



# Monitoring penguins in the Antipodes Island Group

Methods and baseline data



DOC TECHNICAL SERIES 37

Jo Hiscock

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## Methods and baseline data

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### Abstract

New Zealand's subantarctic islands are the main stronghold for eastern rockhopper (*Eudyptes chrysocome*) and erect-crested (*E. sclateri*) penguins, but both populations are currently in decline. Furthermore, although their populations have been surveyed since the 1950s, survey methods have been variable, making it difficult to compare counts between years. Therefore, the main objective of the expedition outlined in this report was to obtain accurate baseline survey data for the rockhopper and erect-crested penguin populations in the Antipodes Island Group, and to standardise survey methods. Ground counting of nests in colonies was found to be the most accurate survey method and a total of 36 703 nests were ground counted, which represents c. 86% of the total estimated nests on the island. The remainder of nests were counted using binoculars from vantage points on the main island or from a boat. It is recommended that future surveys of penguins on the Antipodes Island Group follow this methodology to ensure comparability of survey data.

Keywords: eastern rockhopper penguin, *Eudyptes chrysocome*, erect-crested penguin, *Eudyptes sclateri*, Antipodes Island Group, baseline survey, survey methods

# 1. Introduction

The majority of crested penguin populations are currently in decline across the globe, including in New Zealand's subantarctic islands (Birdlife International 2013). For example, on Campbell Island/Motu Ihupuku, the eastern rockhopper penguin (*Eudyptes chrysocome filholi*) has declined by 94% since the 1940s (Cunningham & Moors 1994).

The Antipodes Island Group supports approximately 65% of the world's population of erect-crested penguins (*Eudyptes sclateri*) and 1% of the world's population of eastern rockhopper penguins. From the scant data that are currently available, it appears that colonies of both erect-crested and rockhopper penguins have declined on the islands in this group. However, methods have varied between censuses, leading to results being largely incomparable across years.

The purpose of this report is to standardise population census methods for these penguin species by outlining reliable and repeatable count methods. This will make it easier to replicate and/or interpret the counts completed in 2011, allowing future population trends to be monitored.

# 2. Background

The Antipodes Island Group is located over 800 km to the southeast of the South Island of New Zealand on the edge of the Bounty Platform (49°41'S, 178°45'E) (Fig. 1). This island group consists of the main Antipodes Island (2038 ha), along with six smaller islands and numerous rock stacks. The islands form one of the five island groups in the New Zealand Subantarctic World Heritage Area and are National Nature Reserves, which provides them with the highest level of protection under New Zealand legislation. In recognition of the mostly pristine and unmodified nature of the islands, entry is by permit only and is restricted to expeditions that will result in direct management benefit for the islands.

The Antipodes Island Group supports breeding colonies of erect-crested and rockhopper penguins. Penguin colonies are found on the main Antipodes Island, Bollons Island, Archway Island and the Windward Islands.

Penguin colonies in the Antipodes Island Group are often mixed assemblages of erect-crested and rockhopper penguins. However, each species nests in slightly different habitat within the colonies. Consequently, it is necessary to conduct ground counts to obtain accurate census data for these species.

Historic photographs and records from the 1950s indicate that rockhopper penguins used to outnumber erect-crested penguins on these islands (Taylor 2006). However, recent data show that the rockhopper penguin population on the Antipodes Island Group has declined dramatically since then, which is also consistent with population trend data from Campbell Island/Motu Ihupuku further to the south (Cunningham & Moors 1994).

The first attempt to map the penguin colonies on the Antipodes Island Group was undertaken by Rowley Taylor in 1978 and this was then repeated in 1989 (Taylor 2006). Both surveys were carried out in November and December when chicks were present, and used a combination of boat and ground-based surveys. In 1978, 95 colonies were mapped, with rough estimates of 115 000 breeding pairs of erect-crested penguin nests and 50 000 breeding pairs of rockhopper penguin nests. By the 1989 survey, ten of these colonies had completely disappeared.

The next attempt to survey penguins on the Antipodes Island Group was completed in 1995, when a multidisciplinary expedition visited the islands and counted nests in October–November. Counts at the largest colonies were conducted by measuring colony boundaries and nest

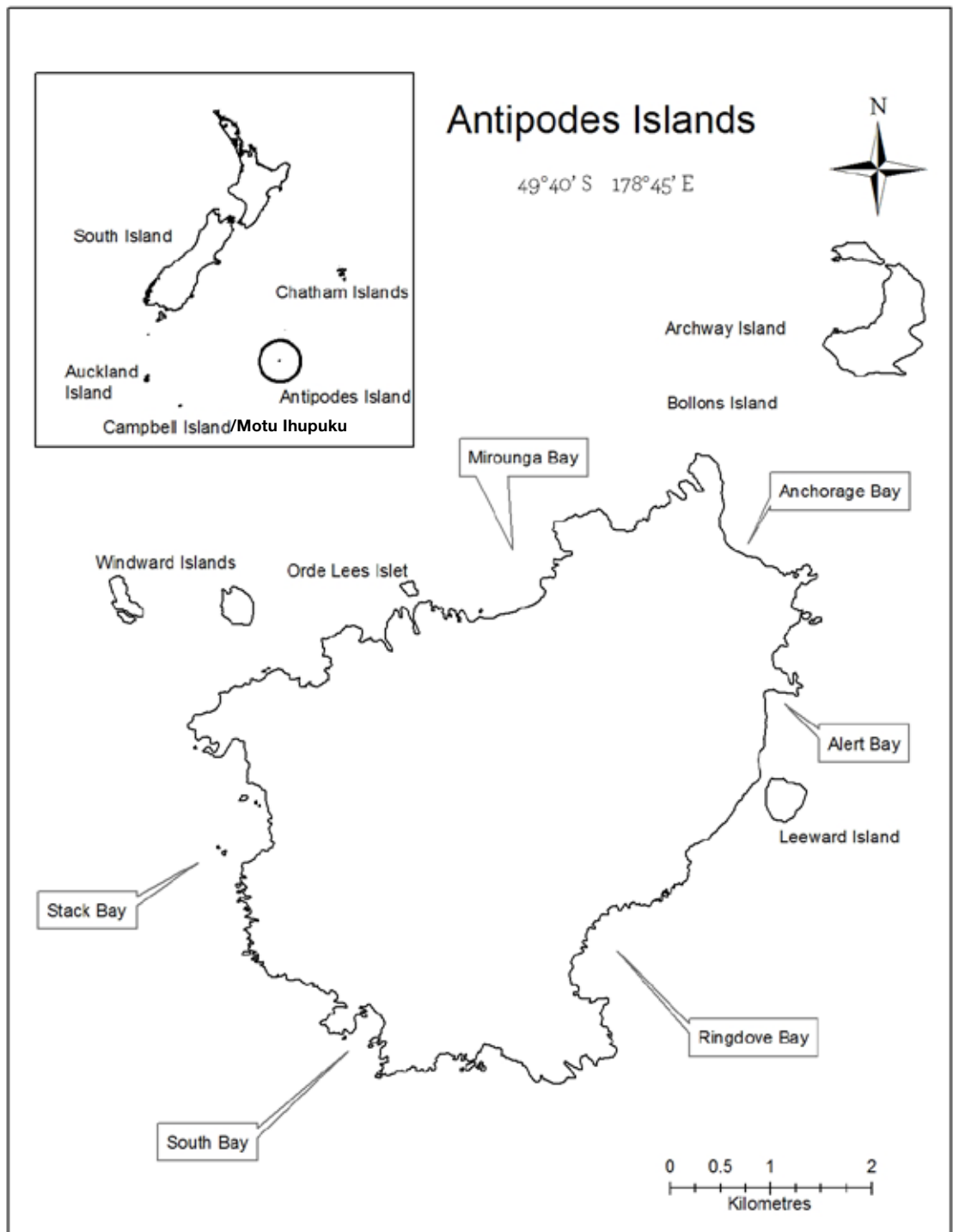


Figure 1. Map of the Antipodes Island group and its location in relation to the South Island of New Zealand and other subantarctic islands.

densities, and then using these data to calculate the total number of nests for the colony. Many colony counts were made from vantage points on the island and at sea. Accessible small and medium-sized colonies were surveyed by ground counts of all nests for each species. In total, it was estimated that 52 000 erect-crested penguin nests and 4 000 rockhopper breeding pairs were present (McClelland et al. 2001).

In October 1998, a small number of colonies were surveyed (Davis 1998). During this survey, nest counts were made in the colonies and from vantage points using binoculars. The results from this survey showed that the number of breeding pairs had declined since the 1995 survey.

### 3. Methods

For this study, erect-crested and rockhopper penguin colonies in the Antipodes Island Group were surveyed from 22 October to 6 November 2011. Several parameters were measured to estimate the population size for each species: the presence/absence of colonies, ground counts of colonies, density and transect data from several colonies, and an overall island census estimate using ground count and binocular count data.

#### 3.1 Presence/absence of colonies

Colony presence can be confirmed by viewing from the sea or a vantage point on land, or by visiting the colony.

Circumnavigation of the islands by boat is the most efficient way of checking for the presence or absence of colonies. In good weather conditions, all of the islands in the group can be circumnavigated to check colony persistence. However, boats cannot get very close to the south coast of Antipodes Island (west of South Bay) because of underwater rocks, so most colonies in this area must be checked from land.

Waypoints for locations of all the colonies that were identified by Taylor in 1978 and 1989 were referenced from a hand-drawn map, and, where appropriate, were adjusted to better represent the current location of the colonies (Appendix 1). These waypoints will form the basis of any repeat surveys for colony persistence in the future.

During the 2011 survey, RV *Tiama*—a 15-m yacht skippered by Henk Haazen—was used to survey the islands from sea. The colonies along the south coast, Stack Bay and Anchorage Bay were checked by visiting the site, as they are close together, making it difficult to distinguish boundaries and correctly identify individual colonies from the sea (Fig. 2).

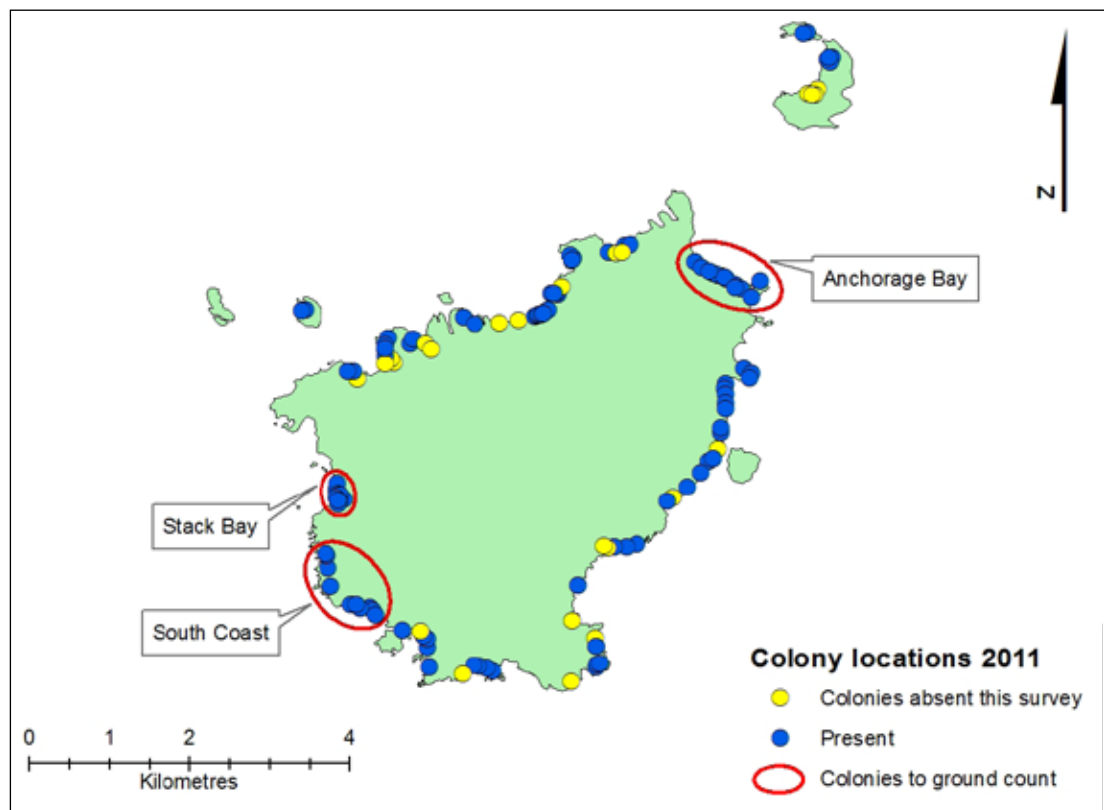


Figure 2. Location of penguin colonies that were visited on land in 2011 to confirm their presence.



