peripheral males are also located on the Rock Platform around the harems and between the breeding areas. There are no bog areas here as it is solid rock substrate, although pups are often crushed on the rock platform or fall into one of several rock pools and drown. Some of the pools have high steep rocky sides that prevent pups from climbing out. Any mitigation measures would be extremely difficult to implement since the whole area represents a risk to pups, and therefore any mitigation attempts are likely to be ineffective since the rock substrate prevents any earthworks or modifications.

Mud Bog area: During December and January approximately one third of breeding harems at Davis Point are located here. The substrate is mainly peat bog which causes a number of issues including:

- The main harem areas are usually on a flat pan which turns into a quagmire when wet which is most of the time (e.g. Campbell Island gets an average of 169mm and 130mm of rainfall in December and January respectively[5]). Many pups are suffocated or drowned in mud by fighting males. Mitigation would be difficult since the whole colony is affected;
- Pups often fall off the waterfall or the edge of the cliff into the pool around 5 m below. There is a way back up but it involves swimming approximately 10 m across the pool then climbing approximately 15 m back up a rocky ramp so most pups don't make it. Mitigation difficult since a wide area (approximately 15-20m) would need to be fenced;
- Adult sea lions have eroded some areas of the peat causing ridges that pups can fall over and not climb back. Worse, some smaller areas can fill with water causing small pools or bogs (depending on the water to mud ratio). Dozens of pups can die in a bog less than 1 m diameter. Some mitigation was attempted in 2009/10, however new bog areas are continually forming, especially after heavy rain so any effective mitigation would require regular follow up work to ensure they are in the most appropriate places; and

[5] Mean rainfall from 2010-2015 from NIWA's New Zealand National Climate Database. Available at http://cliflo.niwa.co.nz. Downloaded 15 April 2015.

- The stream running over the waterfall forks, and one branch runs behind the colony before exiting to the sea on the far side. This forms a Giant Bog immediately behind the colony. In 2007/08 and 2009/10, many pups fell off the edge of the colony and couldn't climb back up the 0.5-1 m high sides. Mitigation was attempted in 2009/10 with sections of the bank broken down and two pieces of boardwalk installed as ramps to allow pups to get out. In 2014/15 no pups were observed to drown in the Giant Bog, and one pup observed in the bog managed to exit via one of the installed ramps. However, the dynamics of the colony had changed slightly since 2009/10 meaning harems were now further away from the edge, and the ridge was now higher on the inside preventing pups from climbing up to the edge to fall off. Problematically, one of the ramps installed in 2008/09 was being used as access to the harems by peripheral males meaning the ridge was usually no longer available to researchers as access along the back of the colony.

5.2.2 Paradise Point West

The Paradise Point West colony (52°33'24.5"S 169°11'24.55"E) comprises approximately of two thirds of the breeding harems at Paradise Point. It is separated from the East Colony by around 500 m. The location of the West colony appears to be moving slowly westwards from the original site (i.e. the location has moved approximately 100 m further west since 2007/08 season).

The ground in the current breeding area is flattened and muddy and the harems were initially restricted to an elevated 'island' defined by a relatively steep ridge bordered on two sides by streams with steep 1 m high banks. However, the Paradise Point colonies are not as rigidly defined as the harems at Davis Point and there is some evidence that harems may migrate further up the hill (presumably to fresh ground) as the season progresses. There is a 3 m high bank below the colony which means that some harems form on the boulder beach below colony.

Ferns and grasses have started to recover at 2007/08 location indicating it has likely not been used for breeding for several years. The progressive decline of vegetation heading west towards current breeding location indicates likely successive westward movement of the western breeding area over the preceding five years.

Thick *Dracophyllum* scrub/forest on the western side of the colony border is likely to prevent further westward movement unless the colony relocates to the far side of it.

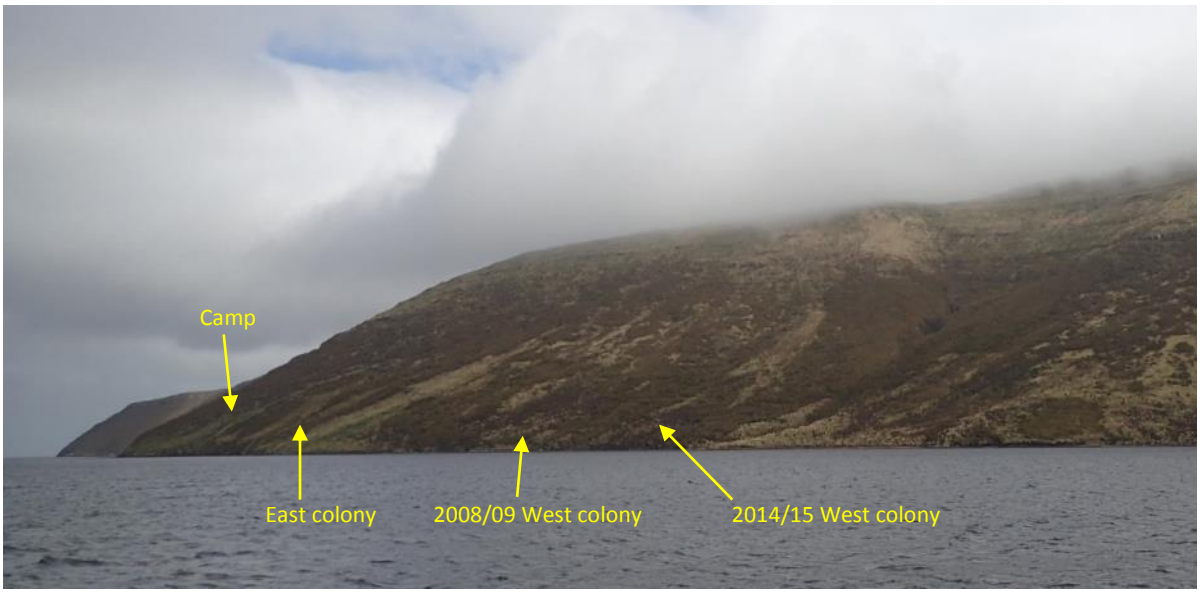

Figure 6: Visual description of Paradise Point West and East NZSL breeding colony including the previous location of the Paradise Point West colony in 2009/10

5.2.3 Paradise Point East

The Paradise Point East colony (52°33'28.5"S 169°12'4.1"E) comprises approximately one third of breeding harems at Paradise Point and is separated from the West Colony by around 500 m.

This colony is in same location as in 2007/08 and 2009/10 (although the field camp had to be moved approximately 20 m further east due to some movement of colony boundary). The ground in the area of the colony is flattened and muddy with harems not rigidly defined. The colony is on the side of a hill and most areas are quite steep. There is some evidence that harems migrate further up the hill (presumably to fresh ground) as the season progresses.

5.2.4 Other sites

Only five pups were tagged outside of the two main colonies at the following locations:

- Two at Beeman Base;
- Two at Northwest Bay (i.e. Sandy Bay and near Northwest Bay hut); and
- One at Six Foot Lake.

5.3 Tagging

Four hundred and eighty one live pups were tagged with identical numbers in both flippers during the trip (see **Table 1**). Flipper tags were Dalton Jumbo tags coloured white, pink or orange with alpha numeric numbers (e.g. P101). No pups were microchipped. All data will be uploaded into the New Zealand sea lion database[6].