When searching for colonies, the boat should be no further than 100 m from the coast, but must also be far enough out to see colonies that are located away from the coast on the coastal slope. Particular attention should be paid to areas that previously had colonies to confirm their presence or absence, but a good eye should also be kept along the coastline and coastal slopes for any new colonies.

Where possible, the presence of rockhopper and/or erect-crested penguins should be noted in the colonies. However, it is often not possible to distinguish between these two species from the sea.

## **3.2 Ground counts of colonies**

### **3.2.1 Timing of survey**

The optimal time for survey is during incubation when peak numbers of nests are present and before failed breeders leave the colonies. Egg-laying occurs in erect-crested penguins from 2 to 21 October, peaking on 12 October (Warham 1972; Davis & Renner 2003). First chicks hatch on about 10 November (McClelland et al. 2001), with a mean hatching date of 17 November (Warham 1972).

Rockhopper penguins are reported to commence laying in late October, with the first chicks hatching on 2 December (Marchant & Higgins 1990). In this study, the first egg was seen on 23 October.

Because of the high levels of predation of penguin eggs and chicks by subantarctic skua (*Catharacta Antarctica lonnbergi*) (Moors 1980), surveys should not be completed after chicks have hatched, as the number of failed nests will be substantially higher than at the egg stage.

In 2011, penguin nests were surveyed from 22 October to 6 November. This timing appeared to be appropriate for erect-crested penguins, but was a little early for rockhopper penguins, as the first rockhopper egg was not seen until October 23.

The ideal dates for survey are from 25 October to 12 November.

### **3.2.2 Colony identification**

All of the colonies that were surveyed by Rowley Taylor in 1978 and 1989, and the colonies that were surveyed in 2011, have been given unique identification codes for future reference and to allow data to be compared.

For the purposes of these codes, the coastline was split into 'areas' or 'polygons' based on bays, islands or stretches of coastline (Fig. 3). The naming convention for each 'area' is a combination of a three-character code for the location (Table 1), followed by a unique three-digit number. Any new colonies that are found should be given a new code with the appropriate location prefix and next available sequential number.

### **3.2.3 Colony access**

A nest count conducted from within the colony should be undertaken at as many colonies as possible. Appendix 1 provides the GPS coordinates for the colonies counted in 2011, as well as the findings and some comments on access to the colonies.

No offshore islands were visited in 2011 because of the difficulty of landing on them and the impracticality of managing quarantine risks between islands. Alert Bay was also not visited because of time constraints and difficulty in finding the access route; however, it is possible to follow ledges down the scarp to access the colonies in this bay.

The amount of travel time required when surveying the South Coast and Stack Bay colonies can be reduced by camping at Ringdove Stream or in the creeks above Stack Bay. From the hut, it takes approximately 3–4 hours to reach the slip above the South Coast colonies and 2 hours to reach Orde Lees. However, once you have dropped off the plateau, especially along the lower slopes around the South Coast, the going is very slow through the tall tussocks

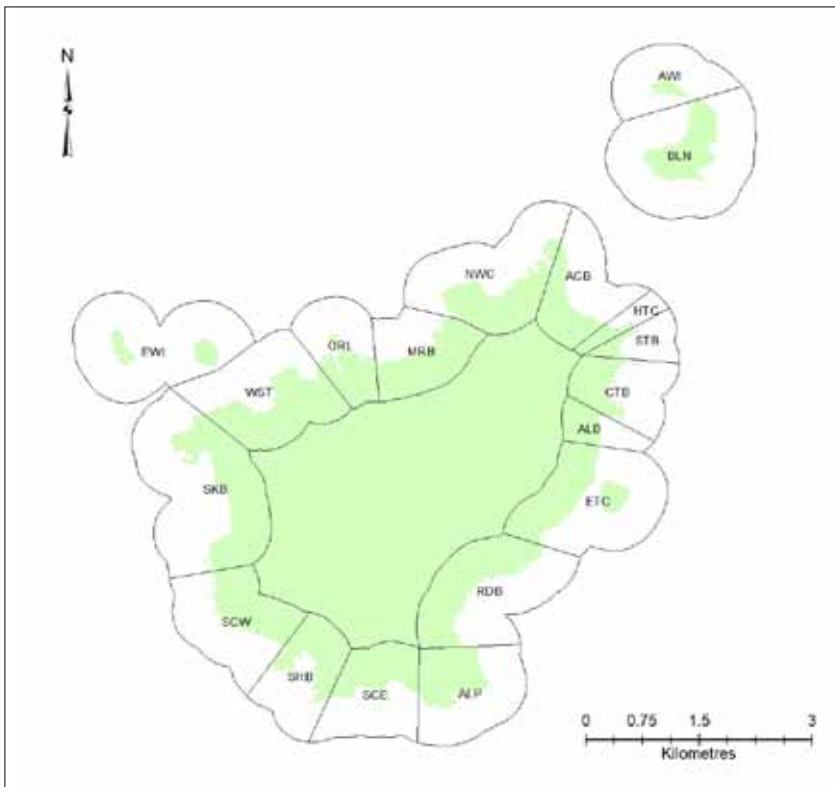


Figure 3. Boundaries of the areas used to name penguin colonies in the Antipodes Island Group. See Table 1 for a definition of these prefixes.

Table 1. Area codes to be used as the prefix when naming any new penguin colonies.

LOCATION	CODE
Albatross Point	ALP
Alert Bay	ALB
Anchorage Bay	ACB
Archway Island	AWI
Bollons Island	BLN
Crater Bay	CTB
East Coast	ETC
East Windward Island	EWI
Hut Cove	HTC
Mirounga Bay	MRB
Northwest Coast	NWC
Orde Lees	ORL
Ringdove Bay	RDB
South Bay	SHB
South Coast East	SCE
South Coast West	SCW
Stack Bay	SKB
Stella Bay	STB
West Coast	WST

### 3.2.4 Methods

Ground counts are made of penguin nests, with a nest being defined as any nest bowl that is being defended by one or more penguins, regardless of whether an egg is present. The 2011 counts were carried out at the very start of the breeding season for rockhopper penguins, at which time eggs were not yet present in many nests. It is often very difficult to determine whether eggs are present in rockhopper nests as they are frequently obscured and out of reach under rock piles.

Counts are made by walking through the colony carrying two tally counters—one for erect-crested penguin nests (Fig. 4A) and the other for rockhopper penguin nests (Fig. 4B).

Small colonies can be counted in one block. However, larger colonies need to be divided up into smaller blocks and the totals for all blocks added together to obtain the total number of nests. Long skinny sections are much easier to count than wide square ones—depending on the density of nests, a width of 2–5 m is usually workable. Counts tend to become less accurate when there are more than 100 nests in a block.

Stockmarker spray paint can be used to divide up colonies—bright colours like orange are the easiest to see. Short stripes can be painted between nests to indicate boundaries; however, it should be clear which side each nest falls on to avoid double-counting. A small number can also be painted in the blocks to help with locating blocks for comparing counts and, if necessary, identifying which blocks need to be recounted.

Only one person should count a block at a time. They should move through the colony to identify birds that are not associated with a nest. More than one person causes confusion amongst the birds and also leads to the counters losing track of where they are up to.

At least two counts should be undertaken for each block, preferably by two different people. If the totals are within 5% of each other, an average can be taken; otherwise, another count needs to be carried out. Recounts are time consuming and cause additional disturbance to the penguins, however, so should be avoided if possible.



Figure 4. A. Erect-crested penguin (*Eudyptes sclateri*) and B. eastern rockhopper penguin (*E. chrysocome filholi*) on nest.

All counts should be recorded on a datasheet for data analysis. One person needs to keep a record of all the totals and averages to ensure that two counts are completed satisfactorily for each block. To compare search effort with previous surveys, the time spent in the colony should also be recorded, along with the number of people completing the count. All of the accepted counts for each block should be entered when managing the data to enable standard errors to be calculated.

### 3.2.5 Disturbance

All preparations for the count should be made away from the colony. Although the penguins may not show any obvious signs of being disturbed when counters are nearby, research has shown that even minimal disturbance causes a stress response in penguins, e.g. increased heart rates (Ellenberg et al 2011).

The amount of time spent in the colonies should be kept to a minimum. Moving through the colony can cause birds to panic, leaving the nest and eggs unattended. Skuas (particularly in the South Coast colonies) are quick to take advantage of this and rapidly learn to follow the counters and eat the eggs. For this reason, a full team should work in the large colonies to ensure that counts are completed as quickly as possible.

## 3.3 Density and transect counts

In 1995, penguin colony boundaries and nest densities were measured to allow the size of the largest colonies to be estimated. In the 2011 survey, this method was repeated for data comparison. All colonies that were surveyed using this method were also ground counted.

The colony boundaries were measured using a compass and hipchain in 1995 and the areas of these mapped polygons were calculated using a digital planimeter (McClelland et al. 2001). By contrast, GPS was used to estimate the colony area in 2011, with surveyors walking the boundary slowly with the GPS track on. The area was then calculated from these tracks in ARCMAP 10. Fewer colonies were surveyed using this method in 2011 than in 1995, as there was more time available to do a full ground count.

Densities should be measured using a 1.78-m length of string as the radius of a 10-m<sup>2</sup> circle ('quadrat'). The string should be held at random points throughout the colony and all the nests inside the quadrat should be counted—with only half of the nests on the boundary being counted. At small colonies, five quadrats should be sampled to estimate average nest density, while ten or more should be sampled at larger colonies.

This method provides a relatively imprecise calculation of breeding pairs, but is a valuable technique if time is short. If possible, areas within a colony that contain different densities of nests should be identified and measured separately to improve the accuracy of the count.

### 3.4 Island census estimate

As many colonies as possible that are observed during the presence/absence survey should be counted with binoculars from a boat, in case they cannot be reached for ground counts. However, counts achieved by either ground counting accessible colonies or using binoculars from a vantage point on the island are more accurate than counts from the sea.

Counts that are made with binoculars are often too far away for the species of individual birds to be identified, and so the totals include both erect-crested and rockhopper penguin nests. However, if rockhopper penguins are identified in a colony, this should be noted. The distribution of colonies and the survey methodology used for each colony is presented in Appendix 3.

During the 2011 survey, a correction was developed for the counts from sea, as several colonies that were counted from the sea were also ground counted, and it was found that the sea-based counts under-represented the actual number of nests present. This was not unexpected, as many nests are obscured from view during sea counts, especially rockhopper nests, which are often located under rocks.

The correction was developed by comparing counts of several colonies in Anchorage Bay, Mirounga Bay and the North West Coast from the sea with ground counts (Table 2). Colonies were grouped by area because the sea counts often did not accurately identify individual colony boundaries, making direct comparison of each colony impractical. As a result of this comparison, it was found that the sea-based count needed to be multiplied by 1.98 (the average difference across the three areas) to obtain the equivalent land count.

Table 2. Colony nest counts used to develop a correction factor for sea-based penguin nest counts in Antipodes Island Group.

COLONY ID	COUNT FROM SEA	GROUND COUNT	CORRECTION
ACB-001 to 009	941	1752	1.86
MRB-001 to 003, 005	456	1049	2.30
NWC-006, 007	185	328	1.77
Total	1582	3129	1.98

## 4. Results

### 4.1 Presence/absence survey, 2011

In total, 103 colonies were found in 2011, which included 30 new colonies. Of the 97 colonies that were found in the 1978 survey, 10% were absent in 1989 and 25% were absent in 2011 (Table 3).

The majority of new colonies found were in close proximity to colonies that had been marked in earlier surveys. If these were discrete colonies and had boundaries that made them distinguishable from neighbouring colonies (i.e. the boundaries were distinct from each other by distance and/or vegetation), they were recorded as new. Many of these new colonies may have been considered as a single colony in previous surveys or may have since fragmented into several colonies. However, two small colonies (WST-014 and WST-016) were found high on the

Table 3. Number of colonies found in the 1978, 1989 and 2011 surveys.

YEARS PRESENT/ABSENT	NUMBER
Present in 1978, 1989 and 2011	72
Present in 1978 and 1989; absent in 2011	15*
Present in 1978; absent in 1989 and 2011	9
Present in 1978 and 2011; absent in 1989	1
New in 2011	30

\* Three colonies (WST-001, WST-002 and MRB-004) were recorded as absent in the 2011 survey. These colonies were not observed during the circumnavigation of the island, but the areas were not specifically checked.

slope when traversing on foot and may have been missed from a boat-based survey. Similarly, NWC-008 is a small colony in a cave that was obscured by a sea arch and was not easily seen from the sea; therefore, it may also have been missed in previous surveys.

The waypoint data from the 1978, 1989 and 2011 surveys are presented in Appendix 1 and can be obtained from the Department of Conservation's (DOC's) Southern Islands Area Office in Invercargill.

### 4.2 Ground count survey, 2011

In total, 34226 erect-crested penguin nests and 2475 rockhopper penguin nests were counted in 44 colonies in the 2011 survey. Only 24 of these colonies were previously recorded by Rowley Taylor in 1978 and 1989. However, as mentioned in the previous section, many of the new colonies were closely associated with those previously recorded, and so may have been considered as a single colony in previous surveys and since fragmented.

The location of the colonies that were ground counted in 2011, and counts from each, can be found in Appendix 2. Tables 4 and 5 compare these data with those collected during the 1995 and 1998 surveys.

Table 4. Comparison of ground count data for erect-crested penguins (*Eudyptes sclateri*) from the 2011, 1998 and 1995 surveys.

SITE	NUMBER OF NESTS		
	2011	1998	1995
Anchorage Bay	2048	1646	2779
Reef Point	578	654	713
Stella Bay	251	303	330
SHB-006c	201	Not surveyed	154
SCW-005	56	Not surveyed	72*
SCW-006	106	Not surveyed	150
SCW-010	227	Not surveyed	300*

\* Numbers are estimates based on binocular counts.

Table 5. Comparison of ground count data for rockhopper penguins (*Eudyptes chrysocome*) from the 2011 and 1995 surveys.

SITE	NUMBER OF NESTS	
	2011	1995
Anchorage Bay	816	1095
Stella Bay	3	11
SHB-006a	54	101
SHB-006c*	0	0
SCW-005	12	28
SCW-010	0	7

\* SHB-006c was checked for rockhopper penguins but no nests were found.

Several colonies counted in 1995 could not be identified, so direct comparison is limited to a subset of those that could be. From comparable ground counts in 1995 and 2011, erect-crested penguin nests decreased from 4498 to 3467 (a 33% decrease), and rockhopper nests decreased from 1242 to 885 (a 39% decrease).

### 4.3 Density and transect count, 2011

Colonies ORL-001 and SHB-006 (Figs 5 & 6) were both surveyed in 1995 and 2011. The results of these surveys are presented in Table 6. The colony boundary of SWC-004 was also tracked in 2011, but no density quadrats were sampled because of the highly variable nest densities within the colony boundary. The track logs of these colonies can be obtained from DOC's Southern Islands Area Office.

At both colonies, all the subsets showed a decrease of between 1.9% and 21.9% in area between the 1995 and 2011 surveys.

At the Orde Lees colony, the estimate of nest density was similar to that obtained in 1995, but the total nest estimate was 5.1% higher than what was ground counted.

At the South Bay colony, the estimate of nest density was much higher (one of the subsets was 0.46 nests/m<sup>2</sup> higher) than in 1995. This estimate appears unreasonably high, which is supported by the nest estimate being 76.1% higher than was ground counted.

### 4.4 Island census, 2011

In total, 42689 penguin nests were counted across all of the colonies; 36701 of these were ground counted (Table 7), 2222 were counted by binocular from viewpoints on land (Table 8) and 3766 were corrected counts made by binocular from the boat at sea (Table 9).

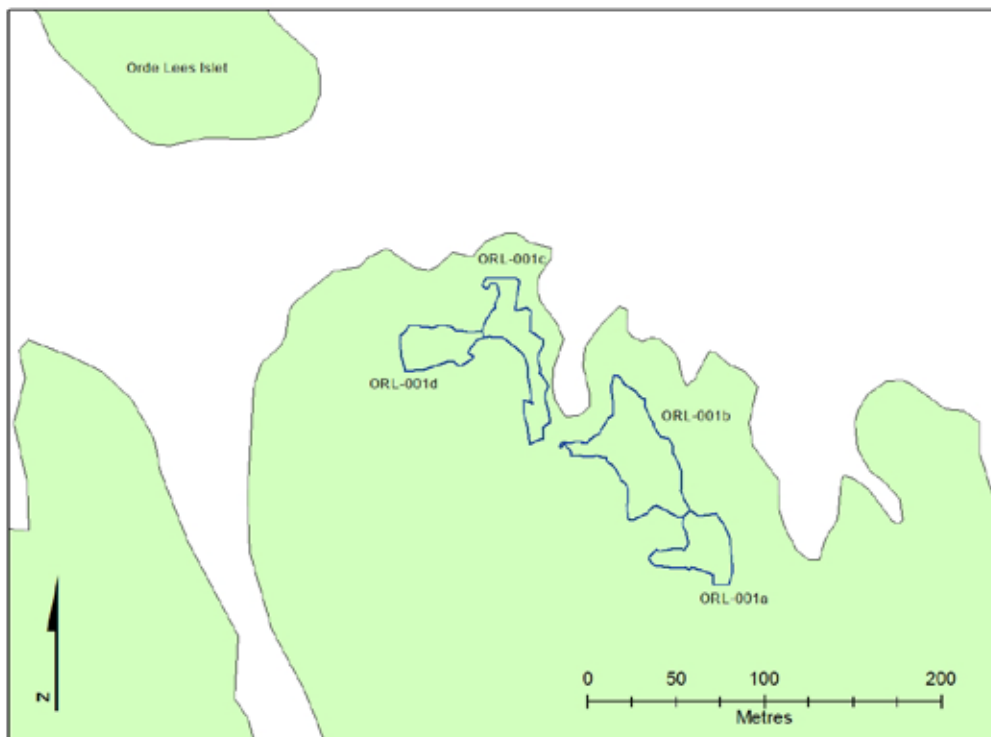


Figure 5. Orde Lees colony boundary in 2011 showing the subsections a, b, c and d used in the density calculation.

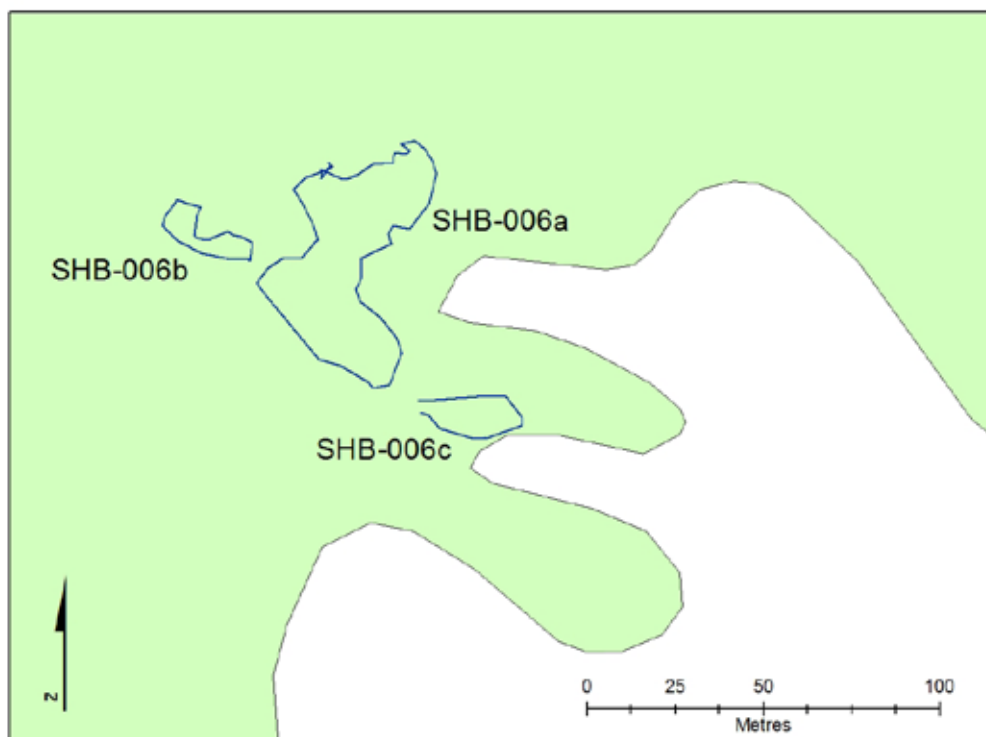


Figure 6. South Bay colony boundary in 2011 showing the subsections a, b and c used in the density calculation.

Table 6. Comparison of nest estimates based on colony area and nest density in 1995 and 2011, and ground counts in 2011.

COLONY	AREA (m <sup>2</sup> )		DENSITY (NESTS/m <sup>2</sup> )		NEST ESTIMATE		GROUND COUNT
	2011	1995	2011	1995	2011	1995	2011
<b>Orde Lees (ORL-001)*</b>							
ORL-001a+b	3385	3590	1.37	1.25	4637	4488	4349
ORL-001c+d	2150	2304	1.23	1.25	2646	2880	2579
<b>Western South Bay (SHB-006)†</b>							
South Bay 1+2 (SHB-006a+c)	1637	1668	1.71	1.25	2799	2085	1558
South Bay 3 (SHB-006b)	182	233	1.26	1.25	229	291	161

\* See Fig. 5 for a map of the boundaries a, b, c and d.

† See Fig. 6 for a map of the boundaries a, b and c.

Table 7. Nest counts of colonies that were ground counted. See Appendix 1 for further details.

COLONY ID	TOTAL NEST COUNT	COLONY ID	TOTAL NEST COUNT	COLONY ID	TOTAL NEST COUNT
ACB-001	63	MRB-003	766	SHB-006	1974
ACB-002	273	MRB-005	33	SKB-001	70
ACB-003	109	NWC-006	266	SKB-002	1191
ACB-004	1020	NWC-007	140	SKB-003	501
ACB-005	62	ORL-001	8412	SKB-004	230
ACB-006	44	SCW-001	2993	SKB-005	811
ACB-007	33	SCW-002	988	SKB-006	121
ACB-008	17	SCW-003	581	SKB-007	115
ACB-009	129	SCW-004	10950	SKB-008	160
HTC-001	669	SCW-005	56	SKB-009	115
HTC-002	443	SCW-006	106	SKB-010	334
HTC-003	578	SCW-007	417	STB-001	254
HTC-004	85	SCW-008	131	WST-014	4
MRB-001	327	SCW-009	781	WST-016	29
MRB-002	93	SCW-010	227		

Table 8. Nest counts of colonies that were binocular counted from the island. Data include the bearing and distance of the colony from the viewpoint.

COLONY ID	TOTAL NEST COUNT	LOCATION OF VIEWPOINT	BEARING TO COLONY (TRUE)	DISTANCE TO COLONY (m)
ALB-001	177	-49.67732, 178.80739	215	160
ALB-002	75	-49.67732, 178.80739	205	220
MRB-006	142	-49.67021, 178.77478	185	170
MRB-007	72	-49.67021, 178.77478	190	210
MRB-008	22	-49.67021, 178.77478	200	250
MRB-009	84	-49.67021, 178.77478	205	275
MRB-011	50	-49.67021, 178.77478	210	315
MRB-012	121	-49.67021, 178.77478	195	235
NWC-008	21	-49.6657, 178.7777	140	50
ORL-002	45	-49.67384, 178.76228	175	25
RDB-003	22	-49.69398, 178.79367	185	365
RDB-006	159	-49.7036, 178.78079	55	240
SCE-003	480	-49.71097, 178.76958	195	155
SCE-004	160	-49.71098, 178.76936	225	190
SCE-005	20	-49.71098, 178.76936	240	240
SHB-003	59	-49.71029, 178.75381	75	320
SHB-004	137	-49.70849, 178.75471	110	215
WST-011	220	-49.67681, 178.74773	225	595
WST-013	70	-49.67681, 178.74773	225	575
WST-015	86	-49.67681, 178.74773	230	625



Table 9. Nest counts for colonies that were binocular counted from the sea.