5.4 Pup weights

Table 2: Summary of mean pup weights for the Campbell Island for 2014/15

Location	Date	Female		Male	
		n	Mean weight (kg; SE)	n	Mean weight (kg; SE)
Davis Point	13/01/15	50	9.9 (0.2)	50	11.7 (0.3)
Paradise Point	16-20/01/15	33	10.7 (0.3)	47	12.0 (0.3)

As many pups of both sexes as possible were weighed at the main colonies as close to the date of pup weighing at the Auckland Islands to provide some comparability. This was the first time that pups have been weighed at Campbell Island. Comparisons with Auckland Island are:

- Mean pup weights at Davis Point (DP) were:
  - Females – 7% and 13% lighter than Sandy Bay (SB) and Dundas Island (DD) respectively
  - Males – 5% heavier and 5% lighter than SB and DD respectively
- Mean pup weights at Paradise Point (PP) were:
  - Females – 1% heavier and 6% lighter than SB and DD respectively

[6] http://data.dragonfly.co.nz/nzsl-demographics/

- Males – 8% heavier and 2% lighter than SB and DD respectively

Overall, the following rankings for weight for:

- Females: DP < SB < PP < DD
- Males: SB < DP < PP < DD

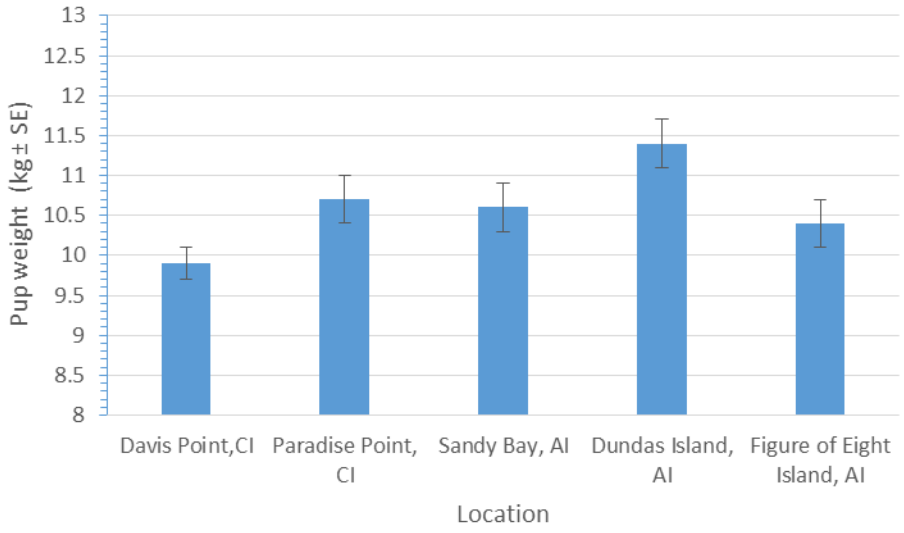

Figure 7: Mean female NZSL pup weights for 2014/15 by colony at Campbell Island (CI) and the Auckland Islands (AI)

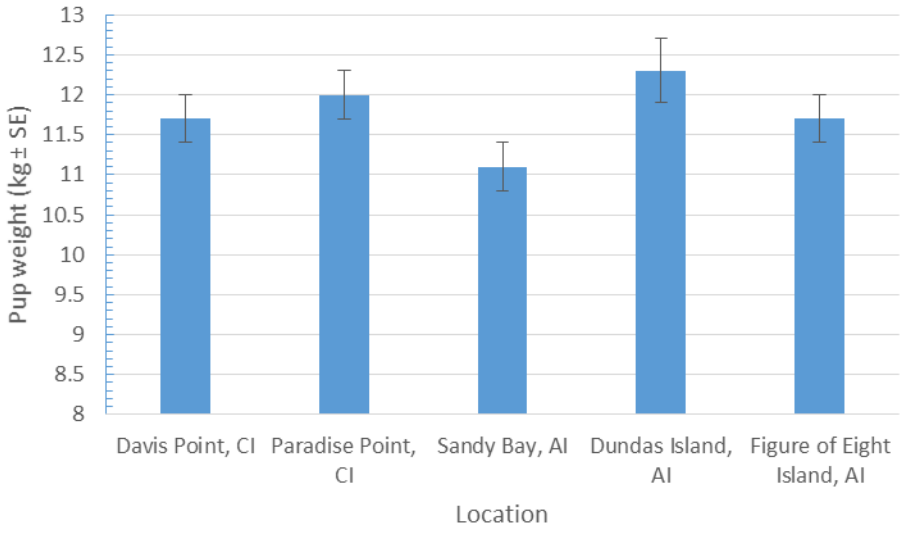

Figure 8: Mean male NZSL pup weights for 2014/15 by colony at Campbell Island (CI) and the Auckland Islands (AI)

5.5 Counts at Davis Point

Direct counts of live and dead pups, adult females, adult and sub-adult males were made at Davis Point Bay from 20 December 2014 until 27 January 2015 (**Figure 9**). The research team alternated surveys at Davis and Paradise Points and the gaps in this data series are when the team was undertaking survey work at Paradise Point. Unlike the Auckland Islands, where the peak in pup

production is around 15-16 January for Sandy Bay or 19-20 January for Dundas Island. The peak at Davis Point appears to be earlier at 2-4 January although it is difficult to make direct comparisons as **Figure 9** shows only live counts rather than live plus dead counts as it used at the Auckland Islands. The decline in live pups at Davis Points after 4 January is a function of pup mortality (i.e. dead pups are not included in these counts) and mothers moving their pups away from the colony.

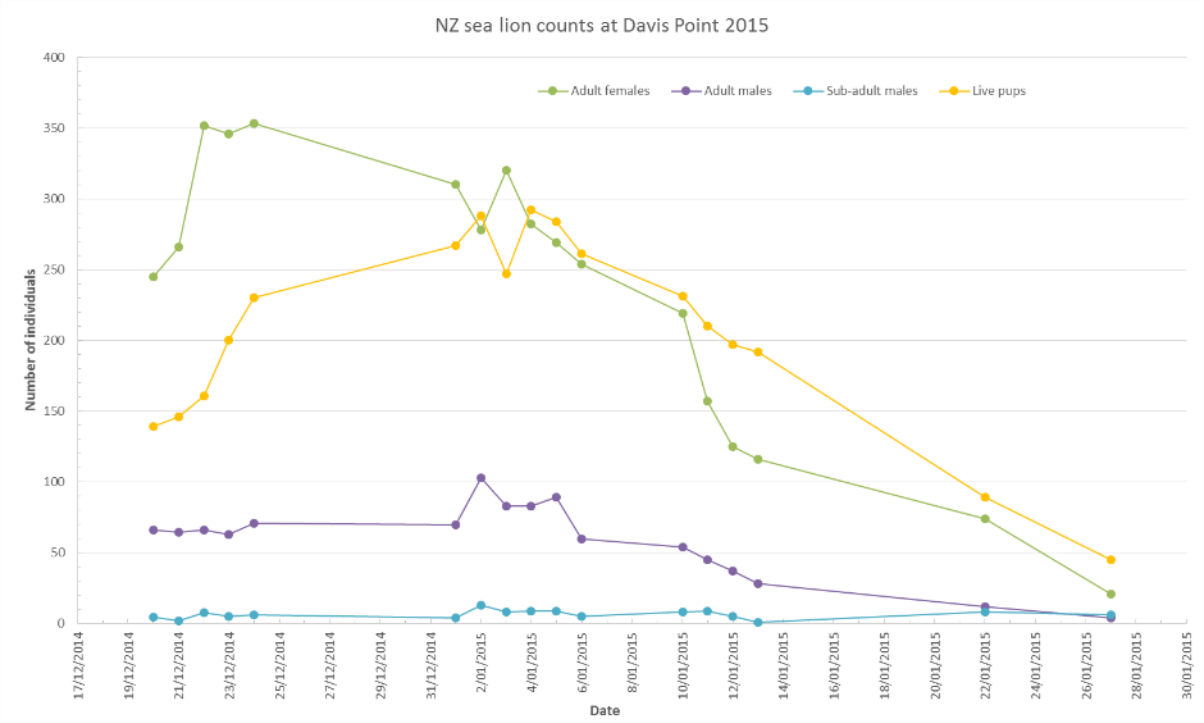

Figure 9: New Zealand sea lion counts at Davis Point, Campbell Island 2014/15.

5.6 Counts at Paradise Point

Counts were only made at Paradise Point between 28 and 30 December 2014. When the research team returned on 16 January 2015, the colony had broken up and there was effectively no colony as individuals had dispersed away and therefore no further counts were undertaken. **Table 3** shows a summary of counts over the December period.

Table 3: Summary of average counts (SE) at Paradise Point West and Paradise Point East at Campbell Island during December 28-30 2014

Location	No counts	Live pups	Adult females	Adult males	sub-Adult males
Paradise Point West	3	75 (5.3)	97 (11.1)	26 (1.5)	7 (0.3)
Paradise Point East	3	45 (2.7)	47 (4.7)	20 (0.9)	2 (0.6)

5.7 Pup mortality

Pup mortality has been monitored each day the research team was at Davis Point and Paradise Points. However, due to highly territorial (i.e. aggressive) males and inaccessible terrain at both colonies it was difficult to always complete dead pup counts. This is particularly true of early in the season (e.g. December). In addition, the research team alternated surveys at Davis and Paradise Points and therefore there are also gaps in this data series when the team were undertaking survey work at the other colony. Pup mortality is estimated in **Figure 10** but it is important to note that the estimates are not necessarily temporally accurate as while there was confirmed pup mortality at Paradise Point prior

to 18 January, researchers were unable to get access to some parts of the colony to count them until then.

Overall pup mortality is presented in **Table 1** with an overall level of 58% at the end of the season. This is slightly higher than the estimate from 2009/10 when it was last undertaken of 55%. Mortality was highest at Davis Point (62%) and slightly lower at Paradise Point West (56%) but considerably lower at Paradise Point East (28%). While the exact reasons for the large difference in mortality rates are unclear, they may relate to factors including that Paradise Point East has not streams or pools meaning there is little water for pups to drown in; the colony is steeply sloped so drainage is likely to be better leading to an overall drier substrate; and that as it is a smaller colony, there may be fewer males fighting and therefore fewer pup deaths as a result.

There were 73 pups autopsied (Davis Point = 69; Paradise Point = 4). Of these, it has been possible to provide a provisional cause of death for 60 (82%) whereas for the remaining 13 (18%), the diagnosis is still open. Open diagnoses could be a result of decomposed or scavenged individuals or no significant findings. These samples with open diagnoses may be able to be further clarified in some cases with further histopathological assessment. Samples were not retained from all autopsies due to logistic and other considerations (e.g. partly scavenged) but full samples were collected from 43 autopsies for subsequent further analysis at Massey University.

Of the 60 autopsies for which a preliminary provisional diagnosis has been made, the following primary causes were identified:

- 61.7% starvation,
- 30.0% trauma – comprising:
    - Trauma (general) 13.3%;
    - Trauma (drowning) 11.7%;
    - Trauma (aspiration) 3.3%;
    - Trauma (bite) 1.7%
- 6.7% bacterial infection,
- 1.7% stillbirth/peripartum death.

It is important to note that these diagnoses are provisional and will be refined and/or confirmed once full histopathological and culturing analysis has been completed at Massey University. As is usual with these preliminary findings, some dead pups showed symptoms of more than one type of mortality but the most likely mortality agent has been identified here as part of preliminary provisional diagnosis. Figure 11 shows the preliminary provisional diagnosis for dead pups at Campbell Island.

Given that only four autopsies were undertaken at Paradise Point and for only two of those was it possible to determine the cause of death (both as starvation), it is not possible to provide colony specific estimates of mortality and data from Davis Point and Paradise Point have been combined for reporting.

- Of the autopsies where infection was the principle cause of death, dead pups had wounds with a purulent discharge but which were not the typical K. pneumoniae like signs that are regularly seen in at Enderby Island in the Auckland Islands group. The only way to confirm the presence of *K. pneumoniae* will be to run the cultures on some of the samples collected.

In addition to the autopsies, substrate samples of mud, soil and water were collected around the colonies in January for testing of environmental *K. pneumoniae* burden through the season.

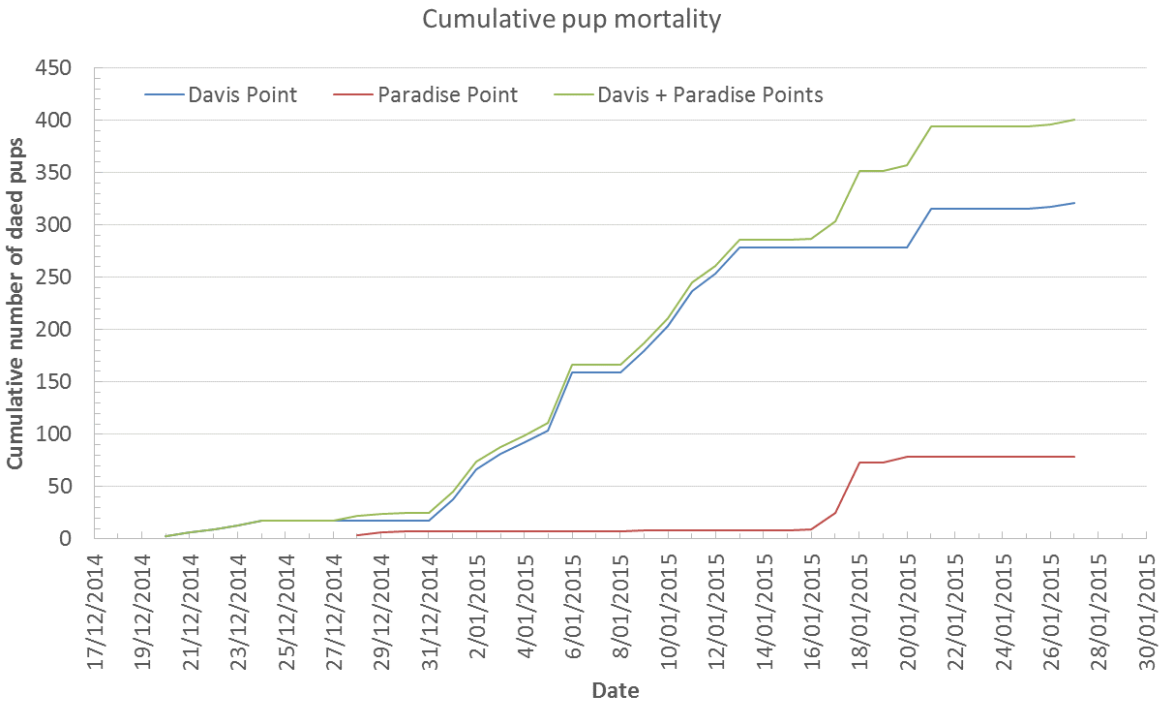

Figure 10: Cumulative New Zealand sea lion pup mortality at Davis Point and Paradise Point, Campbell Island 2014/15