COLONY ID	TOTAL NEST COUNT	CORRECTED COUNT (x 1.98)	COLONY ID	TOTAL NEST COUNT	CORRECTED COUNT (x 1.98)
ALB-003	7	14	ETC-001	11	22
ALB-004	50	99	ETC-002	1	2
ALB-005	24	48	ETC-005	20	40
ALP-001	30	59	ETC-009	31	61
ALP-002	10	20	EWI-001	25	50
ALP-003	66	131	EWI-002	53	105
ALP-005	75	149	MRB-010	254	503
ALP-006	40	79	NWC-003	26	51
AWI-001	1000	1000*	NWC-004	28	55
AWI-002	14	28	NWC-005	47	93
BLN-005	20	40	RDB-004	41	81
BLN-006	40	79	RDB-005	17	34
BLN-007	5	10	SCE-002	10	20
BLN-008	40	79	WST-006	14	28
CTB-001	50	99	WST-007	162	321
CTB-002	21	42	WST-008	128	253
CTB-003	34	67	WST-012	2	4

\* Correction not applied as this figure was an estimate of colony size rather than a direct count of visible nests.

## 5. Recommendations

All future surveys should be conducted at a similar time of year (22 October – 6 November) to the 2011 survey so that results are comparable. If surveys are carried out any earlier the rockhoppers will not be present, but the counts can be conducted a little later (until 12 November), at which time erect-crested chicks will be starting to hatch.

### 5.1 5-year survey—next due 2016

A survey that repeats the ground counts at a subset of colonies should be carried out every 5 years. Colonies that had accurate counts during the 1995 and 1998 surveys should have the highest priority for re-survey. Ground counts are preferable to density estimates, as they provide a more accurate population estimate.

Table 10 shows the tasks that should be completed and the number of days required for two teams of two to three people to complete these surveys (additional time should be allowed for delays associated with adverse weather).

Table 10. Tasks and time required to complete 5-year ground counts of colonies.

TASK	TIME REQUIRED (DAYS)
Entire team surveys the colonies in Hut Cove and Stella Bay (HTC-001 to 004, STB-001) to become familiar with methodology.	1
First team surveys Anchorage Bay (ACB-001 to 009).	
Second team surveys Alert Bay (ALB-001 to 005).	1
First team counts NWC-006 & 007.	
Second team counts MRB-001, 002, 003 & 005.	1
Both teams count Orde Lees (ORL-001)—if all goes well, this could be completed in 1 day, but be prepared to go out twice or take equipment to camp out.	1–2
South Coast camping—days are full days; therefore, this work could not be completed in this timeframe if surveyors travel from the hut instead of camping.	4–5
Head down the South Coast with camping equipment and set up camp at the head of Ringdove Stream or above Stack Bay (1 day).	
First team counts SHB-006 and then carries on to the NW (SCW-006, etc.) until the two teams meet. Second team counts SHB-003 and carries on to the SE along the coast until the teams meet (1 long day)	
Both teams count SWC-004, 005 & 010 (1 long day).	
Pack up and both teams count Stack Bay (SKB-001 to 010) on the way back to the hut (1 long day).	

### 5.2 10-year survey—next due 2021

A full survey that includes surveying for the presence/absence of colonies, and carrying out ground counts and binocular counts to obtain island censuses should be completed every 10 years. If time permits, comparison of binocular counts with ground counts should be conducted at a subset of colonies to determine a correction factor appropriate for that survey.

Table 11 shows the tasks that should be completed and the number of days required for two teams of two to three people to complete these surveys (additional time should be allowed for delays associated with adverse weather).

Table 11. Tasks and time required to complete a 10-year survey.

TASK	TIME (DAYS)
Ground count colonies (see Table 10 for breakdown of tasks)	10
Boat support for island circumnavigation	1
Make binocular counts on the island and check for colony presence	4

## 6. Acknowledgements

Thank you to the team that helped with the fieldwork: Max Smart, Vince Waanders, Davida Mead, Melanie Heather and Bill Abbott. Many thanks to Henk Haazen and the crew of the RV *Tiama* for providing safe transport to and from the Antipodes Island Group. Thanks also to Rowley Taylor for providing unpublished material on previous surveys; to Jacinda Amey, Pete McClelland, Kath Walker and Graeme Taylor for advice and information on previous surveys and access around the island; and to Liz Metsers for assistance with the geospatial data management. Thank you to Louise Chilvers and Chrissy Wickes for help with comments on the original drafts.

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# Appendix 1

## Coordinates for all penguin colonies on the Antipodes Island Group: 1978–2011

Note 1: Colony numbers MRB-014 and WST-005 were not assigned to penguin colonies; therefore, no data associated with these colony names.

Note 2: This data is available from DOC's Southland Conservancy geodatabase. The ArcCatalog folder connection is \\NATISSVR\NEGIS\_Connections\co\_STL.sde.

COLONY ID	LAT	LONG	COUNT TYPE	PRESENCE*		
				2011	1989	1978
ACB-001	-49.6664453	178.8030359	Ground	Present	Unknown	Unknown
ACB-002	-49.6652430	178.7992671	Ground	Present	Present	Present
ACB-003	-49.66655811	178.8040888	Ground	Present	Present	Present
ACB-004	-49.66581599	178.8004742	Ground	Present	Present	Present
ACB-005	-49.66636266	178.8025404	Ground	Present	Present	Present
ACB-006	-49.66652374	178.8034164	Ground	Present	Present	Present
ACB-007	-49.66689487	178.8049591	Ground	Present	Unknown	Unknown
ACB-008	-49.66671243	178.8045780	Ground	Present	Unknown	Unknown
ACB-009	-49.66613425	178.8017709	Ground	Present	Unknown	Unknown
ALB-001	-49.67852882	178.8061455	Binocular—land	Present	Present	Present
ALB-002	-49.67911388	178.8060772	Binocular—land	Present	Present	Present
ALB-003	-49.67974235	178.8063386	Binocular—sea	Present	Present	Present
ALB-004	-49.68074164	178.8064227	Binocular—sea	Present	Present	Present
ALB-005	-49.68131253	178.8064204	Binocular—sea	Present	Present	Present
ALP-001	-49.71085404	178.7881437	Binocular—sea	Present	Unknown	Unknown
ALP-002	-49.71098427	178.7878129	Binocular—sea	Present	Unknown	Unknown
ALP-003	-49.70890612	178.7873864	Binocular—sea	Present	Unknown	Unknown
ALP-004	-49.70801217	178.7870783	Absent	Absent	Present	Present
ALP-005	-49.70896888	178.7872942	Binocular—sea	Present	Present	Present
ALP-006	-49.71127105	178.7876775	Binocular—sea	Present	Present	Present
AWI-001	-49.63873909	178.815543	Estimate	Present	Present	Present
AWI-002	-49.63881067	178.8148944	Binocular—sea	Present	Present	Present
BLN-001	-49.64487766	178.8180674	Absent	Absent	Present	Present
BLN-002	-49.64551393	178.8177423	Absent	Absent	Present	Present
BLN-003	-49.64556028	178.8164759	Absent	Absent	Absent	Present
BLN-004	-49.64563387	178.8171460	Absent	Absent	Absent	Present
BLN-005	-49.64184961	178.8198910	Binocular—sea	Present	Present	Present
BLN-006	-49.64128944	178.8197371	Binocular—sea	Present	Unknown	Unknown
BLN-007	-49.64149414	178.8193958	Binocular—sea	Present	Present	Present
BLN-008	-49.64130194	178.8201785	Binocular—sea	Present	Present	Present
CTB-001	-49.67669243	178.8090782	Binocular—sea	Present	Present	Present
CTB-002	-49.67722284	178.8104838	Binocular—sea	Present	Present	Present
CTB-003	-49.67777898	178.8101517	Binocular—sea	Present	Present	Present
ETC-001	-49.68869313	178.8030288	Binocular—sea	Present	Unknown	Unknown
ETC-002	-49.68401867	178.8059422	Binocular—sea	Present	Present	Present
ETC-003	-49.68589299	178.8056763	Absent	Absent	Present	Present
ETC-004	-49.6866500	178.804950	Presence only confirmed	Present	Present	Present

Continued on next page

## Appendix 1 continued

COLONY ID	LAT	LONG	COUNT TYPE	PRESENCE*		
				2011	1989	1978
ETC-006	-49.69038092	178.8008841	Presence only confirmed	Present	Present	Present
ETC-007	-49.69169009	178.7986125	Absent	Absent	Present	Present
ETC-008	-49.69215956	178.7977085	Presence only confirmed	Present	Present	Present
ETC-009	-49.68353813	178.8059146	Binocular—sea	Present	Absent	Present
EWI-001	-49.67403959	178.7322283	Binocular—sea	Present	Unknown	Unknown
EWI-002	-49.67390427	178.7329172	Binocular—sea	Present	Present	Present
HTC-001	-49.66739623	178.8064317	Ground	Present	Present	Present
HTC-002	-49.66778347	178.8075737	Ground	Present	Present	Present
HTC-003	-49.66683221	178.8106341	Ground	Present	Present	Present
HTC-004	-49.66768987	178.8065243	Ground	Present	Unknown	Unknown
MRB-001	-49.6699797	178.7748803	Ground	Present	Present	Present
MRB-002	-49.67009596	178.7759575	Ground	Present	Present	Present
MRB-003	-49.66958223	178.7760038	Ground	Present	Present	Present
MRB-004	-49.66914092	178.7765996	Not seen	Unconfirmed†	Present	Present
MRB-005	-49.66968608	178.7754678	Ground	Present	Unknown	Unknown
MRB-006	-49.67175285	178.7746547	Binocular—land	Present	Present	Present
MRB-007	-49.67204591	178.7742209	Binocular—land	Present	Present	Present
MRB-008	-49.67234267	178.7736451	Binocular—land	Present	Present	Present
MRB-009	-49.67243613	178.7731587	Binocular—land	Present	Present	Present
MRB-010	-49.67251413	178.7728596	Binocular—land	Present	Present	Present
MRB-011	-49.67263435	178.7724876	Binocular—land	Present	Present	Present
MRB-012	-49.67223535	178.7738973	Binocular—land	Present	Unknown	Unknown
MRB-013	-49.67375977	178.7664787	Absent	Absent	Present	Present
MRB-015	-49.67326675	178.7697801	Absent	Absent	Present	Present
NWC-001	-49.66493287	178.7855248	Absent	Absent	Absent	Present
NWC-002	-49.66473506	178.7865811	Absent	Absent	Absent	Present
NWC-003	-49.66386686	178.7879482	Binocular—sea	Present	Present	Present
NWC-004	-49.66405068	178.7869799	Binocular—sea	Present	Present	Present
NWC-005	-49.66487353	178.7842716	Binocular—sea	Present	Present	Present
NWC-006	-49.66516203	178.7783330	Ground	Present	Present	Present
NWC-007	-49.66579059	178.7786161	Ground	Present	Present	Present
NWC-008	-49.66597561	178.7782507	Binocular—land	Present	Unknown	Unknown
ORL-001	-49.67340739	178.7601852	Ground	Present	Present	Present
ORL-002	-49.67407241	178.7622983	Binocular—land	Present	Present	Present
RDB-001	-49.69786570	178.7880028	Absent	Absent	Absent	Present
RDB-002	-49.69767870	178.7872334	Absent	Absent	Absent	Present
RDB-003	-49.69723254	178.7930665	Binocular—land	Present	Present	Present
RDB-004	-49.69760042	178.7912386	Binocular—sea	Present	Present	Present
RDB-005	-49.69769664	178.7891918	Binocular—sea	Present	Present	Present
RDB-006	-49.70233904	178.7834499	Binocular—land	Present	Present	Present
RDB-007	-49.70629153	178.7828381	Absent	Absent	Present	Present
SCE-001	-49.71308892	178.7834592	Absent	Absent	Absent	Present
SCE-002	-49.71259388	178.7699654	Binocular—sea	Present	Present	Present
SCE-003	-49.71230377	178.7689513	Binocular—land	Present	Present	Present
SCE-004	-49.71217009	178.7674231	Binocular—land	Present	Present	Present
SCE-005	-49.71214335	178.7666096	Binocular—land	Present	Present	Present
SCE-006	-49.71315287	178.7647579	Absent	Absent	Present	Present
SCW-001	-49.70658263	178.7479355	Ground	Present	Present	Present
SCW-002	-49.70633258	178.7445914	Ground	Present	Present	Present

Continued on next page

## Appendix 1 continued

COLONY ID	LAT	LONG	COUNT TYPE	PRESENCE*		
				2011	1989	1978
SCW-004	-49.70252796	178.7402300	Ground	Present	Present	Present
SCW-005	-49.70111510	178.7399076	Ground	Present	Present	Present
SCW-006	-49.70731102	178.7490159	Ground	Present	Unknown	Unknown
SCW-007	-49.70681892	178.7484864	Ground	Present	Unknown	Unknown
SCW-008	-49.70670604	178.7463455	Ground	Present	Unknown	Unknown
SCW-009	-49.70630135	178.7456542	Ground	Present	Unknown	Unknown
SCW-010	-49.70096541	178.7397046	Ground	Present	Unknown	Unknown
SHB-001	-49.71276714	178.7588359	Presence only confirmed	Present	Present	Present
SHB-002	-49.71049413	178.7582602	Presence only confirmed	Present	Present	Present
SHB-003	-49.70957799	178.7581547	Binocular—land	Present	Present	Present
SHB-004	-49.70921975	178.7574595	Binocular—land	Present	Present	Present
SHB-005	-49.70876679	178.7570032	Absent	Absent	Present	Present
SHB-006	-49.70875983	178.7537201	Ground	Present	Present	Present
SKB-001	-49.69415680	178.7409368	Ground	Present	Unknown	Unknown
SKB-002	-49.69474043	178.7419937	Ground	Present	Present	Present
SKB-003	-49.69370107	178.7405705	Ground	Present	Present	Present
SKB-004	-49.69295726	178.7407090	Ground	Present	Present	Present
SKB-005	-49.69420910	178.7413108	Ground	Present	Unknown	Unknown
SKB-006	-49.69461596	178.7406655	Ground	Present	Unknown	Unknown
SKB-007	-49.69484403	178.7412136	Ground	Present	Unknown	Unknown
SKB-008	-49.69491603	178.7410415	Ground	Present	Unknown	Unknown
SKB-009	-49.69495894	178.7412801	Ground	Present	Unknown	Unknown
SKB-010	-49.69530034	178.7411710	Ground	Present	Unknown	Unknown
STB-001	-49.66864287	178.8093735	Ground	Present	Present	Present
WST-001	-49.67671330	178.7539375	Not seen	Unconfirmed <sup>†</sup>	Present	Present
WST-002	-49.67722954	178.7550786	Not seen	Unconfirmed <sup>†</sup>	Present	Present
WST-003	-49.67921480	178.7473708	Absent	Absent	Absent	Present
WST-004	-49.68116744	178.7428513	Absent	Absent	Absent	Present
WST-006	-49.67634559	178.7475402	Binocular—sea	Present	Present	Present
WST-007	-49.67680290	178.7513269	Binocular—sea	Present	Present	Present
WST-008	-49.67630887	178.7517107	Binocular—sea	Present	Present	Present
WST-009	-49.67911916	178.7487928	Absent	Absent	Present	Present
WST-010	-49.67868045	178.7483259	Absent	Absent	Present	Present
WST-011	-49.68051692	178.7417876	Binocular—land	Present	Present	Present
WST-012	-49.67846872	178.7472125	Binocular—sea	Present	Present	Present
WST-013	-49.68034962	178.7419532	Binocular—land	Present	Unknown	Unknown
WST-014	-49.67709631	178.7470190	Ground	Present	Unknown	Unknown
WST-015	-49.68042385	178.7411023	Binocular—land	Present	Unknown	Unknown
WST-016	-49.67753789	178.7470497	Ground	Present	Unknown	Unknown

\* All colonies considered new in 2011 have been recorded as unknown for the previous surveys because of there being no information for determining whether they were not present, present but not found or fragments of other colonies.

<sup>†</sup> These colonies were not seen during the survey, but no dedicated effort was made to determine whether they were still present. For the purposes of this survey, it was assumed that they were absent.

# Appendix 2

## Raw data and access notes for ground-counted penguin colonies in 2011

\*Effort is the number of people and the approximate number of hours required to paint sections and count the colonies in 2011; it does not allow for any travel time. Note: The team started at the colonies near the hut; therefore, these times are generous as team members were still familiarising themselves with the methodology and working in the colonies.

COLONY ID	DATE	LAT	LONG	YEAR PRESENT	NUMBER OF NESTS		EFFORT* REQUIRED TO COUNT COLONY	ACCESS NOTES
					ERECT-CRESTED	ROCK-HOPPER		
ACB-001	2 Nov 2011	-49.66645	178.80304	2011, 1989, 1978	0	63	3 people x 4 hours	Access possible from the landing via a narrow ledge leading around the base of the basalt columns
ACB-002	2 Nov 2011	-49.66524	178.79927	2011, 1989, 1978	213	60		
ACB-003	2 Nov 2011	-49.66656	178.80409	2011, 1989, 1978	0	109		
ACB-004	2 Nov 2011	-49.66582	178.80047	2011, 1989, 1978	707	313		
ACB-005	2 Nov 2011	-49.66636	178.80254	2011, 1989, 1978	0	62		
ACB-006	2 Nov 2011	-49.66652	178.80342	2011, 1989, 1978	0	44		
ACB-007	2 Nov 2011	-49.66689	178.80496	2011	27	6		
ACB-008	2 Nov 2011	-49.66671	178.80458	2011	6	11		
ACB-009	2 Nov 2011	-49.66613	178.80177	2011	2	127		
HTC-001	22 Oct 2011	-49.66740	178.80643	2011, 1989, 1978	664	5	5 people x 1.25 hours	
HTC-002	22 Oct 2011	-49.66778	178.80757	2011, 1989, 1978	427	16	5 people x 2 hours	
HTC-003	22 Oct 2011	-49.66683	178.81063	2011, 1989, 1978	578	0	5 people x 1 hour	
HTC-004	10 Nov 2011	-49.66769	178.80652	2011	85	0	2 people x 10 minutes	
MRB-001	6 Nov 2011	-49.66997	178.77488	2011, 1989, 1978	327	0	3 people x 3 hours	Access via a steep gut; the waypoint at the top is -49.67014, 178.77711
MRB-002	6 Nov 2011	-49.67009	178.77595	2011, 1989, 1978	75	18		
MRB-003	6 Nov 2011	-49.66958	178.77600	2011, 1989, 1978	614	152		
MRB-005	6 Nov 2011	-49.66968	178.77546	2011	33	0		
NWC-006	23 Oct 2011	-49.66516	178.77833	2011, 1989, 1978	247	19	2 people x 1.5 hours	Access is easiest down the northern ridge, then follow a series of ledges through the basin to reach the southern colony
NWC-007	23 Oct 2011	-49.66579	178.77862	2011, 1989, 1978	81	59		
ORL-001	25 Oct 2011	-49.67341	178.76019	2011, 1989, 1978	7832	580	5 people x 7 hours	

*Continued on next page*

COLONY ID	DATE	LAT	LONG	YEAR PRESENT	NUMBER OF NESTS		EFFORT* REQUIRED TO COUNT COLONY	ACCESS NOTES
					ERECT-CRESTED	ROCK-HOPPER		
SCW-001	28 Oct 2011	-49.70658	178.74794	2011, 1989, 1978	2968	25	2 people x 5.5 hours	A good slip gives easy access down the hillside (waypoint for the top is -49.70376, 178.75476) to reach colonies SHB-006 and SCW colonies
SCW-002	28 Oct 2011	-49.70633	178.74459	2011, 1989, 1978	792	196	2 people x 40 minutes	
SCW-003	28 Oct 2011	-49.70451	178.74084	2011, 1989, 1978	573	8	2 people x 30 minutes	
SCW-004	29 Oct 2011 & 2 Nov 2011	-49.70253	178.74023	2011, 1989, 1978	10949	1	3 people x 7 hours & 2 people x 9 hours	
SCW-005	28 Oct 2011	-49.70112	178.73991	2011, 1989, 1978	56	0	2 people x 10 minutes	
SCW-006	28 Oct 2011	-49.70731	178.74902	2011	106	0	2 people x 10 minutes	
SCW-007	28 Oct 2011	-49.70682	178.74849	2011	416	1	2 people x 30 minutes	
SCW-008	28 Oct 2011	-49.70671	178.74635	2011	131	0	2 people x 10 minutes	
SCW-009	28 Oct 2011	-49.70630	178.74565	2011	690	91	2 people x 30 minutes	
SCW-010	29 Oct 2011	-49.70097	178.73970	2011, 1989, 1978	227	0	2 people x 20 minutes	
SHB-006	28 Oct 2011	-49.70876	178.75372	2011, 1989, 1978	1920	54	3 people x 3 hours	
SKB-001	3 Nov 2011	-49.69416	178.74094	2011	39	31	2 people x 8 hours	Easy access via the creek at the southern end of the bay
SKB-002	3 Nov 2011	-49.69474	178.74199	2011, 1989, 1978	1191	0		
SKB-003	3 Nov 2011	-49.69370	178.74057	2011, 1989, 1978	361	140		
SKB-004	3 Nov 2011	-49.69296	178.74071	2011, 1989, 1978	230	0		
SKB-005	3 Nov 2011	-49.69421	178.74131	2011	804	7		
SKB-006	3 Nov 2011	-49.69462	178.74067	2011	119	2		
SKB-007	3 Nov 2011	-49.69484	178.74121	2011	113	2		
SKB-008	3 Nov 2011	-49.69492	178.74104	2011	148	12		
SKB-009	3 Nov 2011	-49.69496	178.74128	2011	68	47		
SKB-010	3 Nov 2011	-49.69530	178.74117	2011	123	211		
STB-001	20 Oct 2011	-49.66864	178.80937	2011, 1989, 1978	251	3	5 people x 30 minutes	
WST-014	29 Oct 2011	-49.67710	178.74702	2011	4	0		
WST-016	29 Oct 2011	-49.67754	178.74705	2011	29	0		

\* Effort is the number of people and the approximate number of hours required to paint sections and count the colonies in 2011; it does not allow for any travel time. Note: The team started at the colonies near the hut; therefore, these times are generous as team members were still familiarising themselves with the methodology and working in the colonies.



# Appendix 3

## Maps showing penguin colony locations

Colonies may comprise just erect-crested or rockhopper nests, or be of mixed assemblage

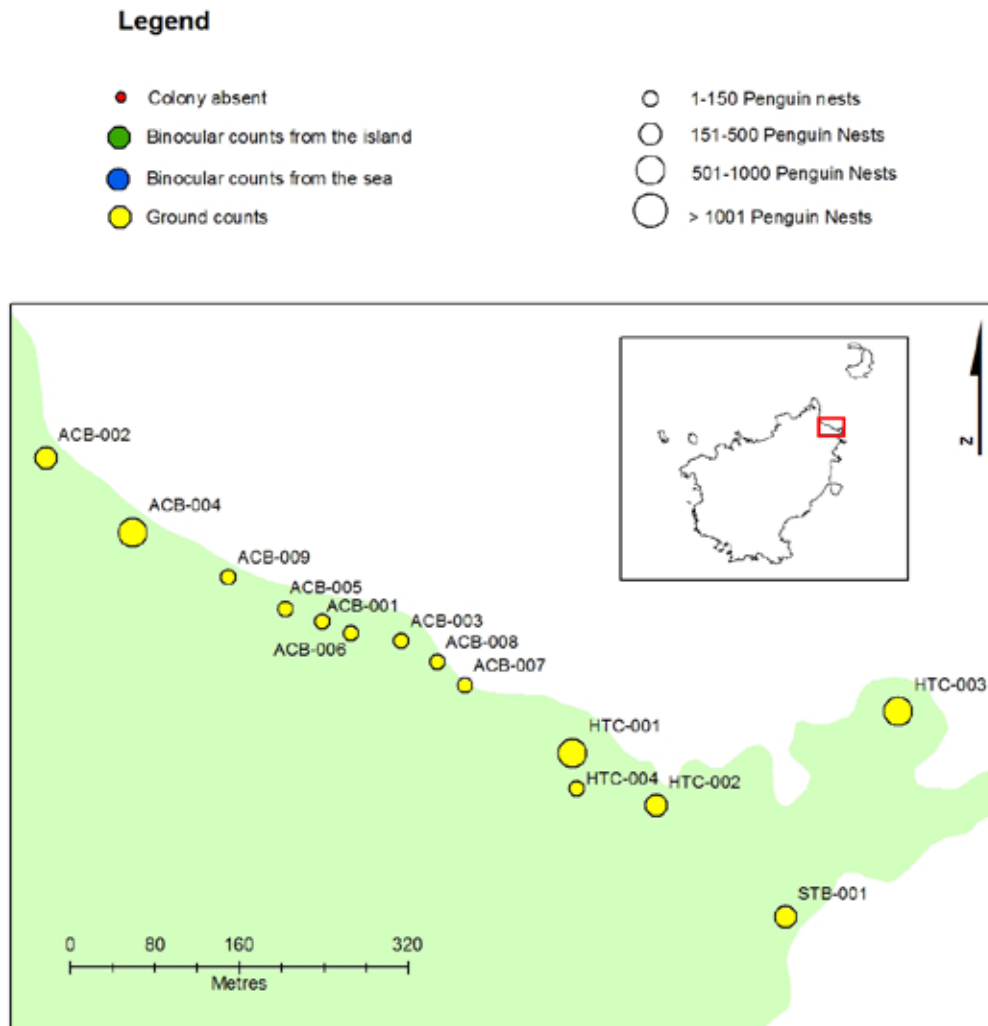


Figure A3.1. Location of colonies at Anchorage Bay (ACB), Hut Cove (HTC) and Stella Bay (STB).

### Legend

- Colony absent
- Binocular counts from the island
- Binocular counts from the sea
- Ground counts
- 1-150 Penguin nests
- 151-500 Penguin Nests
- 501-1000 Penguin Nests
- > 1001 Penguin Nests

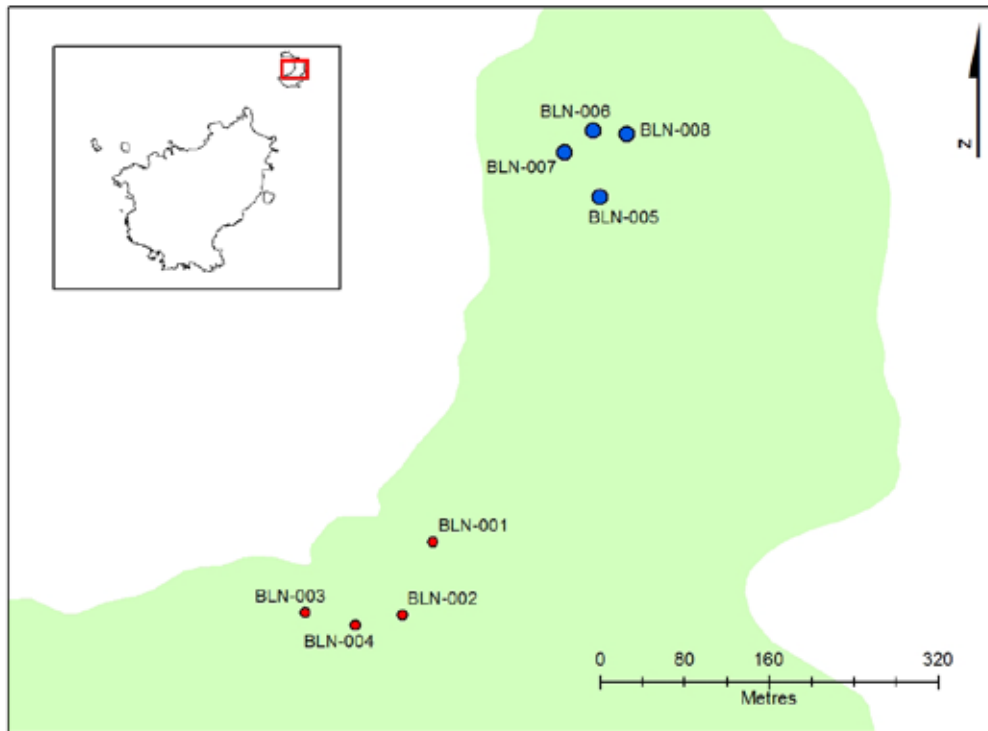


Figure A3.2. Location of colonies at Bollons Island (BLN).

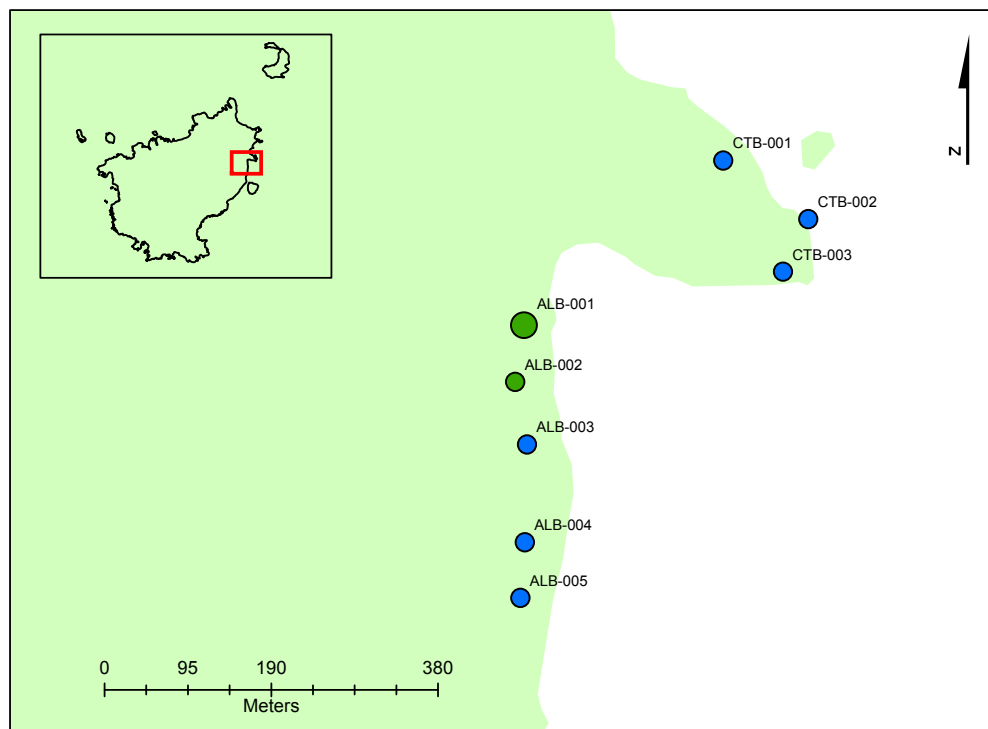


Figure A3.3. Location of colonies at Crater Bay (CTB) and Alert Bay (ALB).

### Legend

- Colony absent
  - Binocular counts from the island
  - Binocular counts from the sea
  - Ground counts
- 1-150 Penguin nests
  - 151-500 Penguin Nests
  - 501-1000 Penguin Nests
  - > 1001 Penguin Nests

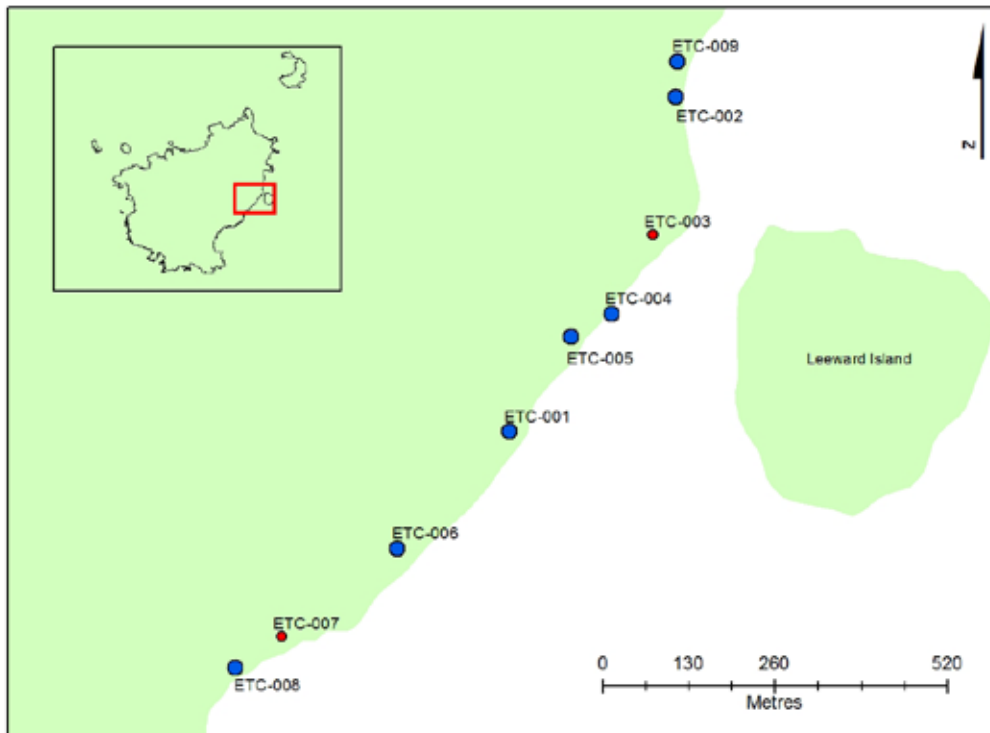


Figure A3.4. Location of colonies at East Coast (ETC)..

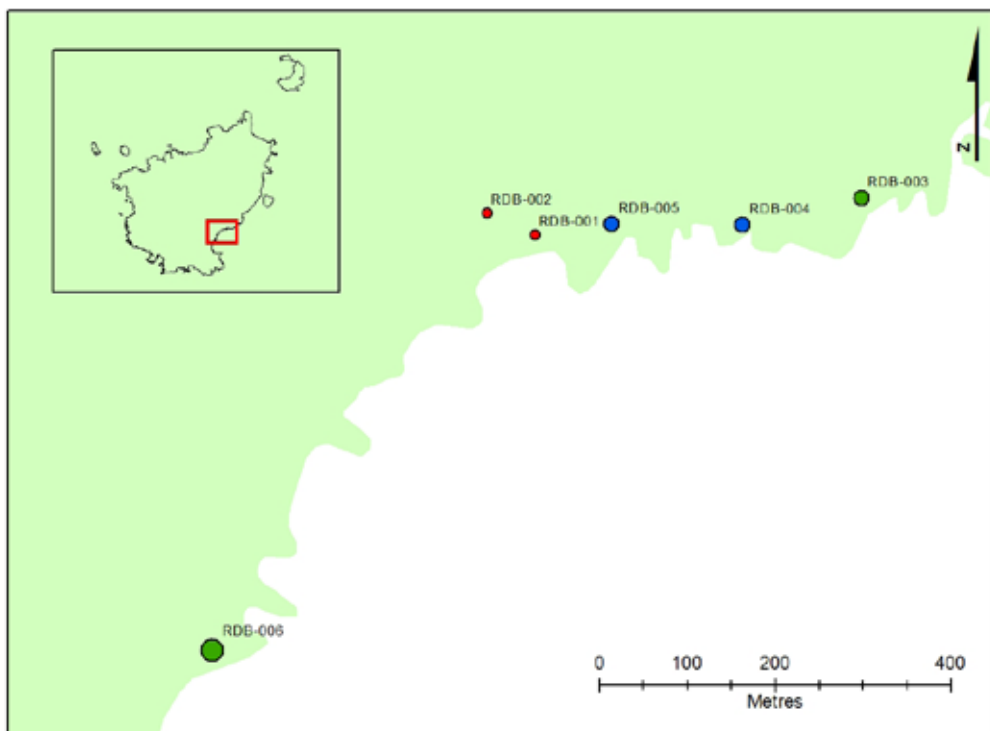


Figure A3.5. Location of colonies at Ringdove Bay (RDB).

### Legend

- Colony absent
- Binocular counts from the island
- Binocular counts from the sea
- Ground counts
- 1-150 Penguin nests
- 151-500 Penguin Nests
- 501-1000 Penguin Nests
- > 1001 Penguin Nests

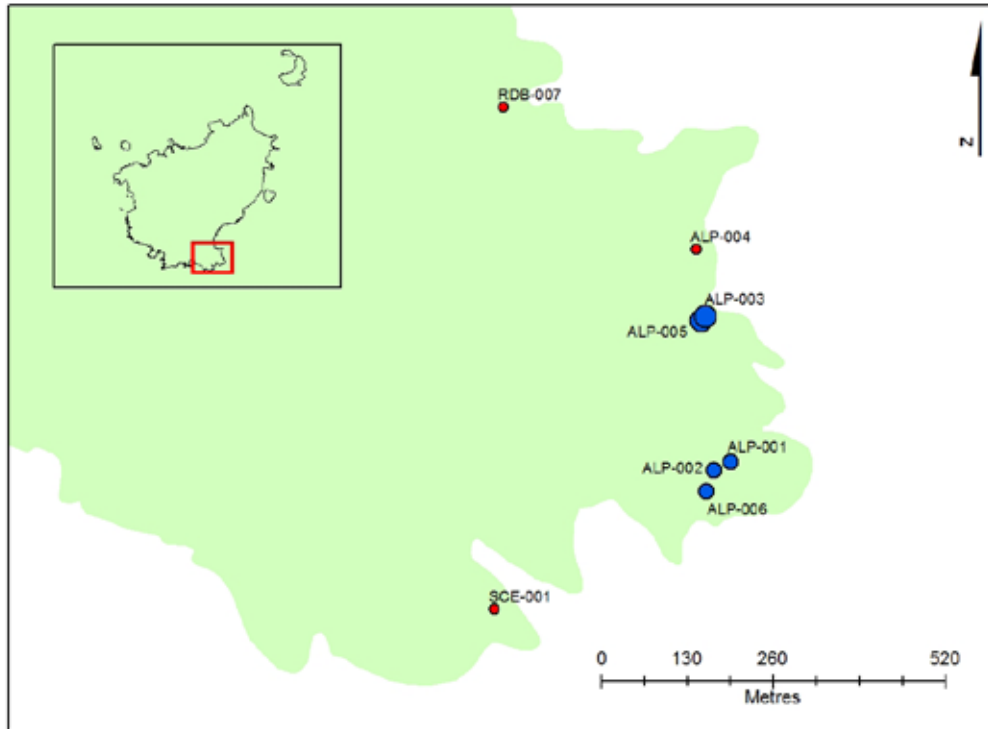


Figure A3.6. Location of colonies at Albatross Point (ALP).