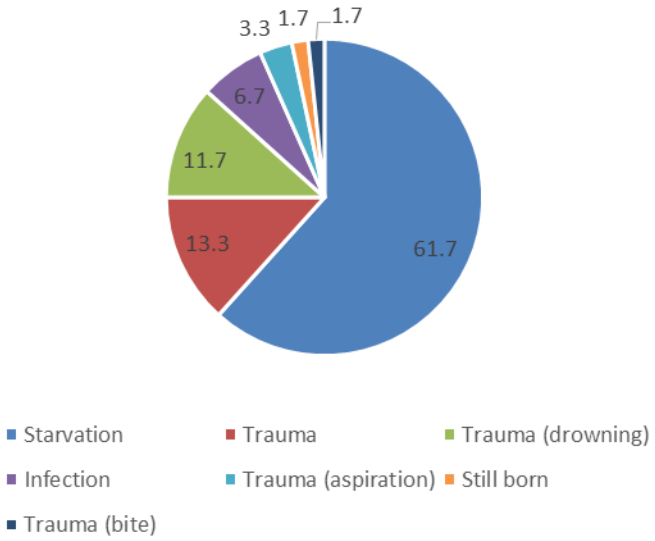

Figure 11: Preliminary and provisional diagnosis (%) of cause of death of New Zealand sea lion pups at Campbell Island 2014/15 (n=60)

5.8 Resighting

There were 131 resightings of adult sea lions previously tagged. These can be broken down by:

- Location:
    - Davis Point = 115

- Paradise Point = 13
- Beeman Base = 2
- Garden Cove = 1

- Type:
  - 32% green (402 tags put out in 2009/10 – 5 years old)
  - 68% yellow (397 put out in 2007/08 – 7 years old)
  - 0% pink or blue (161 put out in 2002/03 – 12 years old)

All resights from individuals previously tagged at Campbell and none seen from anywhere else (e.g. Auckland Islands). However, sea lions tagged at the Auckland Islands have been previously recorded at Campbell Island.

5.9 Shark attack scars

During survey work at Campbell Island, regular checks were made for sea lions exhibiting scars from shark bites (presumably from great white sharks *Carcharodon carcharis*) which are very distinctive. Shark bite scarring has been confirmed at Campbell Island previously but has not been quantified (A. Maloney *pers. comm.* in Robertson & Chilvers 2011). During the entire survey 2014/15 period, only a single adult male was seen with a shark bite scar which would put the rate of scarring at less than 1%. Robertson & Chilvers (2011) reported that 27% of adult NZ sea lions at Sandy Bay on Enderby Island have shark bite scars.

5.10 Mitigation of pup mortality in holes

There have been issues in previous years with pups being trapped and dying in holes at colonies at both the Auckland Islands and at Campbell Island. One of the new programmes of work for this season was the exploration of this issue and mitigation options. Characterising and assessing pup mortality, including deaths in holes, was a core part of this project but additional mitigation work (e.g. building ramps to allow pups to get out of holes) was funded separately by WWF.

A detailed description of the sites (including photos) and the potential issues with each site is provided in Appendix 1. During the 2009/10 research trip two ramps were installed in some holes at Davis Point to allow pups to escape. These were still in place during the recent trip but were partly buried in the ground and some were used by males as access ways into the colony. Due to the highly territorial nature of the colony it was not possible for the team to install ramps at Davis Point until later in the season after most of the males had moved away.

During the season, pups seen stuck in holes were physically removed by the team and put back into the colony. It was estimated that at least 60 pups were rescued from holes which they would not otherwise been able to escape but it is not clear exactly how many different individuals this may represent (e.g. some pups may have been removed more than once). At the end of the season, three wooden ramps were installed in areas deemed to be most likely to lead to pup deaths in coming seasons and also some steep banks on the edges of holes were lowered allowing pups to climb out without the building of any ramps. These mitigation measures will be in place for next season 2015/16 and will hopefully allow pups to escape thereby reducing mortality. Ongoing monitoring is recommended to ensure the effectiveness of all mitigations installed.

Overall this programme of work has been very successful and has led to a direct reduction in early NZSL pup mortality as a result.

Figure 12: Photos of holes that are known to kill pups and also ramps that allow pups to escape holes at Davis Point, Campbell Island

6. General Discussion and Recommendations

Based on a review of field operations and other issues, we discuss and make the following recommendations for potential future work at Campbell Island:

1. Pup production at Campbell Island appears approximately stable since at least 2008/09 which is a positive finding and now represents almost a third of estimated pup production for the species. However, the survey methods have been sporadic (e.g. approximately every five years) and have primarily focused on colonial breeding. Survey effort, with the exceptions of 2002/03 and 2008/09, have not investigated potential non-colonial breeding which was apparently the norm at Campbell prior to the establishment of breeding colonies at Davis Point around (likely during the mid-1990s) and Paradise Point (sometime between 2003 and 2008). Given the high level of pup mortality seen at Campbell Island during survey years, it is interesting that overall pup production appears stable. While there are a variety of possible explanations for this (including high survival and reproductive rates), it is possible that immigration of non-colonial breeders into the existing colonies is maintaining overall production at a stable level. To address this uncertainty, we **recommend** that:
    a. Future survey effort be directed to further assess annual pup production to investigate whether the levels described to date are reflective of ongoing annual

production at these levels. For example, surveys could be conducted three years in a row to provide improved estimates of inter-annual variation; and

b. Future survey effort be directed to further assess non colonial breeding which could take the form of increased search effort away from the existing colonies during the season and/or follow up survey work later in the season to investigate the prevalence of untagged pups presumably born away from the colonies (potentially similar to the mark-recapture approach undertaken in 2002/03).

2. Early pup mortality (i.e. to the end of January) at Campbell Island is extremely high both in comparison to that seen at the Auckland Islands and also in comparison with other similar otariid species. The three surveys over the last decade have used similar methodology and all recorded pup mortality in excess of 50% within the first two months. This level appears unsustainably high despite apparently stable pup production since at least 2008/09 and could lead to a decline in future pup production as recruitment into the breeding population is likely to be significantly reduced. This consistently high level of mortality warrants further consideration and investigation. We **recommend** that:
    a. Future survey effort be directed to further assess annual pup mortality to investigate whether that the rates described to date are reflective of ongoing mortality at these levels. For example, surveys be conducted three years in a row to provide improved estimates of inter-annual variation;
    b. Population modelling of the Campbell Island population be undertaken to assess the sustainability of these high levels of pup mortality and what it may mean for future pup production at Campbell Island; and
    c. Further investigation is undertaken of the causes of pup mortality to identify the causal agent..
3. Pending final confirmation of the cause of death, it appears that starvation and trauma are responsible for 62% and 30% respectively of overall pup mortality. While starvation may be difficult to mitigate directly, it may be possible to migrate trauma though the continued use of active mitigation measures such as ramps to allow pups to escape holes and/or modification of breeding colonies to reduce the incidence of pups dying in holes. We **recommend** that:
    a. All existing histo-pathology samples collected from dead pups at Campbell Island are fully analysed to confirm cause of death and provide an accurate insight into the actual causes of mortality; and
    b. Further work is done on investigating options for mitigation of pup deaths in holes and from other sources. This would include monitoring and maintenance of ramps presently installed at Campbell Island.
4. The Davis Point and Paradise Point colonies are approximately one day's walk in opposite directions from the main DOC base at Beeman. Therefore to survey both colonies requires four days of transit. However, the colonies are approximately only 15-20 minutes by boat from Beeman. The yacht *Tiama* and tour vessels transported the research team when they were available but the majority of the time, researchers walked. Having access to appropriate vessels and trained personnel would greatly reduce the transit time to and from colonies and allow for that extra time to be spent working at the colonies and/or searching for non-colonial breeding. Two vessels (i.e. small Stabicraft with outboards) were used during the 2002/03 sea lion surveys and were very successful. We would therefore **recommend** that:
    a. Consideration be given to the use of dedicated vessels for transport for future survey work.

7. Acknowledgements

This project was funded by the Deepwater Group Ltd (www.deepwater.org) and the Ministry of Primary Industries. This research would not have been possible without the support of many people, and for which we are very grateful:

- Henk Haazen (Master of the RV *Tiama*) and Steve Kafka (Master of *Evohe*) and their great crews who were extremely professional and accommodating;
- Heritage Expeditions for transport of personnel between colonies at Campbell Island;
- DOC staff including Ian Angus, Laura Boren, Katie Clemens-Seely, Sharon Trainor, Janice Kevern, Doug Veint;
- Members of the CSP Technical Working Group who provided useful feedback on this project;
- Wendi Roe at Massey University for helpful advice and support;
- Richard Wells of Deepwater Group Ltd for encouraging, supporting and driving this project;
- Thanks to the Deep Water Group who were primary funders of this research with additional support from MPI; and
- WWF provided funding towards the building of ramps to help mitigate pups dying in holes.

8. References

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Appendix 1: Description of New Zealand sea lion breeding colonies at Campbell Island during the 2014/15 season including notes about mitigation options for reducing pup mortality in holes