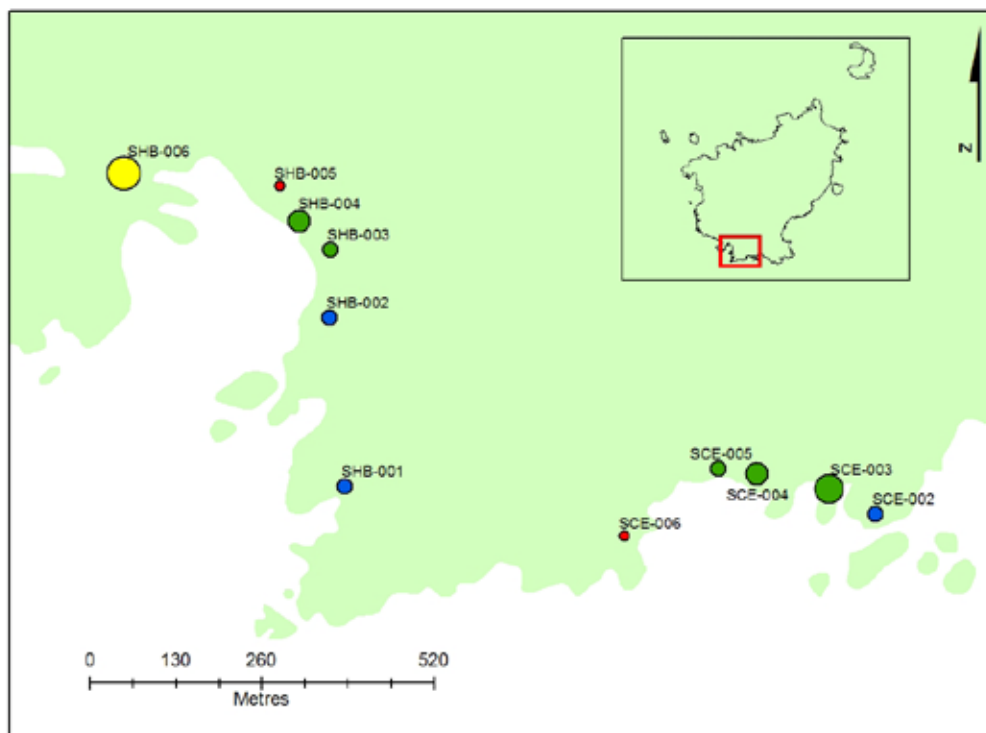


Figure A3.7. Location of colonies at South Bay (SHB) and South East Coast (SCE).

### Legend

- Colony absent
- Binocular counts from the island
- Binocular counts from the sea
- Ground counts
- 1-150 Penguin nests
- 151-500 Penguin Nests
- 501-1000 Penguin Nests
- > 1001 Penguin Nests

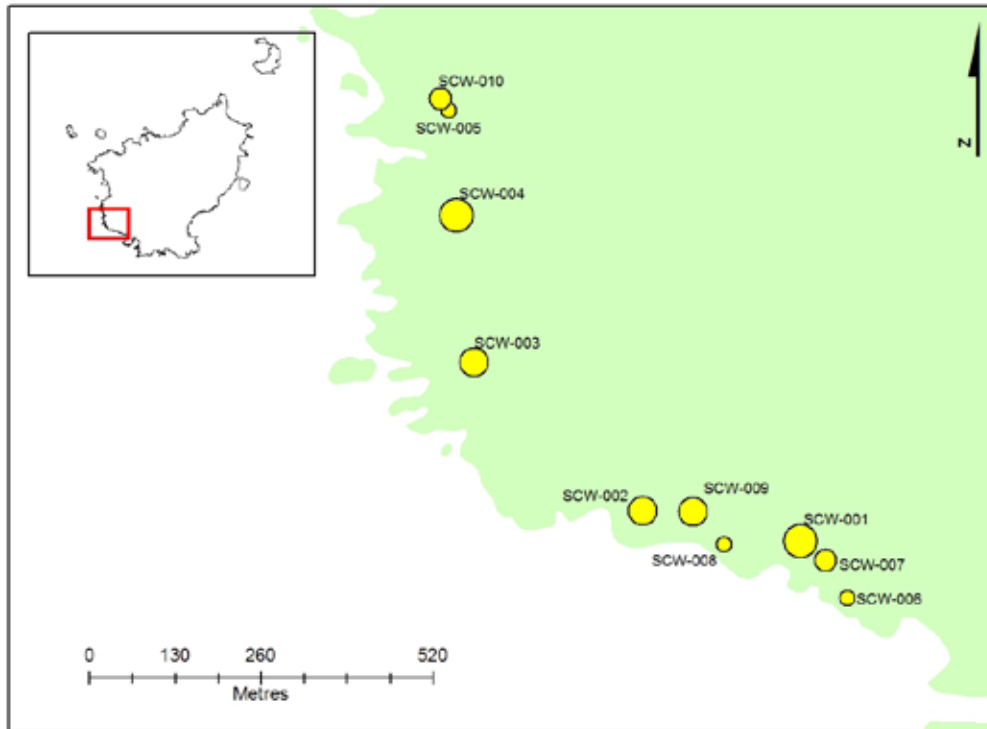


Figure A3.8. Location of colonies at South Coast West (SCW).

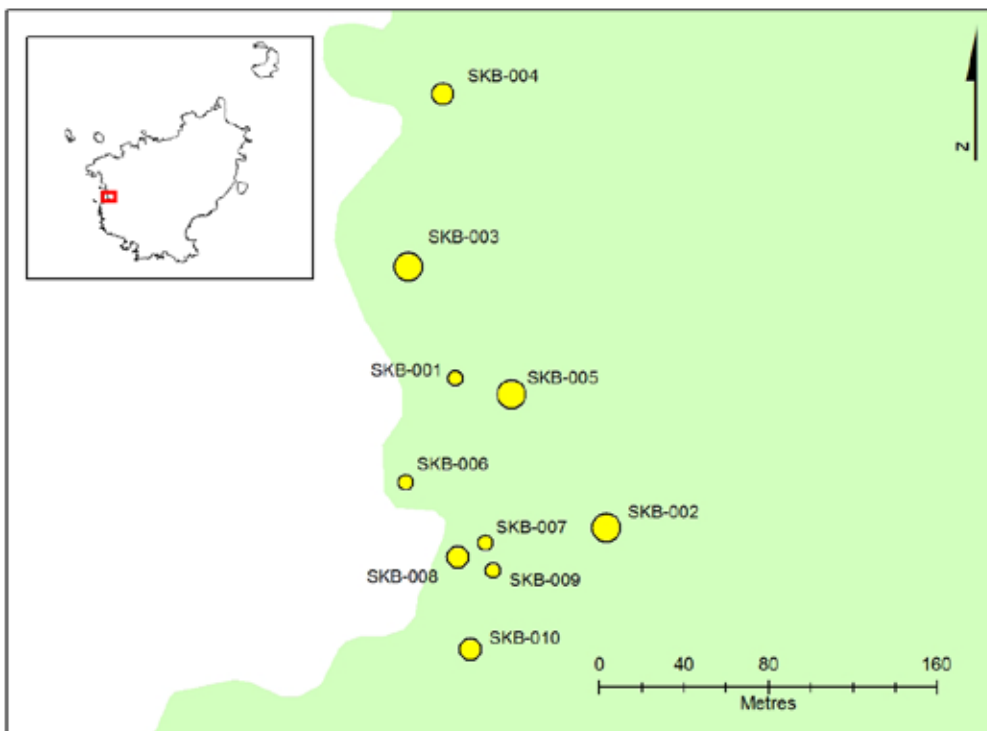


Figure A3.9. Location of colonies at Stack Bay (SKB).

### Legend

- Colony absent
- Binocular counts from the island
- Binocular counts from the sea
- Ground counts
- 1-150 Penguin nests
- 151-500 Penguin Nests
- 501-1000 Penguin Nests
- > 1001 Penguin Nests

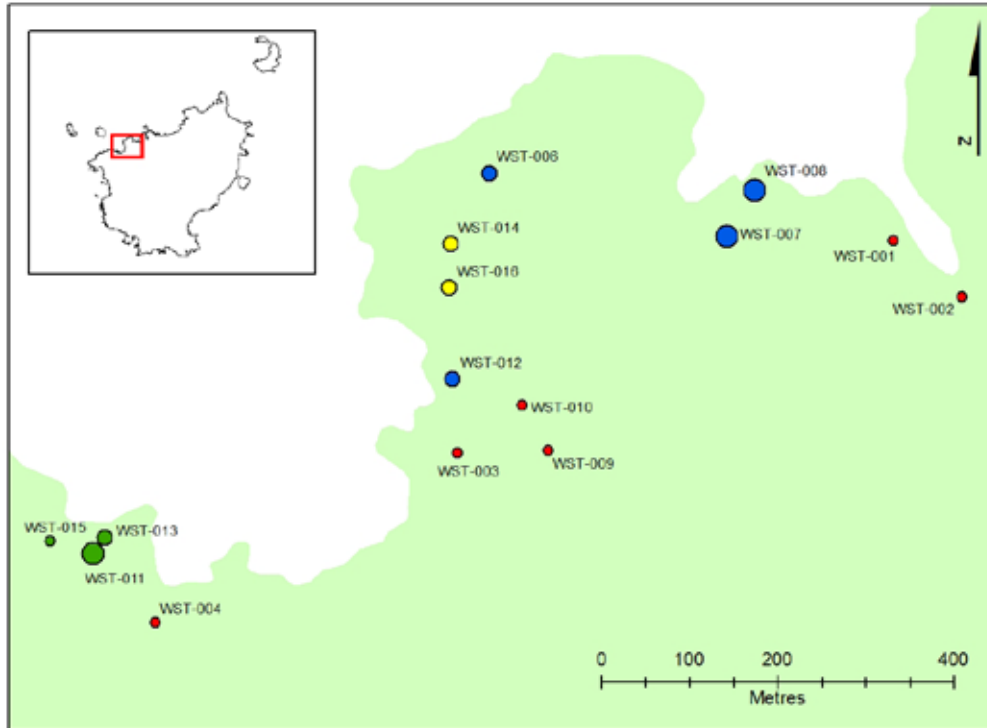


Figure A3.10. Location of colonies at West Coast (WST).

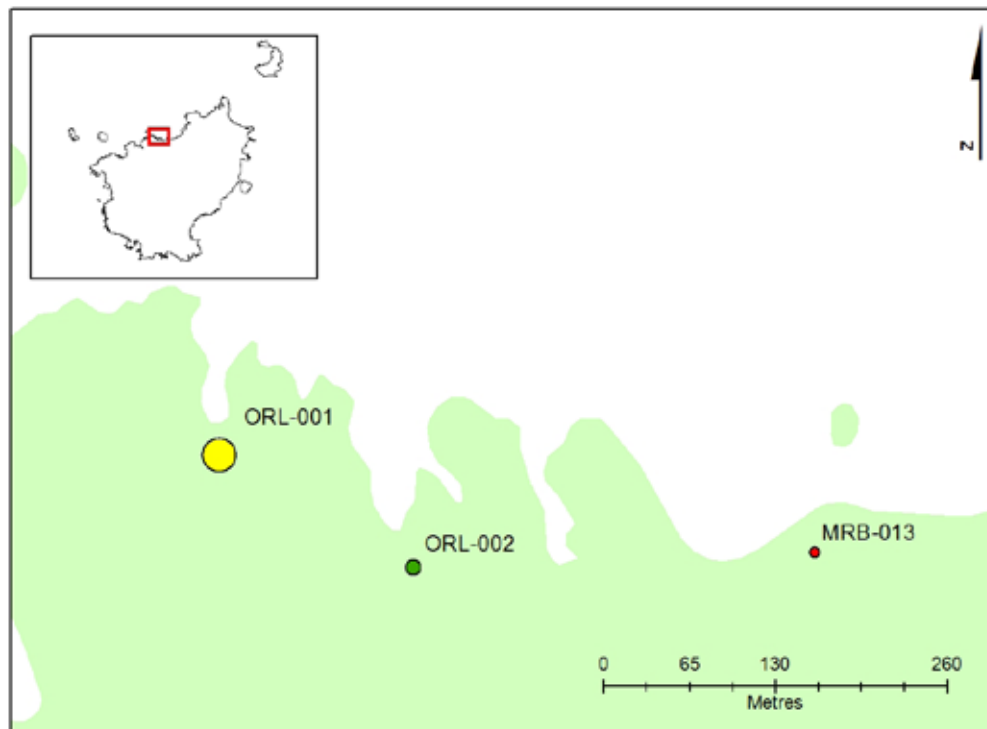


Figure A3.11. Location of colonies at Orde Lees (ORL).

### Legend

- Colony absent
- Binocular counts from the island
- Binocular counts from the sea
- Ground counts
- 1-150 Penguin nests
- 151-500 Penguin Nests
- 501-1000 Penguin Nests
- > 1001 Penguin Nests

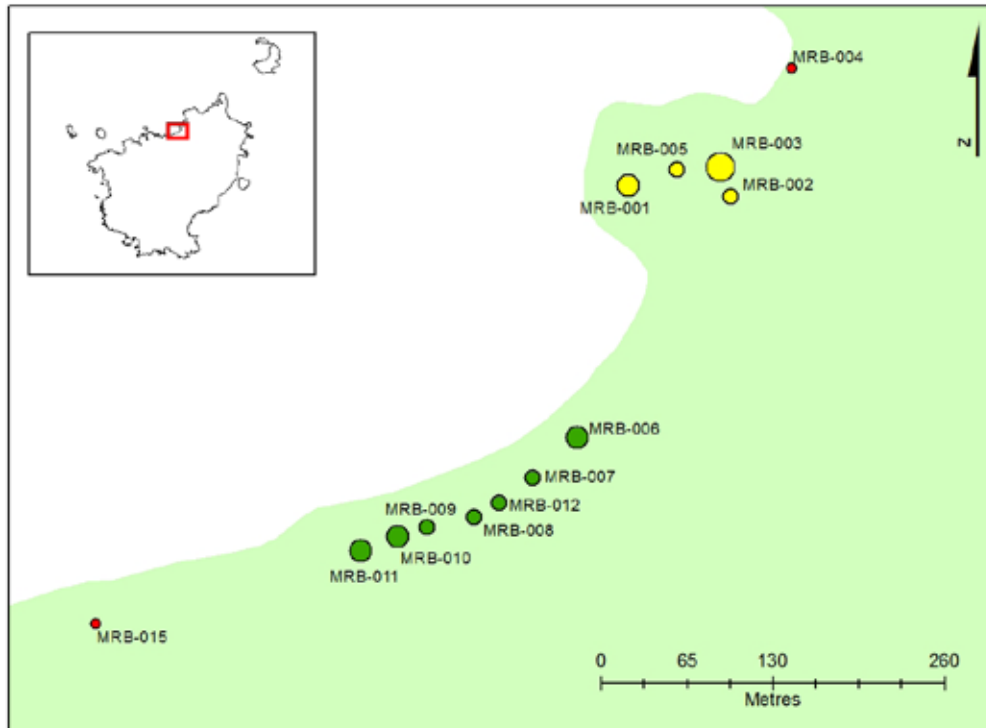


Figure A3.12. Location of colonies at Mirounga Bay (MRB).

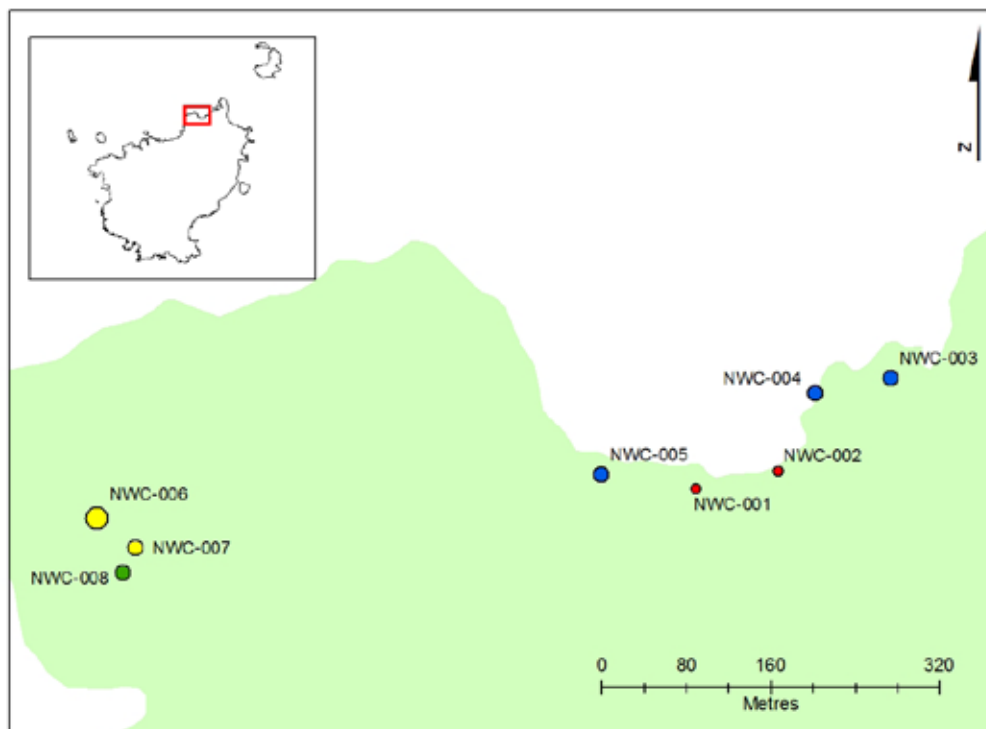


Figure A3.13. Location of colonies at North West Coast (NWC).

### Legend

- Colony absent
- Binocular counts from the island
- Binocular counts from the sea
- Ground counts
- 1-150 Penguin nests
- 151-500 Penguin Nests
- 501-1000 Penguin Nests
- > 1001 Penguin Nests

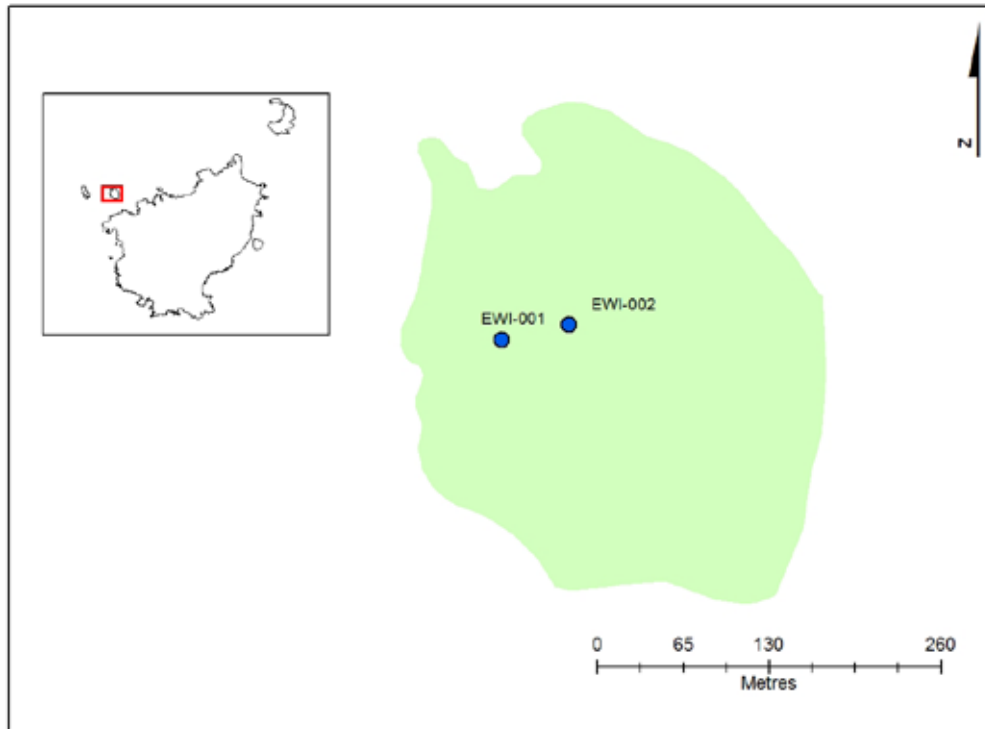


Figure A3.14. Location of colonies at East Windward Islands (EWI).

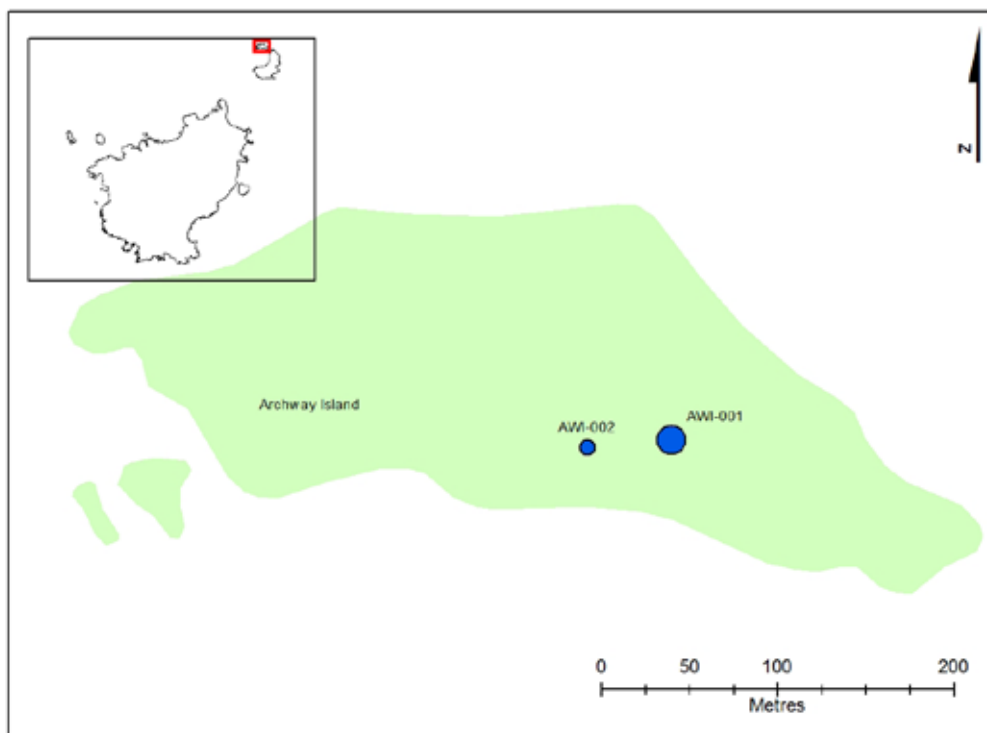


Figure A3.15. Location of colonies at Archway Island (AWI).



# Appendix 4

## Datasheet for record keeping in the field during a penguin census in the Antipodes Island Group

<b>Antipodes Island Group Penguin Census</b>			
Colony	<input style="width: 95%;" type="text"/>	Date	<input style="width: 95%;" type="text"/>
Start time	<input style="width: 95%;" type="text"/>	Finish time	<input style="width: 95%;" type="text"/>
Latitude	<input style="width: 95%;" type="text"/>	Longitude	<input style="width: 95%;" type="text"/>
Sketch/comments			

Observer	Area 1		Area 2		Area 3		Area 4		Area 5		Area 6		Area 7		Area 8	
	EC	RH	EC	RH	EC	RH	EC	RH	EC	RH	EC	RH	EC	RH	EC	RH
Average																