INTERIM REPORT

CAMPBELL ISLAND COLONY REPORT 2014-15

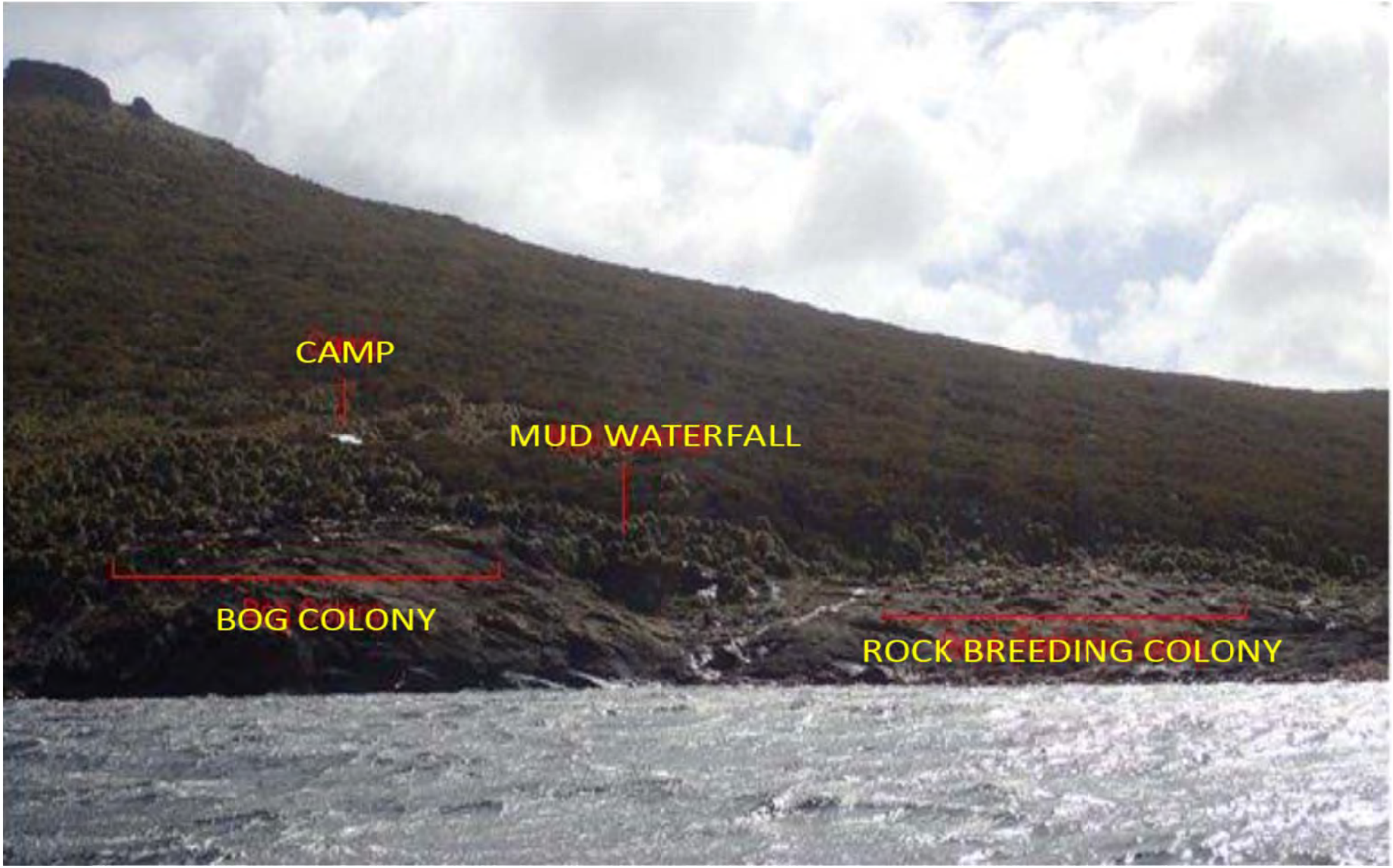
Chris Muller

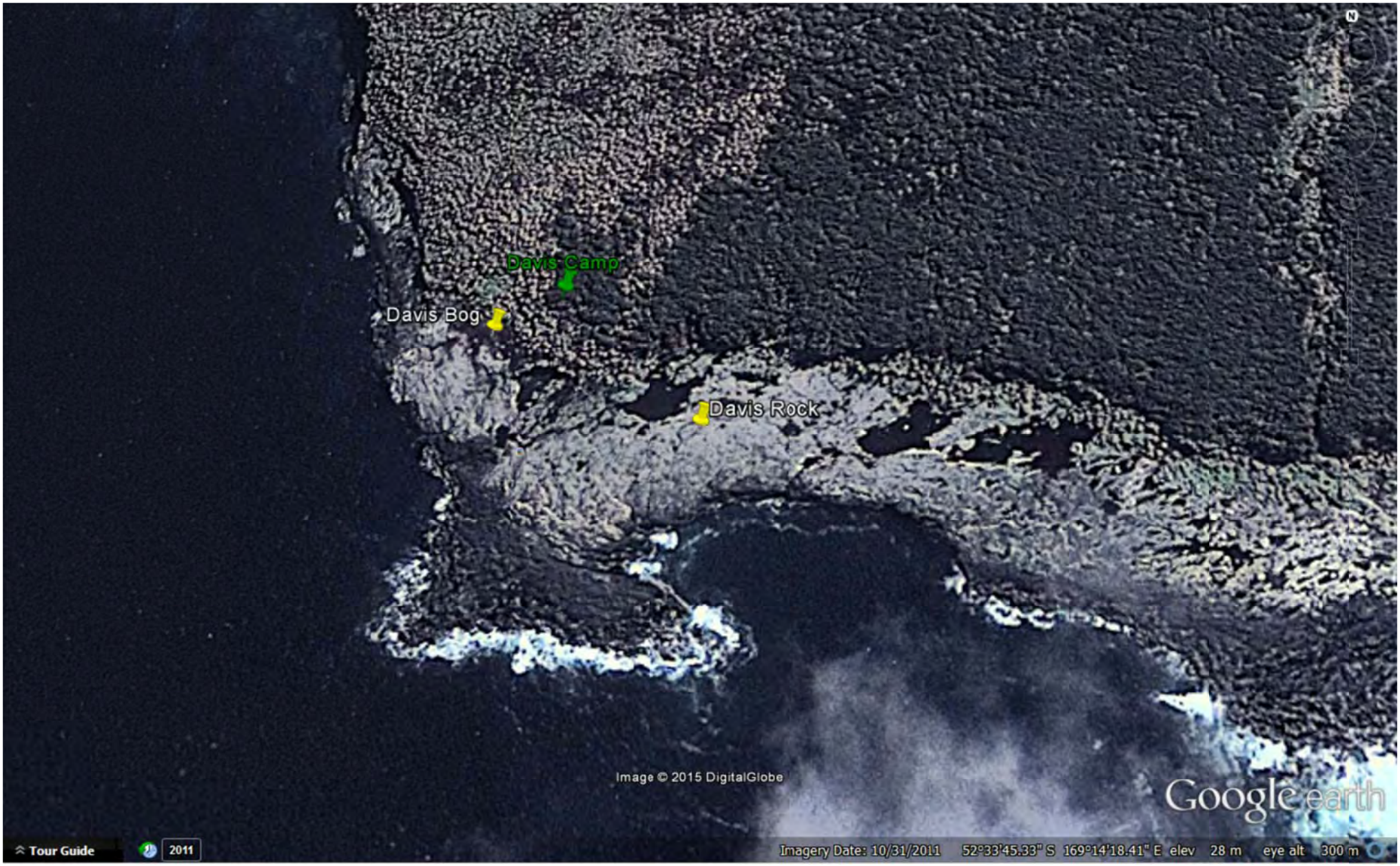
Blue Planet Marine

10 January 2015

Campbell Island colonies

Davis Pt




Davis Camp
Davis Bog
Davis Rock
Image © 2015 DigitalGlobe
Google earth
Tour Guide
2011
Imagery Date: 10/31/2011 52°33'45.33" S 169°14'18.41" E elev 28 m eye alt 300 m

Rock Platform Colony

Approximately 2/3 of breeding harems at Davis Pt are located here. Separated from the Bog Colony by around 50m, and the Mud Waterfall. Some peripheral males are located on the rock platform between the colonies.

No bog areas, although pups are often crushed on the rock platform, or fall into one of several rock pools and drown. Pools have high (for a pup!) steep rocky sides preventing pups from climbing out.

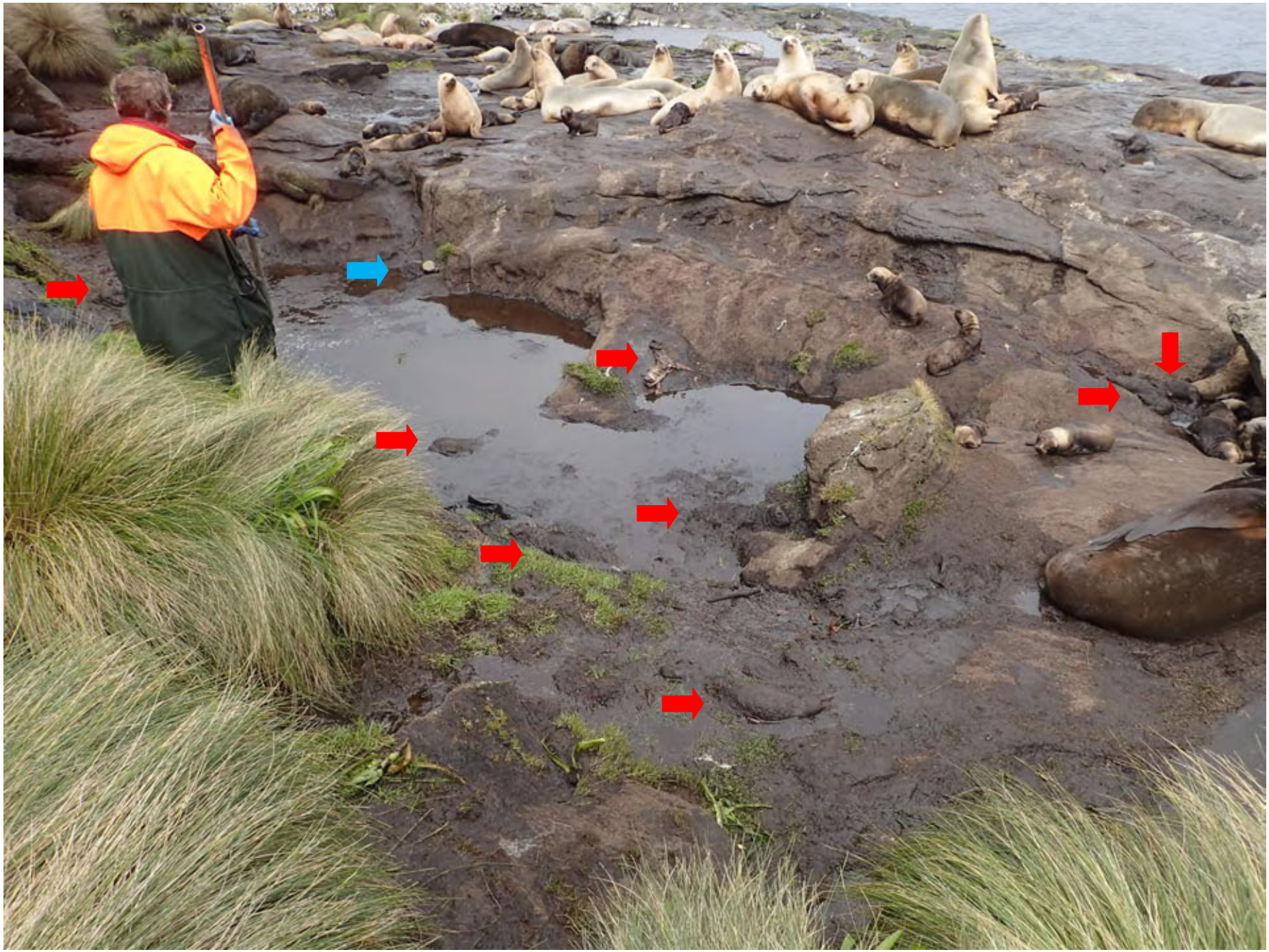
Any mitigation measures would be extremely difficult to implement since the whole colony is a problem, and attempts are likely to be ineffective since the rock substrate prevents any earthworks or modifications.

No mitigation has been attempted here.

Specific issues

Rock platform showing rock pools:

Death Pool including at least 8 dead pups:



Pup having fallen in the Death Pool and escaped, but can't climb back up:

Collecting the dead from Death Pool:

Collecting the dead from other rock pools:

Males with at least 3 crushed pups on rocks:

Pup over the edge into Giant Pool, no way back:

Giant Pool, showing height of rock shelf:

Mud Bog Colony

About 1/3 of breeding harems at Davis Pt are located here. Separated from the Bog Colony by the Mud Waterfall.

Substrate is mainly peat bog, causing a number of issues:

- The main harem areas are usually on a flat pan which turns into a quagmire when wet. Many pups are suffocated or drowned in mud by fighting males. Mitigation would be difficult since the whole colony is affected.
- Pups often fall off the waterfall or the edge of the cliff into the pool around 5m below. (There is a way back up but it involves swimming approx 10m across the pool then climbing approx 15m back up a rocky ramp so most pups don't make it). Mitigation difficult since a wide area (approx 15-20m) would need to be fenced.
- Adult sea lions have worn away some areas of the peat lower than others causing ridges that pups can fall over and not climb back. Worse, some smaller areas can fill with water causing small pools or bogs (depending on the water to mud ratio). Dozens of pups can die in a bog less than 1m diameter. Some mitigation was attempted in 2008-9, however new bog areas are continually forming, especially after heavy rain.
- The stream running over the waterfall forks, and one branch runs behind the colony before exiting to the sea on the far side. This forms a Giant Bog immediately behind the colony. In 2008-9 many pups fell off the edge of the colony and couldn't climb back up the 0.5-1m high sides. Mitigation was attempted in 2008-9. Sections of the bank were broken down and 2 pieces of boardwalk were installed as ramps to allow pups to get out. In 2014-15 no pups were observed to drown in the Giant Bog, and one pup observed in the bog managed to exit via one of the installed ramps. However, the dynamics of the colony had changed slightly since 2008-9 meaning harems were now further away from the edge, and the ridge was now higher on the inside preventing pups from climbing up to the edge to fall off. Problematically, the mitigation was being used as access to the harems by peripheral males meaning the ridge was usually no longer available to researchers as access along the back of the colony!

Specific issues

Bog colony showing mud pans in the colony and Giant Bog behind:

3 dead pups in bog at side of colony:

2 live pups in small bog:

3 live pups in small bog:

2 Dead pups in small mud patch on rocks below Bog Colony:

Mud waterfall from side showing harems at top right, cliff, and pool below:

Cliff next to Mud Waterfall, with dead pup in pool:

Mud waterfall from below, showing live pup at top:

Top of Mud Waterfall showing live pup at top, and dead pup at bottom:

Top of Mud Waterfall showing edge of colony:

Bog Colony showing Death Bog, centre left:

Bog colony tussock showing extent of erosion:

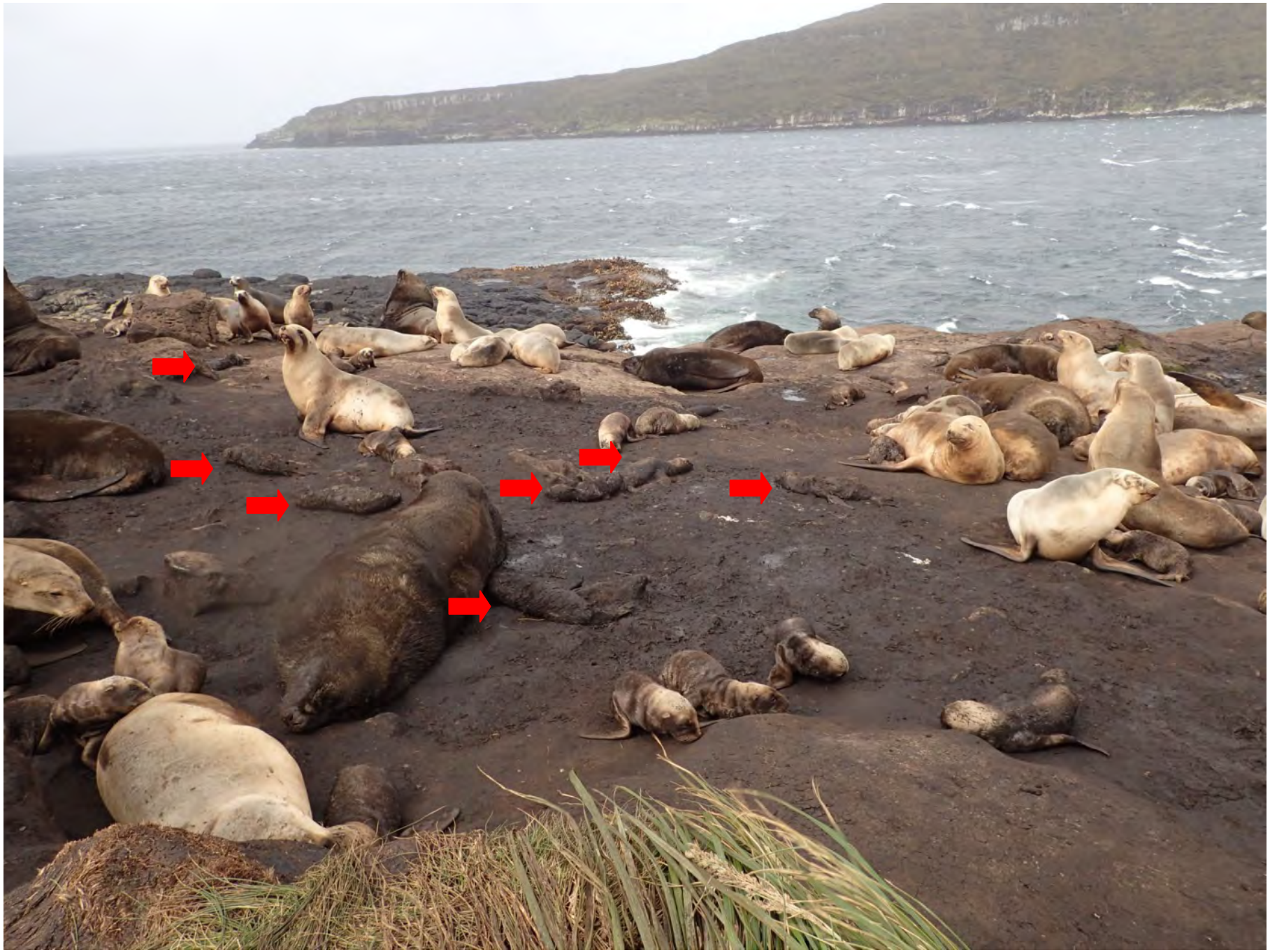
Death Bog with at least 8 dead pups:

Death Bog with live pup #1:

Death Bog with live pup #2, self-rescue:

Harems on mud pan with at least 8 dead pups:

Harems on mud pan with at least 7 dead pups:



Harems on mud pan on edge of cliff, with dead pup in centre:

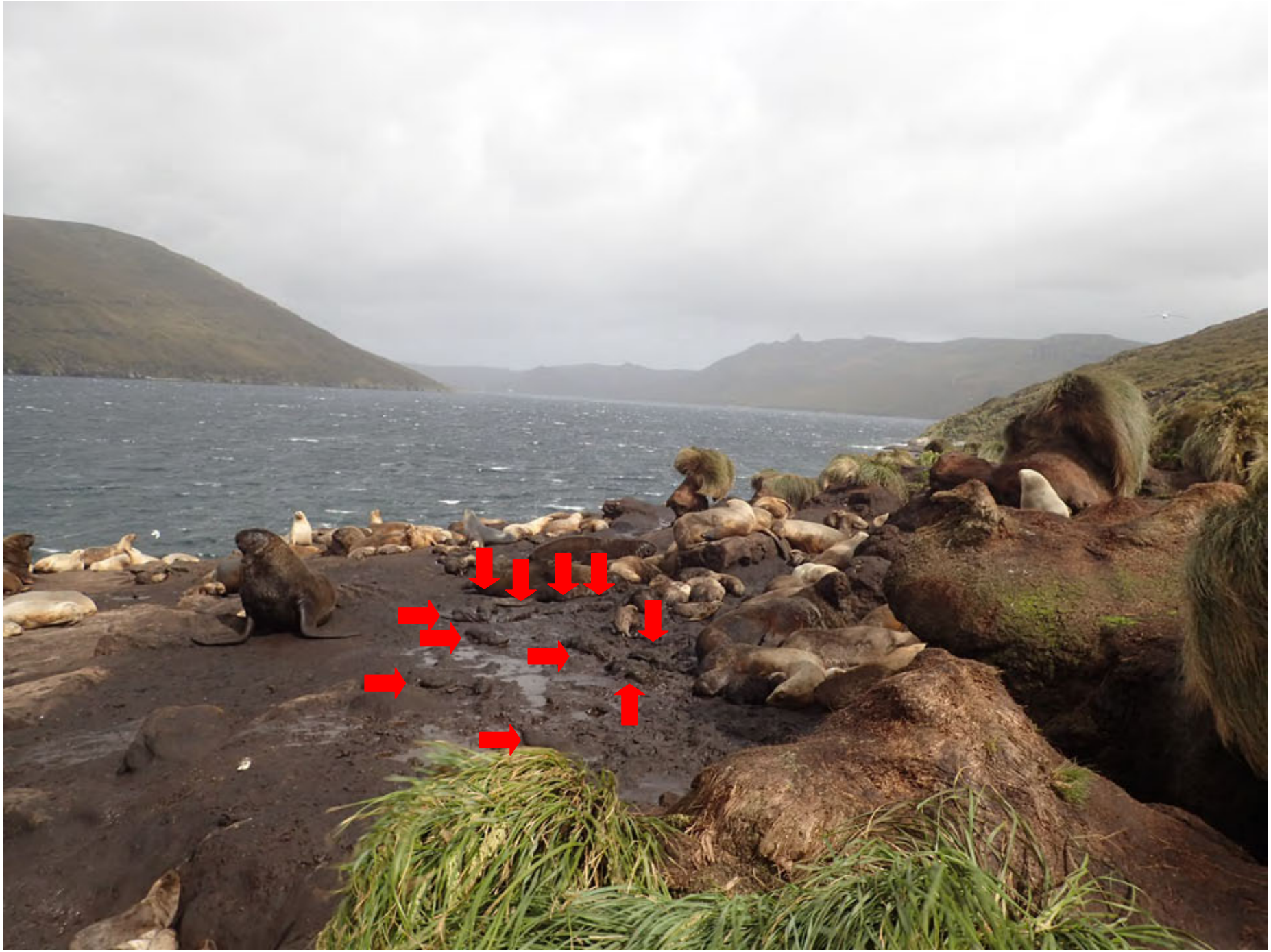
Close-up of dead pup buried in mud:

Small mud bog with dead pup:

Sea cliff below Bog Colony showing pups over the edge; 1 live and 5 dead:

GoPro location #1, Death Bog and harems on mud pan:

GoPro location #2, (tussock, L foreground) overlooking harems on mud pan with aggressive males L and R, and at least 12 dead pups between them:



Rescuing pup from Death Bog:

2008-9 mitigation showing boardwalk section and lowered ridge in centre to allow access back to harems:

Paradise Pt


CAMP
EAST
COLONY
2008/09
WEST
COLONY
WEST
COLONY


Paradise West 2014-15
Paradise West 2008-9
Paradise East
Paradise East
Paradise Camp 2008-9
Paradise Camp 2014-15
Image © 2015 DigitalGlobe
Google earth
Tour Guide
2011
Imagery Date: 10/31/2011 52°33'19.34" S 169°12'03.10" E elev 0 m eye alt 758 m

East Colony

Approximately 1/3 of breeding harems at Paradise Pt are located here. Separated from the West Colony by around 500m.

Colony in same location as in 2008-9 (although camp had to be moved approximately 20m further east due to some movement of colony boundary). Ground flattened and muddy, harems not rigidly defined. Some evidence that harems migrate further up the hill (presumably to fresh ground) as the season progresses.

Paradise East colony terrain #1

Paradise East colony terrain #2

Paradise East colony terrain #3

West Colony

Approximately 2/3 of breeding harems at Paradise Pt are located here. Separated from the East Colony by around 500m.

2008-9 season colony location: Lat 52 33 23.844000000011789, Long 169 11 29.3100000000055858
2014-15 season colony location: Lat 52 33 23.999999999999915, Long 169 11 28.99999999999995
(NB. GPS positions are approximate only, satellite imagery will be more accurate).

Colony has moved approximately 100m further west since 2008-9 season. Ground in the current breeding area is flattened and muddy, harems not rigidly defined. Some evidence that harems migrate further up the hill (presumably to fresh ground) as the season progresses. 3m high bank below colony means some harems form on the boulder beach below colony.

Ferns and grasses have started to recover at 2008-9 location indicating it has likely not been used for breeding for several years. Progressive decline of vegetation heading west towards current breeding location indicates likely successive westward movement of breeding area over the preceding 5 years.

Current breeding area defined by relatively steep ridge bordered on 2 sides by streams with steep 1m high banks. Thick Dracophyllum forest on west border is likely to prevent further westward movement.

West colony showing central ridge with east boundary stream:

West Colony looking west: showing current breeding on ridge, and likely previous year's breeding area in foreground:

Area between 2008-9 location and current breeding area, showing erosion with evidence of recovering vegetation:

2008-9 breeding location showing evidence of past erosion but well-recovered vegetation:

Camps

Camp mitigation methods attempted!

Additional camp mitigation 1:

Additional camp mitigation 2:

Tent bog:

Fence with sea lion outside #1: