

# PENGUIN RESEARCH



THE TAWAKI PROJECT

## BOUNTY-ANTIPODES EXPEDITION 2022

8 NOVEMBER - 21 DECEMBER 2022



The  
Tawaki Trust



ANTARCTIC  
RESEARCH  
TRUST





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*PENGUIN RESEARCH*

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## Executive Summary

The Tawaki Project's Bounty-Antipodes 2022 expedition took place between 8 November and 21 December 2022.

### Bounty Islands – 10-15 November 2022

The expedition spent six days at the Bounty Islands (on two of which landing was impossible) to conduct comprehensive drone surveys of the archipelago with the aim to conduct counts of Erect-crested penguins and other seabirds. 19 of the 24 islands and rock stacks were successfully surveyed; only Con Island rocks completely awash in high seas were not included. High-resolution orthomosaics and detailed digital elevation models were generated from the drone imagery. The orthomosaics allowed counting of penguins and other animals. Additionally, 30 penguins were blood sampled for stable isotope, genetic analysis as well as disease screening.

**A total of 2,776 penguin nests were counted during ground-truthing counts on Proclamation Island, the highest number since the first comprehensive ground count sin 1997. Preliminary analysis of the orthomosaics found penguins present on 12 islands, with a total number of birds of 30,676 individuals present at the time of the drone surveys. Ground-truthing counts indicate that 85% of the penguins present were associated with a nest, so that the total breeding population of Erect-crested penguins on the Bounty Islands is estimated to be around 25,899 breeding pairs.**

The drone data also allowed a full survey of the breeding population of Bounty Island shags. **A total of 910 Bounty Island shags were counted 573 of which were sitting on a nest.** It appears as if the Bounty Island shag breeding population has remained stable since the first (and only) breeding population census in 1978 (569 nests).

Other seabird as well as NZ fur seal populations were also counted although no estimate of the breeding population is possible for these groups.

## Antipodes Islands – 16 November - 18 December 2022

There were two main aspects to the work on the Antipodes Islands.

### *Penguin population estimates*

Drone surveys of all known Erect-crested and Eastern Rockhopper penguin colonies were conducted. Except for three colony locations, all known penguin colonies were surveyed by drone. **The presence of 81 colonies was confirmed, 26 colonies reported in 2011 were no longer present in 2022.** Combined with the disappearance of 21 colonies between 1978 and 2011, the number of penguin colonies has **decreased by 36% in the last 44 years.**

Drone imagery counts are pending at the time of writing. However, preliminary analysis of colony extent determined from drone surveys suggests that some **colonies have shrunk in size between 28-63% since 2004.**

Ground counts conducted in colonies close to the Antipodes Hut also seem to paint a grim picture of the state of Erect-crested penguins on the island. In eastern Anchorage Bay, numbers of Erect-crested penguin nests were only 62% of what was counted here in 2011; at Reef Point, breeding pairs were 49% of the numbers counted 11 years ago; and in Stella Bay penguin nests were only 24% of the 2011 numbers.

While the potential effects of the prolonged La Niña might explain at least some of the low nest numbers found, it seems likely that Erect-crested penguins on the Antipodes Islands are experiencing a significant and ongoing decline. Eastern rockhopper penguin numbers also seem to have dropped in numbers, although analysis of the drone data will bring more clarity about the state of that species.

### *Foraging study of penguins*

We conducted the first tracking study of breeding Erect-crested and Eastern Rockhopper penguins using GPS dive loggers. Additionally, we fitted novel camera loggers to Erect-crested penguins to visually investigate their foraging behaviour and examine their prey composition.



In Erect-crested penguins, GPS dive logger deployments were carried out at the northern and the southern ends of Antipodes Island to examine potential location-dependent differences in foraging behaviour. All deployments happened during the chick-guard stage when only the females forage to feed the chicks. A total of 20 logger deployments were carried out in Anchorage Bay and 14 deployments on the south coast. Two devices in the south could not be recovered. Preliminary data shows that penguins generally foraged within a 20 km radius from the island, with birds from Anchorage Bay moving to the north, while south coast birds headed principally in a southerly direction with little to no overlap in the foraging areas of both groups.

Five Eastern Rockhopper penguins from Anchorage Bay were also fitted with GPS dive loggers. The birds were more variable in their foraging trajectories with some foraging tracks going to the south while others showed northerly tracks comparable to Erect-crested penguins. Like the bigger species, the rockhopper penguins stayed within 20km of their colonies.

Detailed analysis of all foraging data is pending.

## Conclusion & Outlook

As was to be expected given the dearth of previous scientific data on penguins from the Bounty and Antipodes Islands, we returned from the subantarctic with more questions than answers.

The population trajectories of Erect-crested penguins from the Bounty and Antipodes Islands differ substantially. On the Bounty Islands, penguin numbers appear to be stable at least since the 1990s whereas on the Antipodes Islands, numbers are substantially lower than during previous surveys. It is vital to understand what is driving penguin numbers on both islands, to establish whether conservation actions can help to stop or even revert the decline on the Antipodes Islands. A first step is to assess whether the pre-moult dispersal of penguins from both islands differs, i.e., during the most vulnerable period for adult penguins. To

**that end, we plan to deploy satellite trackers on Erect-crested penguins at the Antipodes and Bounty Islands in January 2024.**

The significantly lower numbers of Erect-crested penguin nests on the Antipodes Islands are as confusing as they are concerning. Although previous expeditions documented an ongoing decline, the apparent increased rate of decline we observed seems exaggerated. We suspect that nest numbers on the Antipodes may have been artificially deflated as a result of Erect-crested penguins skipping to breed.

Considering that the 2022 expedition occurred at the tail end of a prolonged, three-year La Niña period that brings with it above average ocean temperatures, the foraging conditions may have been suboptimal leading to fewer overall breeding attempts in the population. If this was the case, the ENSO neutral conditions forecasted for the coming summer should result in an increase in penguin breeding pairs compared to 2022/23. **We therefore plan to re-do drone surveys of at least the major penguin colonies on Antipodes Island.**

The timing of the 2022 expedition was perfect to conduct the comprehensive surveys of both Bounty and Antipodes Islands. However, the timing was less ideal with regards to comparing the foraging behaviour of Erect-crested and Rockhopper penguins. Rockhopper chicks only started hatching in early December so that our ability to study the foraging behaviour during the chick rearing period was limited to our last week on the island. To allow a more comparative study of the foraging strategies of the two penguin species on Antipodes Island it is therefore vital that next year's expedition commences 2-3 weeks later, so that our arrival coincides with Rockhopper chick hatching but still allows us to record foraging data on chick guarding Erect-crested penguins. **Our tentative dates for the 2023/24 expedition are,**

- **4 December 2023 – Travel to Antipodes Is**
- **16 January 2024 – Pick-up Antipodes Is; Journey to Bounty Is**
- **19 January 2024 – Depart Bounty Is**



## Table of Contents

<b>Executive Summary .....</b>	<b>3</b>
Bounty Islands – 10-15 November 2022 .....	3
Antipodes Islands – 16 November - 18 December 2022 .....	4
<i>Penguin population estimates.....</i>	4
<i>Foraging study of penguins .....</i>	4
Conclusion & Outlook .....	5
<b>Table of Contents .....</b>	<b>7</b>
<b>Acknowledgements .....</b>	<b>8</b>
<b>Expedition dates .....</b>	<b>9</b>
<b>Expedition team.....</b>	<b>10</b>
<b>Part I – Bounty Islands: 10-15 November 2022 .....</b>	<b>11</b>
Bounties timeline .....	11
Drone surveys of Bounty Islands.....	13
<i>Apparently erroneous land area in LINZ records.....</i>	14
Ground-truthing counts of Erect-crested penguin nests.....	17
Blood sampling of Erect-crested penguins .....	18
Installation of albatross & penguin time-lapse cameras .....	19
Observations of ringed albatross, GLS recovery and sampling.....	25
Observations of <i>Lepidium</i> (Cook’s Scurvy grass) .....	26
Preliminary results.....	29
<i>Ground counts of Erect-crested penguins .....</i>	29
<i>Drone counts of seabirds and fur seals .....</i>	29
Historic assets .....	33
<b>Part II – Antipodes Islands: 16 Nov – 18 Dec 2022 .....</b>	<b>34</b>
Antipodes timeline.....	34
Deployment of data loggers on penguins .....	35
Blood sampling Erect-crested & Eastern Rockhopper penguins .....	38
Microchipping Erect-crested & Eastern Rockhopper penguins.....	38
First records of leucistic and isabelline Erect-crested penguins.....	40
Drone surveys of penguin colonies.....	41
Drone survey trials of Light-mantled sooty albatross .....	44
Preliminary results.....	49
<i>Penguin counts – Antipodes.....</i>	49
<i>Penguin colonies – past and present .....</i>	52
<i>Penguin GPS tracking – preliminary results.....</i>	54
Notes on logistics .....	56
<i>Gear transfer at Antipodes Islands .....</i>	56
<i>Camp on the south coast.....</i>	58
<i>Hut maintenance .....</i>	60
Historic assets .....	62
<b>Detailed trip timeline.....</b>	<b>65</b>

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James Frankham and Richie Robinson from NZ Geographic for being fantastic field companions and producing an amazing article on the expedition.



## Expedition dates

08 – 10 November 2022	Dunedin to Bounty Islands on board of <i>Evohe</i>
10 & 11 November 2022	Landed on Proclamation Island
12 & 13 November 2022	Cruising north of Bounties due to rough seas
14 November 2022	Landed on Proclamation Island
15 November 2022	Visited East Group before journeying to Antipodes Islands
16 November 2022	Arrival at Antipodes Island, disembark research team.
17 November – 17 December 2022	Field work on Antipodes Islands
17 December 2022	<i>Evohe</i> arrives, landing not possible due to rough conditions
18 December 2022	Field team off the island by late afternoon
18-21 December 2022	Antipodes Islands to Dunedin



*Evohe off East Windward Island, Antipodes Islands, 18 December 2022*

## Expedition team

NAME	ROLE	AFFILIATION
Thomas Mattern	Expedition leader	University of Otago, Tawaki Trust & Global Penguin Society
Klemens Pütz	Researcher	Antarctic Research Trust
Dave Houston	Researcher, DOC rep	Department of Conservation, Tawaki Trust
Robin Long	Researcher	Lincoln University, West Coast Penguin Trust
Jeff White	PhD student	University of Miami, FL, USA
Bianca Keys	PhD student	University of Otago
Hannah Mattern	Drone pilot	Logan Park High School
<i>James Frankham*</i>	<i>Journalist</i>	<i>New Zealand Geographic</i>
<i>Richard Robinson*</i>	<i>Photographer</i>	<i>New Zealand Geographic</i>

*\* Only Bounty Islands portion and first two days on Antipodes*



*Robin Long, Klemens Pütz, Thomas Mattern  
Dave Houston, Bianca Keys, Jeff White, Hannah Mattern*



## Part I – Bounty Islands: 10-15 November 2022

### Bounties timeline

The expedition left Dunedin around midday on 8 November 2022 and arrived at the Bounties at 11am on 10 November 2022.

First landing on Proclamation Island was made in the afternoon of 10 November, which included the rigging of guiding ropes to the top plateau and flying of the first drone missions. Evohe anchored overnight ca. 100m east of Proclamation Island (Figure 1).

On 11 November, the team landed just after 8am on Proclamation Island to fly drone missions, start ground-truthing counts of Erect-crested penguin nests, carry out blood sampling of penguins for stable isotope research and disease screening (for DOC). The afternoon of that day, time-lapse cameras were installed to monitor Salvin's albatross and penguin breeding success.

Sea conditions on 12 November prevented landing and the Evohe cruised northwards to wait for an improvement. On 13 November, sea conditions were still too rough to attempt landing. The Evohe anchored to the south of Depot Island for about three hours before cruising north again to spend another day away from the islands.

Seas calmed down on 14 November although first landing attempts in the morning were aborted due to questionable conditions at Proclamation Island. Landings were eventually successful after lunch so that drone surveys of the Main and Centre Groups, ground counts and blood sampling work could be completed. Additionally, Salvin's albatross with Darvic leg rings were checked for GLS loggers. Evohe anchored again 100m east of Proclamation Island.

In the morning of 15 November, Evohe steamed towards the East Group and idled east of Molly Cap to conduct drone surveys of the island as well as North Rock from the deck of the boat. The vessel departed the Bounties with destination Antipodes Islands around lunchtime.



**Figure 1.** *Evohe anchored east of Proclamation Island, 14 November 2022.*



## Drone surveys of Bounty Islands

On 10, 11, 14 and 15 November 2022, our team managed to complete drone surveys of 15 islands and rock stacks representing all sites that provide habitat for fauna and fauna. The only feature not to be surveyed was Con Island as it is completely awash in high seas. Most drone missions were flown from the top of Proclamation Island (Figure 2). Attempts to land on Depot Island to fly drone missions from there were not made due to unfavourable sea conditions and the volume of birds on the island. Landing on Funnel Island was also not attempted, and drone missions of the Centre Group were completed from Proclamation Island as well. Molly Cap and North Rock were surveyed by a single drone team that flew the respective missions from the deck of the Evohe.



**Figure 2.** *Dave Houston (Department of Conservation & Tawaki Trust) and Thomas Mattern (University of Otago, Global Penguin Society & Tawaki Trust) flying drone missions from the top of Proclamation Island. Photo credit: Richard Robinson, New Zealand Geographic.*



A total of 15 drone missions were flown that took between 08:28 and 1:19:37 hours to complete. The cumulative mission time amounted to 7:55:12 hours.

Two repeat missions were flown for Depot Island as the first attempt was incomplete (drone battery ran out after 40 minutes) and the second attempt suffered from too harsh light resulting in overly contrasted imagery. The mission for Proclamation was also flown twice as the first attempt was drawn out temporally due to technical problems with the drone half-way through the mission.

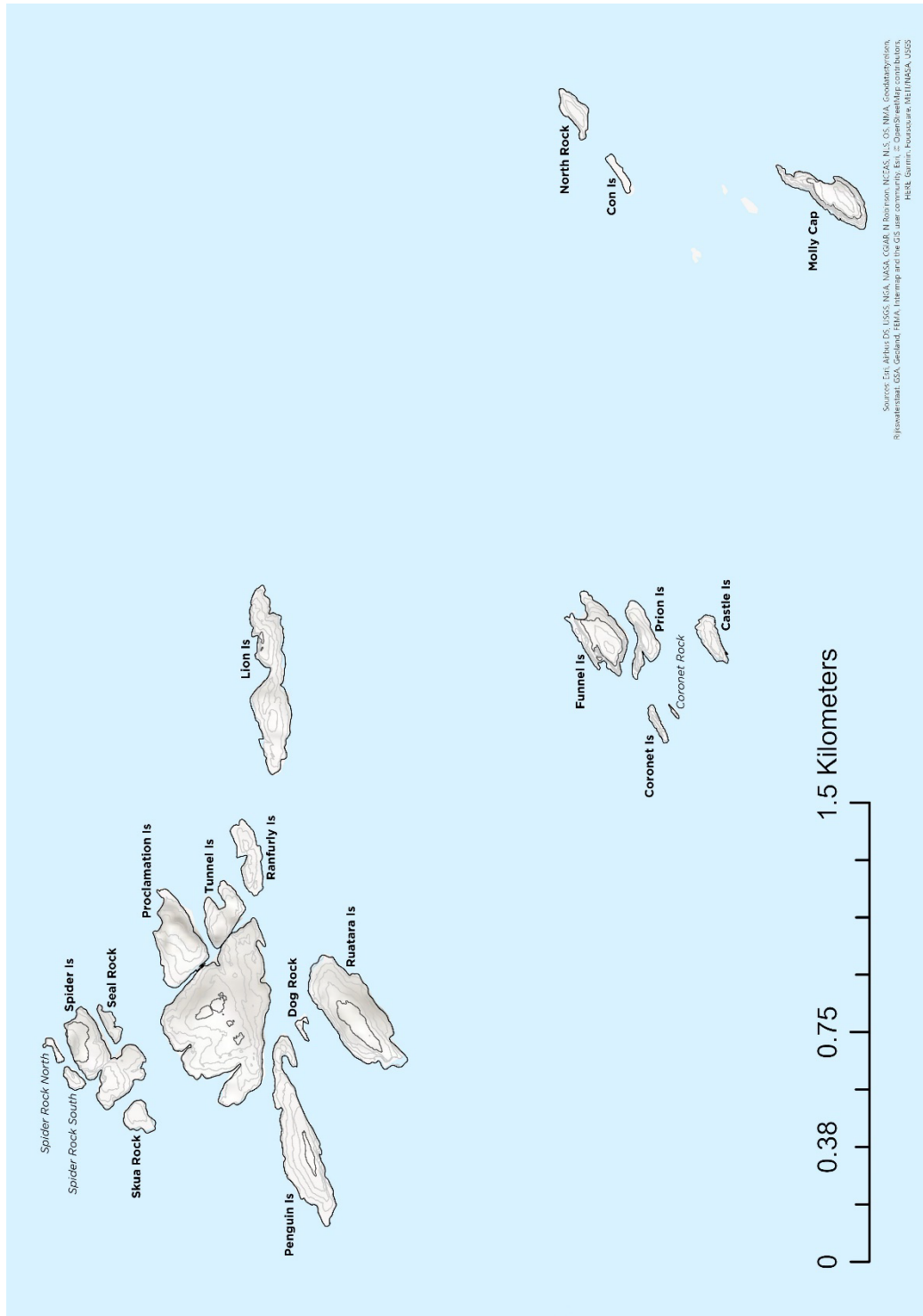
Drone flight altitudes ranged between 40m and 80m above the launch point so that the drones flew well above the layer of volant albatross circling above the islands at any given time of the day. No direct interactions (e.g., collisions with albatross, dive bombing by black-backed gulls) occurred during any of the drone missions. Although occasionally back-backed gulls took an interest in the drone and circled the unit for a few minutes. Precautionary evasive manoeuvres were not necessary at any time.

Each drone team consisted of the pilot and a spotter who maintained visual contact with the drone at all time using binoculars. This was virtually impossible during the surveying of the Centre Group as the drone was too far. However, the proximity alert of the drone still provided some level of control over potential interactions between drone and gulls. The surveys were completed without incident.

### *Apparently erroneous land area in LINZ records*

The total land area of the Bounty Island archipelago is often given as 135 ha (e.g. <https://bit.ly/doc-bounty-info>) which likely derives from the LINZ protected areas data set apparently based on survey data from 1960 (<https://bit.ly/linz-pa>).

However, using the Digital Elevation Model data generated from the drone imagery, our data shows that the **total land area of the Bounties amounts to only around 50 ha**. This is important as past population assessments of seabirds on the Bounties were extrapolated to available landmass so that overestimations seem a possibility. An overview of topographic characteristics of the surveyed islands derived from drone photogrammetry are given in Figure 3 and Table 1.



**Figure 3.** Overview of the Bounty Island archipelago showing topography derived from drone-based photogrammetry. Isolines represent 10m height intervals, 50m height contour indicated in dark grey.

**Table 1.** *Topographic characteristics of the Bounty Island archipelago. Islands are grouped by Main, Centre and East Group. Subtotals are given for area and maximum for highest point in each group.*

<b>Group</b>	<b>Island</b>	<b>Area (m<sup>2</sup>)</b>	<b>Area (ha)</b>	<b>Highest point (m)</b>
Main Group	Spider Rock North	1,884	0.2	21.5
	Spider Rock South	3,197	0.3	32.9
	Spider Is	40,080	4.0	71.4
	Seal Rock	4,362	0.4	26.0
	Skua Rock	7,318	0.7	27.4
	Depot Is	126,832	12.7	55.0
	Proclamation Is	32,615	3.3	48.7
	Tunnel Is	16,402	1.6	50.3
	Penguin Is	51,017	5.1	55.8
	Dog Rock	1,439	0.1	21.3
	Ruatara Is	58,039	5.8	60.3
	Ranfurly Is	14,683	1.5	38.5
	Lion Is	48,965	4.9	54.9
		<b>406,833</b>	<b>40.7</b>	<b>71.4</b>
Centre Group	Coronet Is	3,122	0.3	40.1
	Coronet Rock	424	0.04	12.1
	Funnel Is	27,159	2.7	74.1
	Prion Is	13,358	1.3	42.7
	Castle Is	8,440	0.8	39.1
		<b>52,503</b>	<b>5.3</b>	<b>74.1</b>
East Group	North Rock	8,357	0.8	38.8
	Molly Cap	24,084	2.4	76.7
	Con Is*	3,345	0.3	-
		<b>35,786</b>	<b>3.6</b>	<b>76.7</b>
<b>TOTAL</b>		<b>495,122</b>	<b>49.5</b>	<b>76.7</b>

\* Note: Con Island outline derived from satellite imagery and was not surveyed with the drone



## Ground-truthing counts of Erect-crested penguin nests

On 11 and 14 November, ground-truthing counts of Erect-crested penguins were conducted on Proclamation Island. On the first day, about half of the island was counted by a single observer (Robin Long) who walked from penguin nest to penguin nest, counted each nest with a tally counter and marking counted nests with a dab of stock marker (Figure 4).

Landing on the islands was not possible on 12 and 13 November, so that ground counts could only be completed on 14 November. On this last day, remaining nests were counted by two observers (RL and Jeff White). (Attempts were also made to count albatross nests, starting on 14 November, but it became apparent that counts could not be completed before our departure and were, therefore, abandoned.)



**Figure 4.** Robin Long (Lincoln University & West Coast Penguin Trust) conducting ground counts of penguin nests on Proclamation Island. Note the blue dab of paint in the lower left corner of the image marking a counted nest. Photo credit: Richard Robinson, New Zealand Geographic.

## Blood sampling of Erect-crested penguins

Between 10 and 14 November, a total of 30 Erect-crested penguins were handled to take blood samples for stable isotope analysis as well as comprehensive disease screening, the latter being work undertaken by the Department of Conservation (Figure 5).



**Figure 5.** *Klemens Pütz (Antarctic Research Trust; holding penguin) and Jeff White (University of Miami) blood sampling of Erect-crested penguins on Proclamation Island. Photo credit: Richard Robinson, New Zealand Geographic.*

Most penguins ( $n=20$ ) were captured close to the northern landing ramp on Proclamation Island shortly after birds made landfall and were commuting to the nesting areas. The remaining 10 birds were selected from nests to avoid a sex bias as mostly males were landing and many of the females remained on the nest incubating their clutch.

## Installation of albatross & penguin time-lapse cameras

In the afternoon of 11 November, a total of seven time-lapse cameras were installed on Proclamation Island. These cameras are programmed to record a still image every hour during daylight hours for the next 12 months. The aim is to obtain information about breeding success of albatross and penguins as well as data on nest attendance patterns. It is currently planned to maintain all cameras in January 2024.

The cameras were deployed on overhanging or inaccessible rocks to prevent interactions with wildlife, especially landing albatross and traversing seals. We used mounts fashioned from stainless steel eye bolts that were attached to the rock by drilling 12 mm holes into the rock and fastening the bolts with anchoring adhesive. The anchor eye bolts were fixed to a second, smaller eye bolt that allowed it to adjust the tilt angle of the camera. This joint was wrapped with self-amalgamating tape to reduce corrosion (Figure 6).



**Figure 6.** *Time-lapse camera (Albatross 1) mounted to a overhang using eyebolts anchored in the rock.*

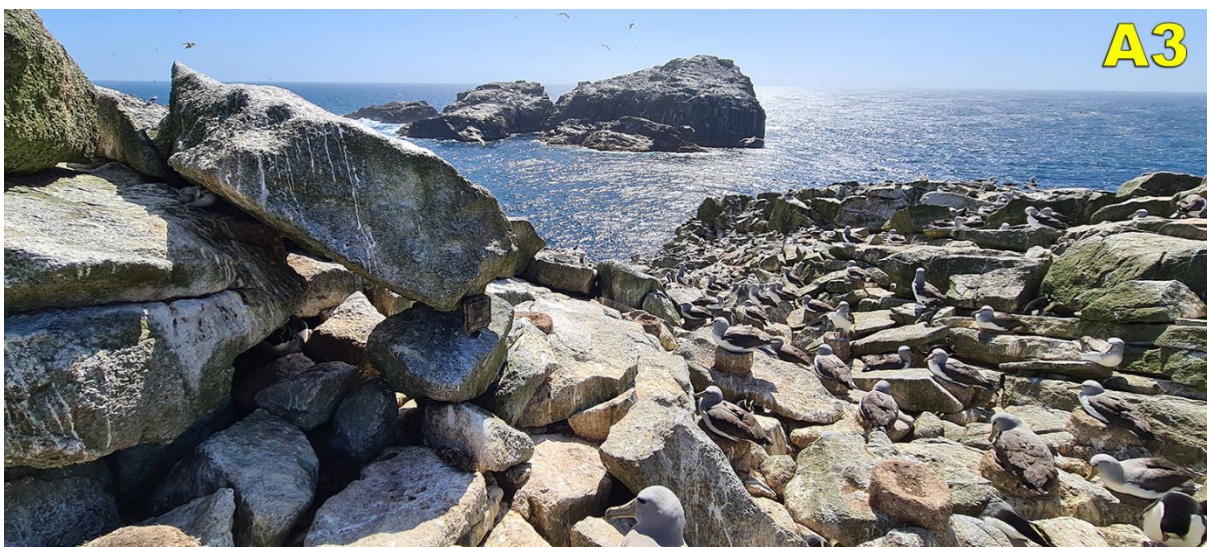
The map in Figure 7 indicates locations of the time-lapse cameras on Proclamation Island; GPS positions are listed in Table 2. Figures 8a-g show photographs of the mounted cameras to provide spatial context. Figure 9 gives an example of the image data to be recorded over the next months.





**Figure 7.** Map indicating locations of the seven time-lapse cameras installed on Proclamation Island on 11 November 2022.





**Figure 8a-c.** *Settings of timelapse cameras A1-A3*





**Figure 8d-e.** *Settings of timelapse cameras A4&5 and P1&2*





**Figure 8f-g.** *Settings of timelapse cameras P1&2*



**Table 2.** *Coordinates of timelapse cameras installed on Proclamation Island, Bounty Islands, 10 November 2022*

Cam ID	Target species	Latitude	Longitude
A1	Salvin's albatross	-47.749866	179.026995
A2	Salvin's albatross	-47.749252	179.027107
A3	Salvin's albatross	-47.749423	179.027241
A4	Salvin's albatross	-47.749381	179.02756
A5	Salvin's albatross	-47.749344	179.027744
P1	Erect-crested penguin	-47.749551	179.027424
P2	Erect-crested penguin	-47.750044	179.026091



**Figure 9.** *Example of timelapse imagery to be recorded over the next 12 months; image taken by camera A3.*

## Observations of ringed albatross, GLS recovery and sampling

While on Proclamation Island, the team kept an eye out for Salvin's albatross with leg rings. Whenever possible ring numbers were read and recorded. In four cases birds with Darvic leg band were also carrying a GLS data logger which were recovered. As this process required handling, feather samples were also taken. All loggers and samples were handed over to Ros Cole (DOC Murihiku) who crewed on the Evohe during the outward-bound part of the journey. Table 3 below gives the ring numbers recorded.

**Table 3.** *Ring and band numbers of Salvin's albatross recorded between 11 and 14 November 2022 on Proclamation Island*

Date	Ring Number	Darvic	Notes
11 Nov 2022	37115	-	
11 Nov 2022	37131	-	
11 Nov 2022	37189	WHITE_501	
11 Nov 2022	38013	-	
11 Nov 2022	38022	RED_024	
11 Nov 2022	38047	RED_033	
11 Nov 2022	38055	RED_040	
11 Nov 2022	3804x	-	GLS recovered
14 Nov 2022	37198	-	
11 Nov 2022		RED_022	
14 Nov 2022		RED_028	
14 Nov 2022		RED_036	
11 Nov 2022		RED_039	
11 Nov 2022		RED_044	GLS recovered
11 Nov 2022		RED_053	
11 Nov 2022		RED_058	
14 Nov 2022		RED_061	
11 Nov 2022		RED_069	
11 Nov 2022		RED_072	
11 Nov 2022		RED_069	
14 Nov 2022		RED_083	
11 Nov 2022		WHITE_507	



## Observations of *Lepidium* (Cook's Scurvy grass)

During the analysis of the drone data – orthomosaics generated from images recorded during the survey missions – the occurrence of Cook's scurvy grass (*Lepidium oleraceum*) was noted. It was previously known to occur on Funnel Island in the Centre Group as well as Molly Cap in the East Group. The presence of the plant was described first in 2004 after a visit to Funnel Island<sup>1</sup>.

From the 2022 drone data, it appears as if Molly Cap contains a substantially greater biomass of the plant than Funnel Island.

On Funnel, the plant seems to be confined to two crevices in the rock along the southwestern flanks of the island just above the rock archway bridging the island's northern gap (Figure 10). No other plants were found on the island even after close inspection of the orthomosaic.

On Molly Cap, the plant was found at two distinct locations – on rock terraces in the southeast, and on a rocky slope in the west of the island (Figure 11). At both sites, *Lepidium* seems to occur in distinct bushy clusters, some sheltered in rock crevices, others expanding on rock ledges.

What may be of particular interest is the that on both islands Cape pigeons seem to associate with *Lepidium* growth. In the case of the southwestern patch on Molly Cap, individual birds seem to be roosting in amongst the plants (see larger detail in Figure 11).

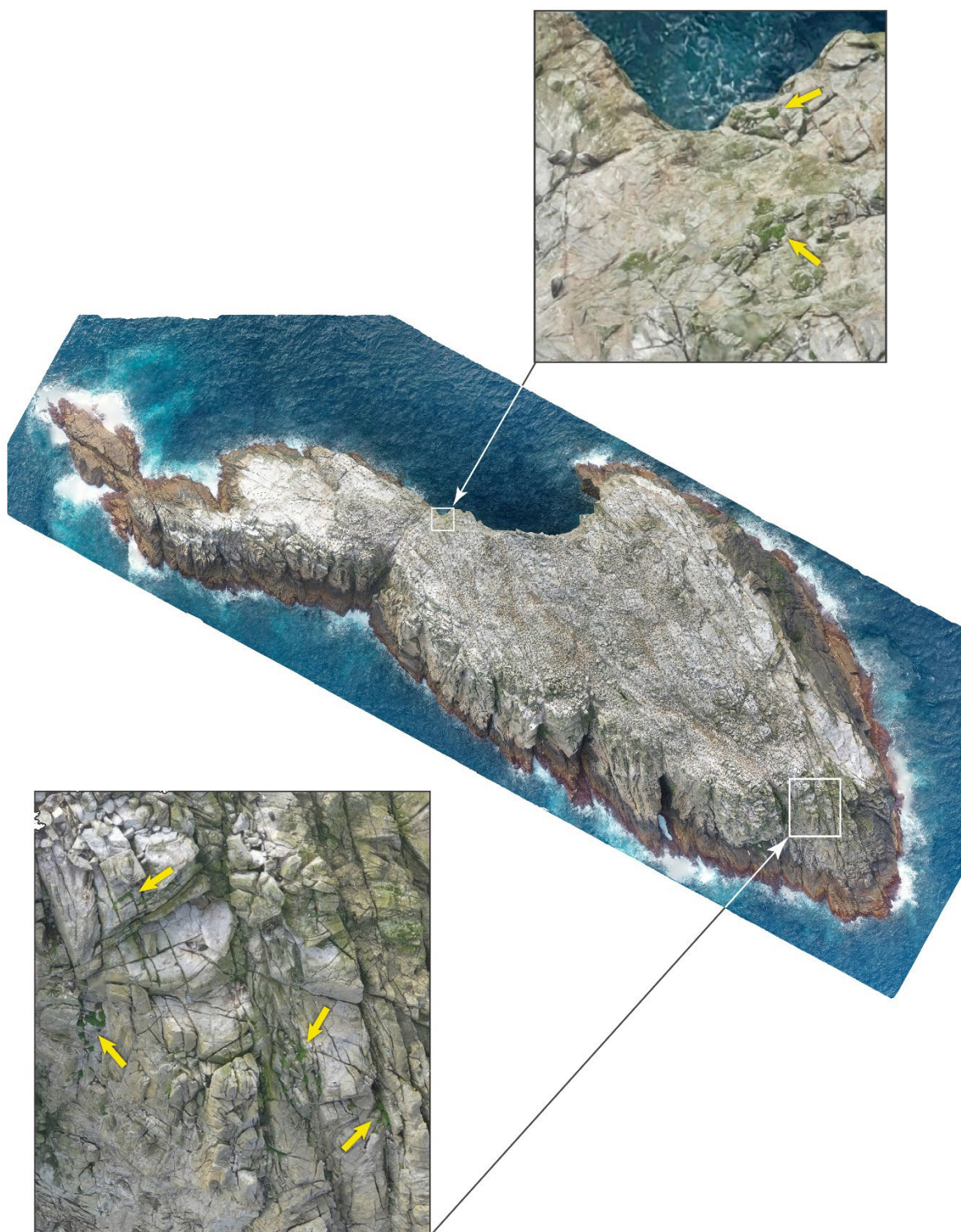
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<sup>1</sup> Amey, J., Lord, J. M., & de Lange, P. (2007). First record of a vascular plant from the Bounty Islands: *Lepidium oleraceum* (nau, Cook's scurvy grass) (Brassicaceae). *New Zealand Journal of Botany*, 45(1), 87–90. <https://doi.org/10.1080/00288250709509705>



**Figure 10.** *Distribution of Lepidium on Funnel Island as determined from drone imagery.*





**Figure 11.** Distribution of *Lepidium* on Molly Cap as determined from drone imagery.



## Preliminary results

### *Ground counts of Erect-crested penguins*

Ground counts of penguins on **Proclamation Island** amounted to **2,776 active nests in the second week of November 2022**. This is the highest number of nests on record for the species on this island; the previously highest counts in 1997 (2,743 nests) are 33 nests short of the 2022 figure.

Overall, these numbers suggest that the penguin population – at least on Proclamation Island – **has remained stable for the past 25 years**.

### *Drone counts of seabirds and fur seals*

All drone imagery was converted to high-resolution orthomosaics during the expedition's stay on the Antipodes Islands. The entire team engaged in analysing the resulting orthomosaics and completed surface counts of animals (Figure 12).



**Figure 12.** *Analysis of drone data in the Antipodes hut, 22 November 2022*

The count data have yet to be groomed to assess and eliminate observer errors so that **results provided below must be considered preliminary**. The exception are the figures provided for Bounty Island shags, which have been finalized and will be submitted for scientific publication shortly.

A total of 17 different islands and rock stacks were surveyed during drone counts. Of these, only Castle Island in the Centre Group was completely devoid of any animals.

**Erect-crested penguins** were present on 12 of the islands (Table 4) with the **total number of birds** determined from analysis of orthomosaics amounting to 30,676 individuals. On Proclamation Islands, preliminary drone data analysis found 3,288 penguins present on the island at the time of the drone mission. Considering the number of nests determined from ground counts, this suggests that ca. 84% of the birds present in the orthomosaics are associated with a nest. Applying this ratio to the total number of penguins counted across the archipelago results in an estimate of **25,899 Erect-crested penguin nests still actively breeding in November 2022.**

**Salvin's albatrosses** were present on 8 islands, with **total number of birds ranging around 67,661 individuals.** On Proclamation Island, the preliminary number of albatrosses on the ground is 6,845 individuals. Compared to counts of drone images recorded in October 2019 (5,119 individuals) there were almost 1,700 birds more present in November 2022. However, as this expedition coincided with the onset of hatching which triggers greater numbers of pairs being present at their nests, this difference in numbers should not be mistaken for an increase of the albatross population on Proclamation Island. No ground-truthing counts of albatross nests could be completed, so that we cannot make any estimations with regards to the breeding population on the Bounty Islands.

**Fulmar Prions** were present on 11 islands. Numbers of prions should be considered a minimum at best, as only birds perched in the open on rocks could be counted. Moreover, due to their small size, prions might have been missed during the counts. Overall, **an average of 6,816 of Fulmar prions** have been counted with Depot and Ruatara Islands containing the largest numbers of prions.

**Bounty Island shags** were present on 13 islands and, therefore, the most widely distributed seabird species across the islands of the Bounty archipelago. Detailed

drone analysis showed that **910 shags were present on the ground** at the time of the drone surveys; of these, **573 birds were sitting on a nest**. This number represents the second estimate of the species' breeding population size since it was first assessed in 1978 (569 pairs); given that the difference of these two estimates is merely 4 nests, it appears that the **Bounty Island shag population has remained stable over the past 44 years**. North Rock and Lion Island contained almost half of the shag breeding population (250 nests) and must be considered the species' strongholds. On Coronet Island, shags were the only animal group present.

**New Zealand fur seals** were present on 15 islands and rocks with a total count of **7,329 individuals hauled out at the time of the drone surveys**. Depot, Penguin and Proclamation Island are the only three islands where seal numbers exceeded 1,000 individuals. Except for six individuals on North Rock and one animal on Molly Cap, fur seals were virtually absent from the East Group. No conclusions about the breeding population can be made from our counts as pupping only commences in late December/early January.

Other bird species counted were **Cape pigeons** (present on 9 islands, 365 individuals), **Giant petrels** (present on 3 islands, 12 individuals), **Antarctic terns** (present on 4 islands, 39 individuals) and **black-backed gulls** (present on 4 islands, 8 individuals).

**We now have a complete, reproducible and reliable record for the Bounty Island archipelago which can serve as baseline for future surveys. The data set can also be revisited in the future, for example using new technologies (e.g., artificial intelligence algorithms).**

The next full drone survey is planned for 2027.



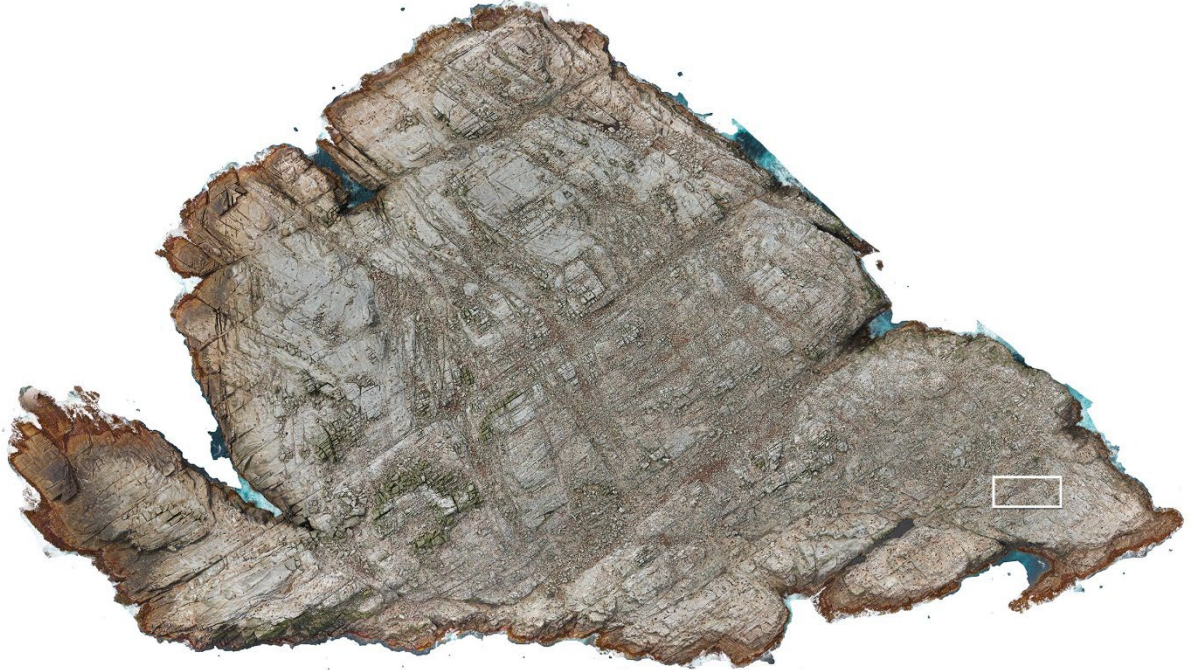
**Table 4.** Species distribution across Bounty Islands in November 2022 as determined from drone surveys.

	ECP	ALB	SHAG	PRI	CP	GP	AT	BBG	SEAL
Spider	X	X	X	X	X	X	-	-	X
Skua Rock	-	-	-	-	-	X	-	-	X
Seal Rock	-	-	-	-	-	-	-	-	X
Proclamation	X	X	X	X	X	-	-	X	X
Depot	X	X	X	X	X	-	-	-	X
Tunnel	X	X	X	X	X	-	-	-	X
Penguin	X	X	X	X	X	-	X	X	X
Dog rock	-	-	-	-	-	-	-	-	X
Ruatara	X	X	X	X	X	-	X	-	X
Ranfurly	X	-	X	X	-	-	-	-	X
Lion	X	-	X	X	-	X	X	-	X
Funnel	X	X	X	X	X	-	X	X	X
Prion Island	X	-	X	-	X	-	-	X	X
Coronet	-	-	X	-	-	-	-	-	-
Castle	-	-	-	-	-	-	-	-	-
Molly Cap	X	X	X	X	X	-	-	-	X
North Rock	X	-	X	-	-	-	-	-	X

Species key: ECP – Erect-crested penguin; ALB – Salvin’s albatross; SHAG – Bounty Island shag; PRI – Fulmar prion; CP – Cape pigeon; GP – Giant petrel; AT – Antarctic tern; BBG – Black-backed gull; SEAL – New Zealand fur seal

## Historic assets

Although our expedition did not land on Depot Island, the drone survey provided visual confirmation that remains of the old castaway depot are still present at the south-eastern end of the island (Figure 13).



**Figure 13.** Remains of the castaway depot on Depot Island as seen on the drone footage, 14 November 2022



## Part II – Antipodes Islands: 16 Nov – 18 Dec 2022

### Antipodes timeline

The Evohe reached the Antipodes after midnight on 16 November 2022 and anchored in Anchorage Bay. In the morning, the vessel steamed to Bollons Island to fly drone missions off the boat that cover Archway and Bollons Island. First team landed in Hut Cove around 10.30am; the rest of the day was used to transfer all gear from Evohe to hut.

17 November was mainly devoted to maintenance work with field work commencing properly on 18 November. During the following four weeks, up to three teams operated at various locations at the same time.

A core tracking team was mainly based around the hut and took care of GPS and camera logger deployments and recoveries as well as repeat ground-counts of the surrounding penguin colonies.

A southern team established a camp on the south coast which served as base for GPS tracking study as well as drone surveys along the southern coastlines.

Although it was planned to operate with two drone teams, the need to monitor penguins at both ends of the island for device recovery, meant that most of the drone work was conducted by a single team. Only on two days, enough observers were free to help with the drone work allowing two team to operate at different locations simultaneously.

The Evohe returned to pick up the expedition on 17 December. However, strong swells prevented landing until midday of 18 December. Transfer of the gear of arriving (Parker Conservation) and departing parties took most of the day. Evohe departed Anchorage Bay 4.30 pm and sailed round the north-western coast to conduct final drone missions including East Windward Island from the boat.

Evohe left Antipodes Islands around 7.30pm, 18 December 2022. Arrival in Dunedin 7am, 21 December 2022.

## Deployment of data loggers on penguins

Our arrival on the Antipodes Islands coincided with the onset of egg hatching in Erect-crested penguins; the few Rockhopper penguin nests we found in Anchorage Bay East still had females incubating eggs indicating that egg hatching was still 2-3 weeks away. As we did not want to disturb nests with chicks of less than a week of age, we delayed deployments of data loggers at the Anchorage Bay East colony (HTC-002 following Jo Hiscock's naming convention<sup>2</sup>) until 21 November 2022, when the first three female Erect-crested penguins were fitted with devices. Overall, a total of 15 female Erect-crested penguins were fitted with GPS dive loggers between 21 November and 8 December 2022, all of which were recovered between 5 and 8 days after deployment. An additional 5 females were fitted with camera loggers that were replaced after the birds' first foraging trip with GPS dive loggers that then stayed on for another 4-5 days.

After the southern camp had been established on 20 November, the first eight GPS dive logger deployments were conducted on 26 November. All birds fitted with devices were from the western end of colony SCW-001. Recovery of these devices occurred on 3 and 4 December 2022. Two devices could not be recovered as both nests had failed with male penguins guarding a dead chick. Subsequent attempts to recover these devices (7-9 and 10-12 December) failed as well and we assume that both device carrying females were predated at sea. On 3 December, an additional six Erect-crested penguin females were fitted with GPS dive loggers. These devices were all recovered between 10 and 12 December. No camera loggers were deployed in the south.

On 7 and 8 December a total of five female Rockhopper penguins were fitted with GPS dive loggers in Anchorage Bay East. One bird was from a nest in the small rock

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<sup>2</sup> Hiscock, J. (2013). *Monitoring penguins in the Antipodes Island Group Methods and baseline data*. Department of Conservation.  
<https://www.doc.govt.nz/globalassets/documents/science-and-technical/docts37entire.pdf>



alcove below the ladder down to the bay. The remaining four birds were nesting in the caves below the Erect-crested penguin rock platform at the eastern end of Anchorage Bay. All devices could be recovered 4-6 days after deployment.

Devices were fitted using adhesive tape and a cable tie. The principal function of the cable tie was it to prevent birds from preening off the tape and thereby removing devices while at sea. No other adhesive components (i.e., rubber glue, epoxy) were used due to the relatively short deployment period. Devices were removed by either peeling tape stripes off the device or cutting the tape at the base of the devices with a pocketknife. Tape rests were then peeled from the feathers without major damage to the birds' plumage (see Figures 14a-c).



**Figure 14a.** GPS dive logger deployed on a female Erect-crested penguin (left) and state of plumage after recovery six days later (right).





**Figure 12b.** Camera logger deployed on a female Erect-crested penguin (left) and state of plumage after recovery 24 hours later (right).



**Figure 14c.** GPS dive logger deployed on a female Eastern rockhopper penguin (left) and state of plumage after recovery four days later (right).



## Blood sampling Erect-crested & Eastern Rockhopper penguins

Between 21 November and 13 December 2022, a total of 30 Erect-crested penguins and 30 Eastern Rockhopper penguins were blood sampled for stable isotope analysis and disease screening for the Department of Conservation.

Besides conducting stable isotope analysis, the samples will be used in conjunction with morphometric measurements taken to develop a reliable sexing method for both penguin species. Although a recent paper<sup>3</sup> provides a method to sex Erect-crested penguins using bill measurements, the method proved inaccurate and requires confirmation.

## Microchipping Erect-crested & Eastern Rockhopper penguins

All penguins handled for device deployments as well as some individuals that were blood sampled were marked using Passive Integrated Transponders (aka “microchips”). We used 11mm Trovan (ID162C ISO FDX-B) implanted in the back of the neck following the standard operation procedures described for hoiho/Yellow-eyed penguins. Marking records have been collated and submitted to the National Banding office (Table 5).

At Anchorage Bay a total of 22 Erect-crested penguins were microchipped (16 females, 6 males); the same number of birds were tagged on the south coast (15 females, 7 males) bringing the total number of marked Erect-crested penguins to 44 birds.

10 Eastern Rockhopper were microchipped at Anchorage Bay (6 females, 4 males); no rockhopper penguins were tagged on the south coast.

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<sup>3</sup> Davis, L. S., Renner, M., Houston, D., Zhu, L., Finkler, W., & Mattern, T. (2022). The breeding biology of erect-crested penguins, *Eudyptes sclateri*: Hormones, behavior, obligate brood reduction and conservation. *PLOS ONE*, 17(10), e0275106. <https://doi.org/10.1371/journal.pone.0275106>

**Table 5.** Overview of Erect-crested and Rockhopper penguins marked with transponders in 2022 on Antipodes Island.

Species	Date & Time	Site	Bird ID	Sex	Weight
Erect-crested penguin	21/11/2022 12:48	Anchorage Bay	956 0000113 03660	Male	-
Erect-crested penguin	21/11/2022 17:11	Anchorage Bay	956 0000112 70101	Female	4200
Erect-crested penguin	21/11/2022 17:27	Anchorage Bay	956 0000113 08204	Female	4300
Erect-crested penguin	21/11/2022 17:44	Anchorage Bay	956 0000112 96366	Female	3600
Erect-crested penguin	24/11/2022 17:30	Anchorage Bay	956 0000113 01730	Female	3600
Erect-crested penguin	24/11/2022 17:47	Anchorage Bay	956 0000112 88227	Female	3700
Erect-crested penguin	24/11/2022 18:00	Anchorage Bay	956 0000112 93635	Female	3700
Erect-crested penguin	24/11/2022 18:15	Anchorage Bay	956 0000113 11929	Female	4000
Erect-crested penguin	24/11/2022 18:26	Anchorage Bay	956 0000122 46230	Female	4100
Erect-crested penguin	28/11/2022 20:29	Anchorage Bay	956 0000113 09852	Female	3600
Erect-crested penguin	28/11/2022 20:47	Anchorage Bay	956 0000122 40324	Female	3600
Erect-crested penguin	29/11/2022 18:41	Anchorage Bay	956 0000113 06121	Female	3700
Erect-crested penguin	2/12/2022 17:45	Anchorage Bay	956 0000113 07047	Male	3400
Erect-crested penguin	2/12/2022 18:03	Anchorage Bay	956 0000113 04174	Male	4200
Erect-crested penguin	2/12/2022 18:20	Anchorage Bay	956 0000112 70784	Male	4550
Erect-crested penguin	2/12/2022 18:33	Anchorage Bay	956 0000112 93576	Male	3350
Erect-crested penguin	2/12/2022 18:51	Anchorage Bay	956 0000113 00033	Male	4600
Erect-crested penguin	7/12/2022 20:14	Anchorage Bay	956 0000113 02481	Female	3500
Erect-crested penguin	7/12/2022 20:26	Anchorage Bay	956 0000113 04821	Female	3900
Erect-crested penguin	7/12/2022 20:40	Anchorage Bay	956 0000113 03885	Female	4000
Erect-crested penguin	7/12/2022 20:54	Anchorage Bay	956 0000112 99385	Female	4400
Erect-crested penguin	16/12/2022 11:36	Anchorage Bay	956 0000113 01612	Female	4000
Erect-crested penguin	26/11/2022 17:32	South Bay West	956 0000113 07663	Female	3750
Erect-crested penguin	26/11/2022 17:50	South Bay West	956 0000113 05482	Female	3650
Erect-crested penguin	26/11/2022 18:08	South Bay West	956 0000113 06607	Female	3600
Erect-crested penguin	26/11/2022 18:24	South Bay West	956 0000113 05290	Female	3900
Erect-crested penguin	26/11/2022 18:43	South Bay West	956 0000113 12543	Female	3700
Erect-crested penguin	26/11/2022 19:03	South Bay West	956 0000122 55234	Female	3600
Erect-crested penguin	26/11/2022 19:17	South Bay West	956 0000122 40127	Female	3500
Erect-crested penguin	26/11/2022 19:33	South Bay West	956 0000122 55003	Female	3200
Erect-crested penguin	3/12/2022 17:15	South Bay West	956 0000113 08839	Male	4100
Erect-crested penguin	3/12/2022 17:25	South Bay West	956 0000113 08802	Male	3500
Erect-crested penguin	3/12/2022 17:40	South Bay West	956 0000112 84101	Male	4400
Erect-crested penguin	3/12/2022 17:55	South Bay West	956 0000113 01096	Male	4700
Erect-crested penguin	3/12/2022 18:18	South Bay West	956 0000112 97879	Male	4400
Erect-crested penguin	3/12/2022 18:31	South Bay West	956 0000113 06416	Male	4200
Erect-crested penguin	3/12/2022 18:43	South Bay West	956 0000113 08711	Male	4200
Erect-crested penguin	3/12/2022 18:56	South Bay West	956 0000122 15677	Female	3800
Erect-crested penguin	3/12/2022 19:42	South Bay West	956 0000113 08782	Female	3700
Erect-crested penguin	3/12/2022 19:56	South Bay West	956 0000113 10105	Female	3400
Erect-crested penguin	3/12/2022 20:10	South Bay West	956 0000112 99975	Female	3600
Erect-crested penguin	3/12/2022 20:23	South Bay West	956 0000113 12486	Female	3850
Erect-crested penguin	3/12/2022 20:36	South Bay West	956 0000113 07417	Female	3000
Erect-crested penguin	3/12/2022 20:49	South Bay West	956 0000113 12627	Female	3550
Eastern Rockhopper penguin	7/12/2022 19:45	Anchorage Bay	956 0000113 07264	Female	2300
Eastern Rockhopper penguin	7/12/2022 19:59	Anchorage Bay	956 0000112 84893	Female	2200
Eastern Rockhopper penguin	8/12/2022 20:19	Anchorage Bay	956 0000113 02282	Female	2200
Eastern Rockhopper penguin	8/12/2022 20:42	Anchorage Bay	956 0000113 11527	Female	2500
Eastern Rockhopper penguin	8/12/2022 20:53	Anchorage Bay	956 0000112 96672	Female	2200
Eastern Rockhopper penguin	8/12/2022 21:06	Anchorage Bay	956 0000112 95361	Female	2500
Eastern Rockhopper penguin	13/12/2022 20:59	Anchorage Bay	956 0000112 99306	Male	2200
Eastern Rockhopper penguin	14/12/2022 11:32	Anchorage Bay	956 0000112 99105	Male	2500
Eastern Rockhopper penguin	14/12/2022 12:10	Anchorage Bay	956 0000113 00838	Male	2700
Eastern Rockhopper penguin	14/12/2022 12:33	Anchorage Bay	956 0000113 05165	Male	2800



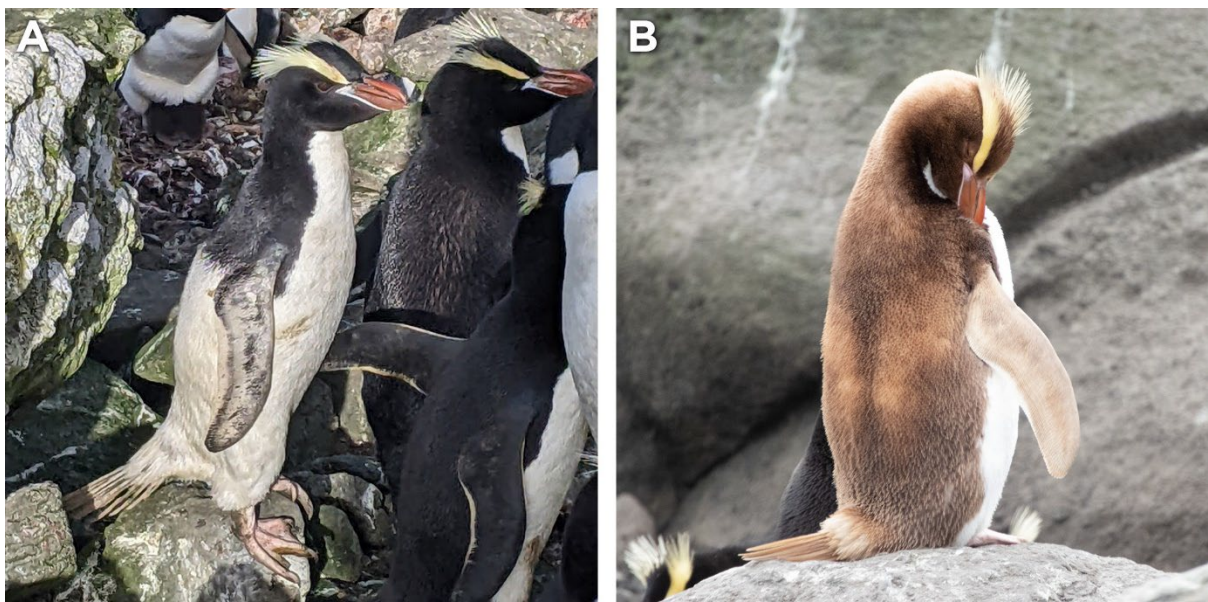
## First records of leucistic and isabelline Erect-crested penguins

During our work with Erect-crested penguin colonies on the south coast of the Antipodes Island, we came across cases of both leucistic and isabelline<sup>4</sup> penguins.

A leucistic male was observed on 5 December 2022 in colony SCW-001 (Figure 15a). The bird did not appear to be breeding but seemed to be in the company of a normal coloured female. The bird was observed on several days and in various parts of the colony.

An isabelline female Erect-crested penguin was encountered in colony SCW-004 on 8 December 2022 (Figure 15b). The bird was sitting preening without any obvious mate nearby. As this was the only time we visited that part of the island, we did not see the bird again.

A short note reporting the observations in *Notornis* is in preparation.



**Figure 15.** *Leucistic and isabelline Erect-crested penguins observed on the south coast of Antipodes Island, December 2022.*

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<sup>4</sup> It should be noted, that while this may be technically the first time isabellinism is *reported* in Erect-crested penguins (c.f. Everitt & Miskelly 2003, *Notornis* 50:43-51), there appears to be a photo of another isabelline Erect-crested penguin and the back of Rowley Taylor's "Straight through from London" (Heritage Expeditions, 2006).

## Drone surveys of penguin colonies

Between 16 November and 18 December 2022, a total of 80 drone missions were flown to survey most of the known penguin breeding colonies on the Antipodes Islands. Unlike on the Bounties where most of the drone missions could be flown autonomously by survey software resulting in ideal overlap of image sequences, most missions on the Antipodes were flown manually. This was because drones generally had to be launched from cliff tops with the area of interest being located some 150-200m below the launch point (Figure 16). Moreover, the intricate topography of the Antipodes meant that often there were obstacles the software facilitating autonomous missions would not account for.

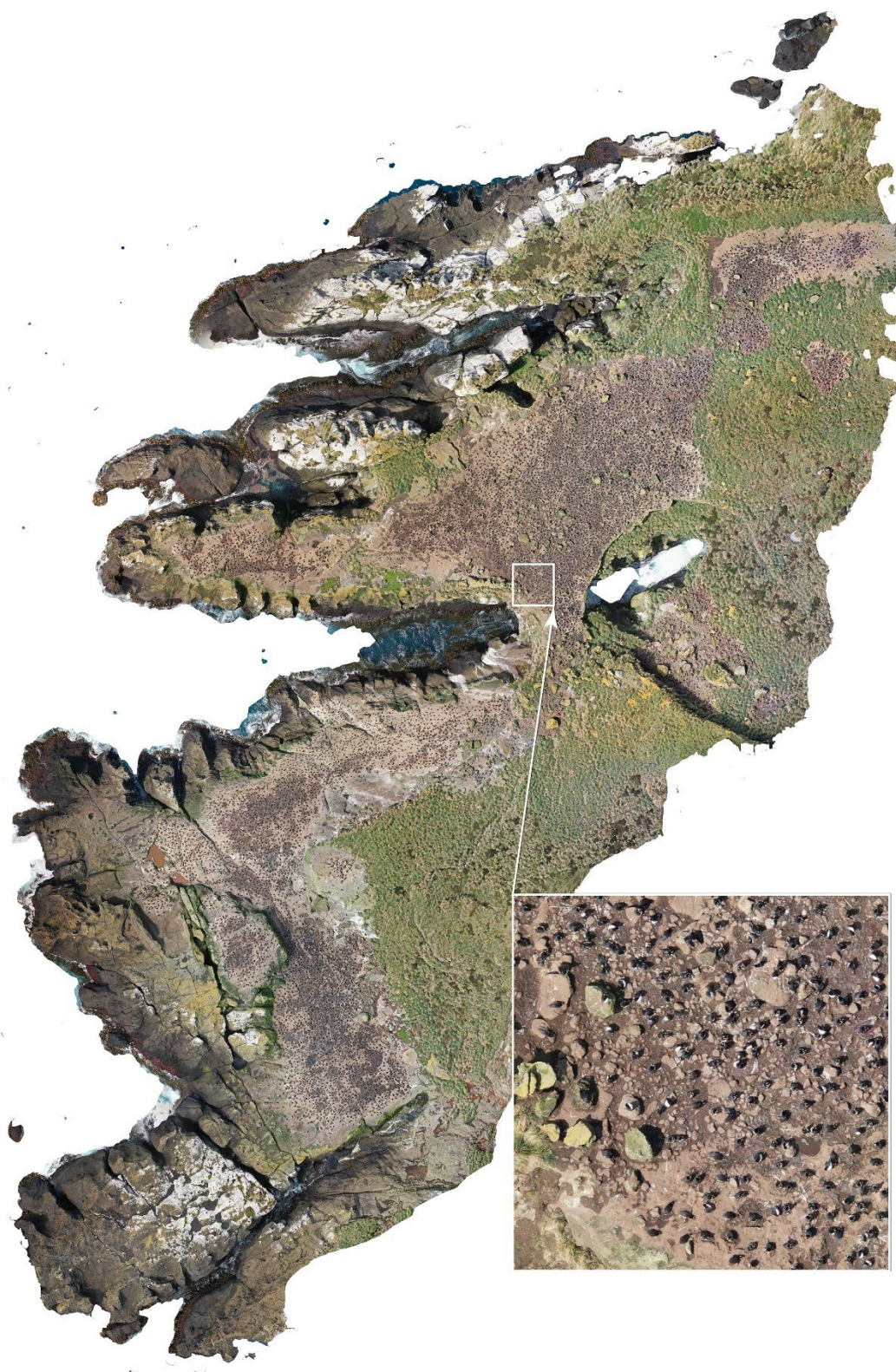


**Figure 16.** Drone team flying manual mission above Crater and Alert Bays.

Nevertheless, a substantial set of orthomosaics could be generated from the 9,431 drone images captured during the missions; processing of the drone data is still ongoing. Accordingly, analysis (i.e., penguin counts) is pending. First orthomosaics generated from the manually flown missions show that the quality of the resulting orthomosaics is comparable to that of autonomous-flight missions (Figure 17).

Some penguin colonies could not be surveyed from above as they are located in caves in the side of cliff faces (Figure 18). Here, we will attempt to obtain accurate counts from still photos, panorama composites and video sequences.





**Figure 17.** High-resolution orthomosaic of the Orde Lees colony generated from manually flown drone mission.





**Figure 18.** *Hannah's Cave along the Northwest Coast of Antipodes Island illustrating penguin colonies that cannot be surveyed in top-down view.*



## Drone survey trials of Light-mantled sooty albatross

Light-mantled sooty albatrosses breed in small, loose colonies in cliff sides all over the Antipodes Islands. While surveying penguin colonies, we also conducted some trials to see if and how drones can be used in the future to survey and map the distribution of sooty albatrosses.

Whereas penguin colonies are spatial discrete occurrences in a predictable coastal environment that can easily be surveyed, the albatrosses appear to breed in small aggregations, sometimes even in a solitary setting. The largest colony we found comprised some 17 nests distributed over a vertical cliff face on the northwest coast (Figure 19a & b). Moreover, the breeding habitat is extremely variable with some nests established on grassy fields close to the sea (Figure 20a & b), others in inaccessible vertical cliff faces above the sea (Figure 19a & b), steep tussock slopes (Figure 20c), or on ledges of rocky outcrops further from the coast (Figure 20d).

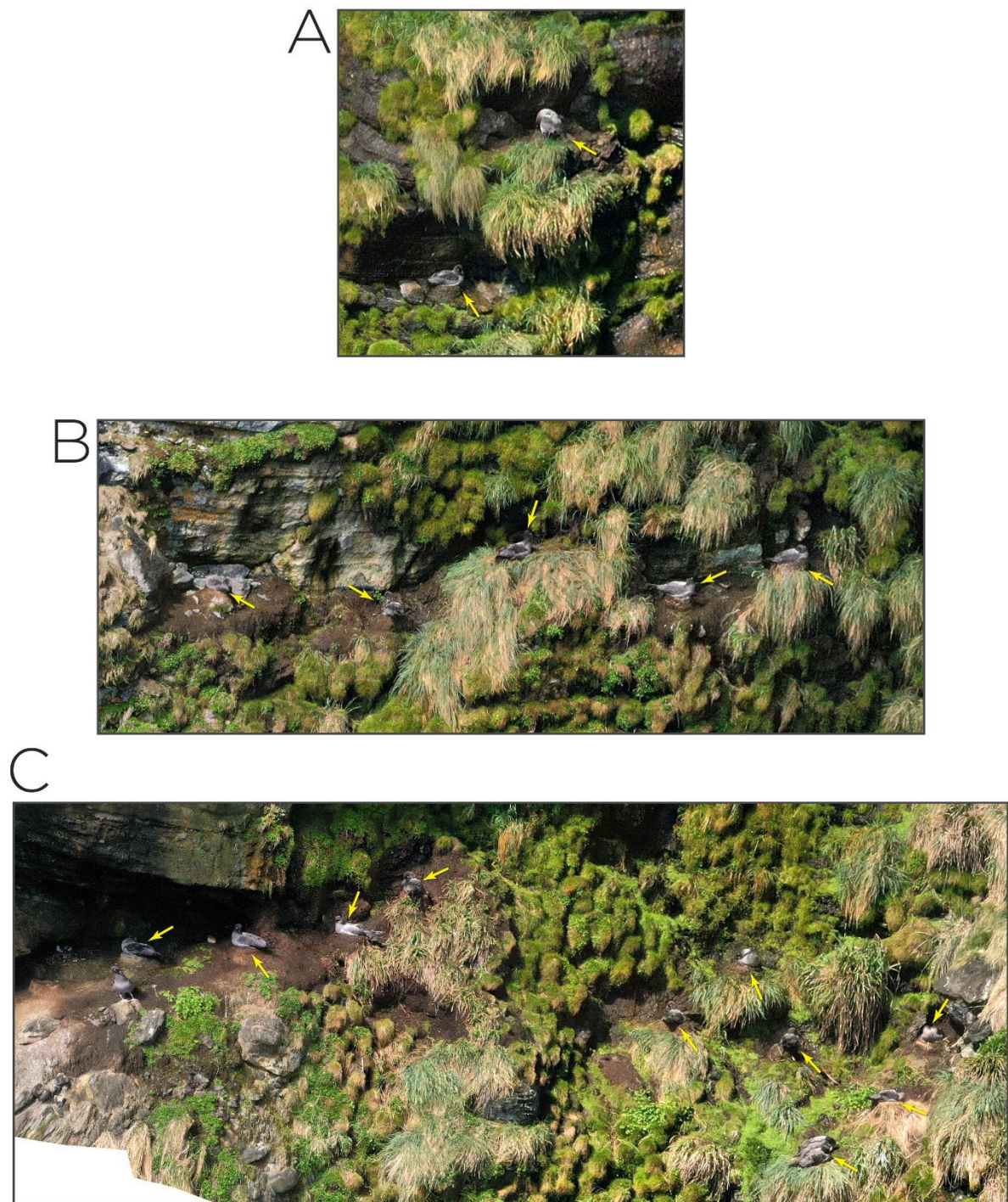
A blind approach to albatross drone-surveys, i.e., surveys without prior knowledge of albatross presence, is likely not viable. Instead, a combination of telescope reconnaissance followed by drone surveys will likely yield the best results. That said, inaccessible cliffs are best surveyed in detail with drones (e.g., North Cape, Perpendicular Head, Cave Point).

Besides providing a permanent, photographic record, drone surveys of sooty albatross have the significant advantage that it is possible to generate high-resolution textured 3D models of the survey area which allows virtual exploration at a computer. We used this method with great success to get an accurate count of Bounty Island shags and are about to submit a first paper describing this approach for publication in a scientific journal. A demonstration of the advantages of inspecting 3D models when surveying cliff breeding species can be viewed here <https://skfb.ly/oDSnw>.



**Figure 19a.** Orthomosaic of light-mantled sooty albatross colony in a near vertical cliff wall, Antipodes Islands (-49.663857, 178.788610).





**Figure 19b.** Details of orthomosaic in 18a. Yellow arrows indicate albatross nests (n=17).





**Figure 20a.** Light-mantled sooty albatross nests in a grassy gully, south coast, Antipodes Islands (-49.705720, 178.742292).



**Figure 20b.** Top-down view of the same colony as Figure 14a. 12-megapixel detail from a 7.5-gigapixel drone-orthomosaic of the southwest coast.





**Figure 20b.** Solitary light-mantled sooty albatross nest in a steep tussock slope at Orde Lees (-49.673898,178.762328).



**Figure 20c.** Albatross nests in a rocky outcrop further from the coast (-49.704745, 178.750823).



## Preliminary results

### *Penguin counts – Antipodes*

While detailed analysis of the drone imagery is still pending, preliminary results from the ground counts and visual comparison satellite and drone imagery seem to suggest a substantial population decline.

In **Anchorage Bay East**, the plots HTC-001, 002 and 004 comprised 1,176 Erect-crested penguin and 21 Rockhopper penguin nests in 2011. When we surveyed these plots in 2022, we counted 455 Erect-crested penguin nests, only 62% of what was counted 11 years ago. We found a total of 13 Rockhopper penguin nests, which corresponds to a 39% reduction in numbers since 2011. At **Reef Point** (HTC-003), 578 Erect-crested penguin nests were recorded in 2011; we only found 285 nests, a reduction of 51%. The 251 Erect-crested penguin nests present in **Stella Bay** (STB-001) in 2011 were reduced to a mere 61 nests during our counts, a 76% reduction. At **Orde Lees**, ground counts of Eastern Rockhopper penguins amounted to a total of 314 nests, down from 540 nests in 2011 (-42%).

It is important to note that penguin numbers could have been deflated as a result of the prolonged La Niña conditions which have been causing marine heatwaves in the southern Pacific for the past three years. Warmer ocean temperatures generally result in reduced productivity so that a significant portion of penguins may have skipped breeding in 2022. Further counts in the coming years will provide some clarity.

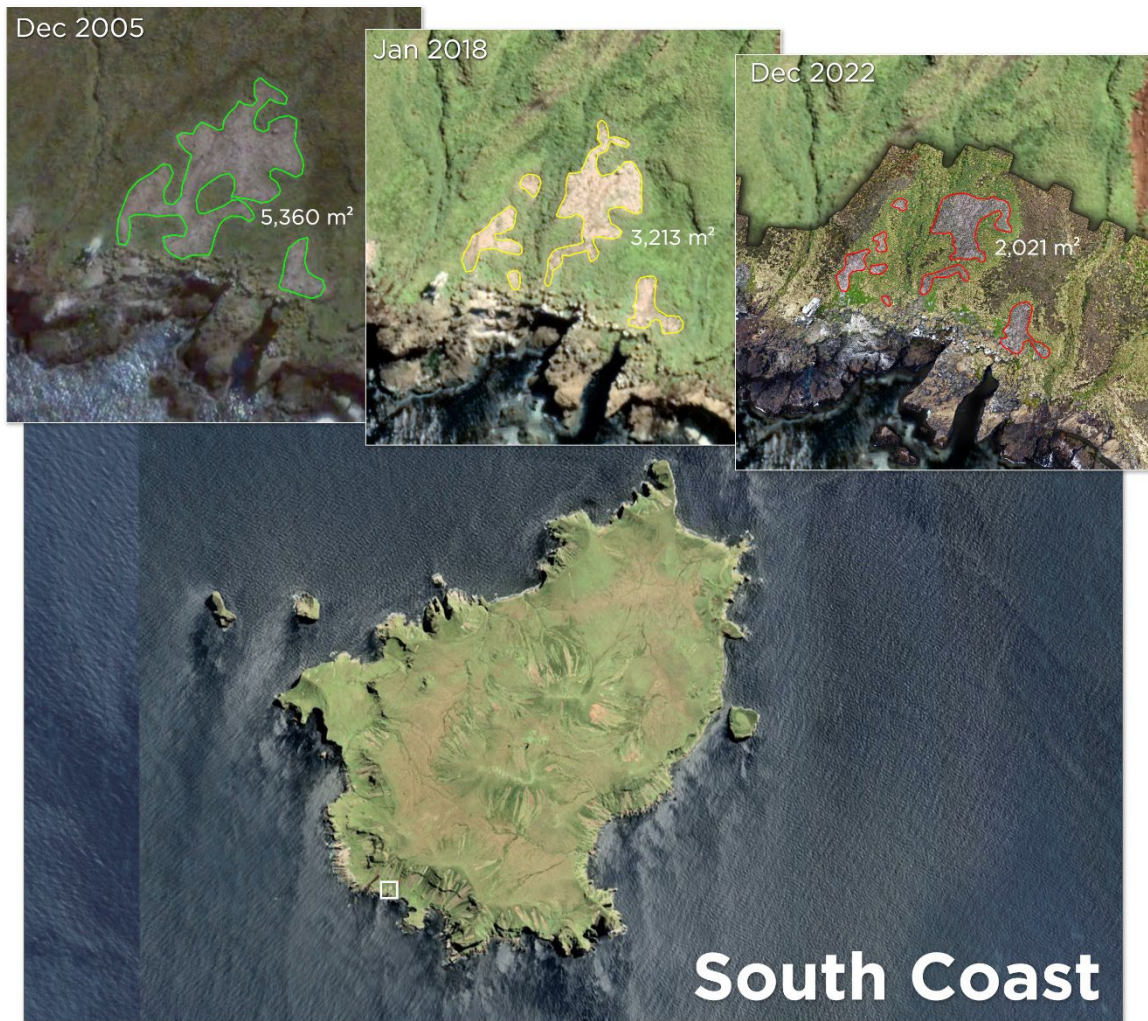
Even so, when comparing the extent of penguin colonies in orthomosaics generated from our drone data with Google Earth satellite imagery, a substantial shrinking of colonies seems apparent. For example, the area free of surface vegetation due to penguin occupancy at **Orde Lees** covered around 10,500 m<sup>2</sup> in December 2005; the same area only covered around 7,624 m<sup>2</sup> in December 2022 and is therefore 28% smaller than 18 years earlier (Figure 21a). On the **south coast**, colony HTC-001 covered 5,360m<sup>2</sup> but has since fragmented into several smaller colonies that cover a total of 2,021m<sup>2</sup>, i.e., a 63% decrease in size (Figure 21b).





**Figure 21a.** Comparison of the extent of the penguin colony at Orde Lees in the years 2005, 2018 and 2022 using Google Earth satellite images for the former two years and the georeferenced orthomosaic generated from drone images in 2022.





**Figure 21b.** Comparison of the extent of the penguin colony at the south coast between 2005 and 2022 using Google Earth satellite images and drone data. Note that the penguin colony formerly known as HTC-001 has fragmented into several smaller colonies over the past 17 years. Note that the brownish sections that encroach some of the penguin colonies in the 2022 image are not landslides but rather extensive fern patches. Green areas are dominated by tussock. The satellite imagery does not reproduce true colours of the vegetation very well so that tussock and fern both appear in a green hue.

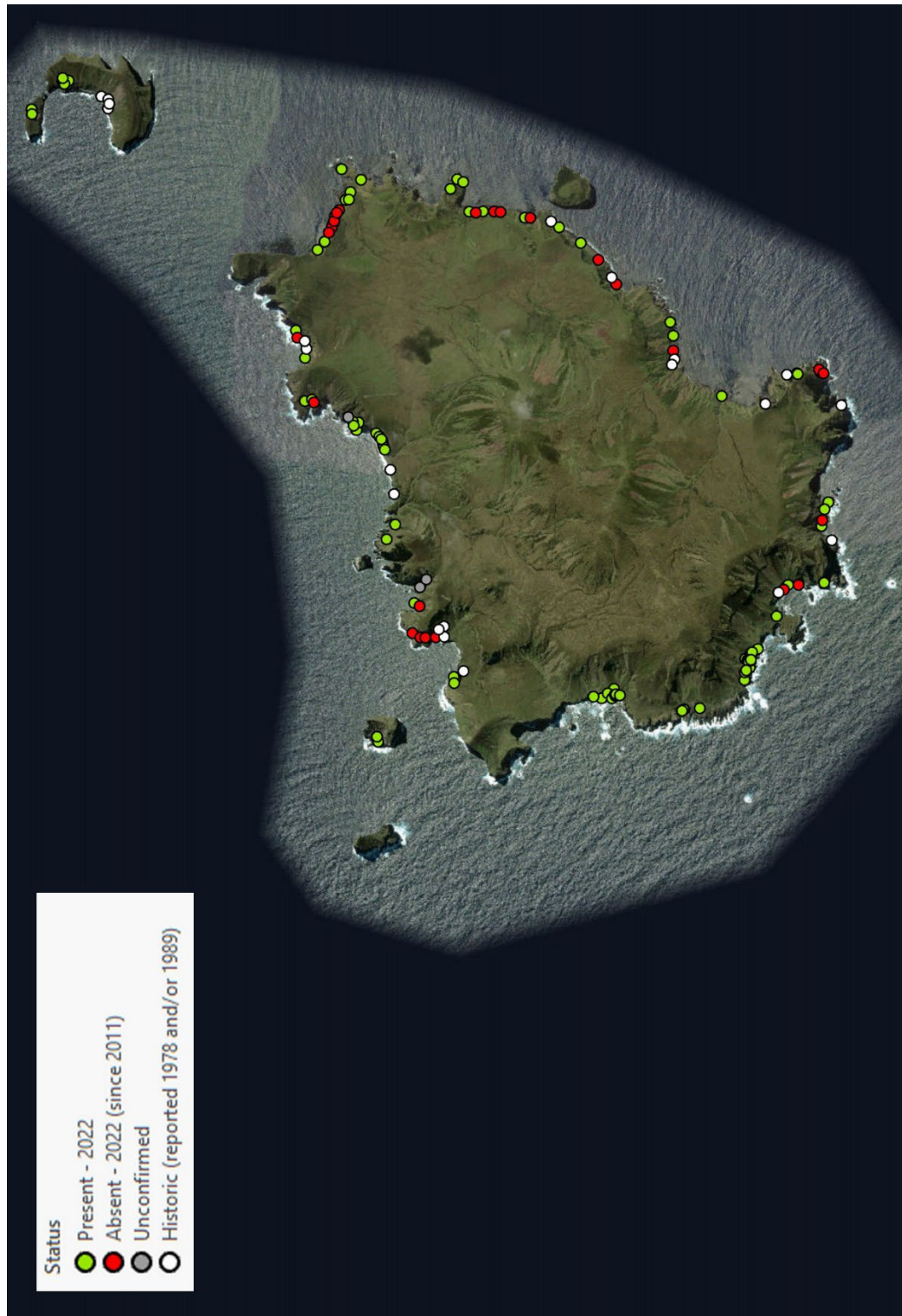


### *Penguin colonies – past and present*

Throughout the four weeks on the Antipodes, the drone teams managed to visit most known penguin colonies and record drone footage for detailed analysis. The count analysis of the Antipodes data is still pending, so no estimates of penguin numbers can be made from the drone data at this stage. However, in line with the ground counts discussed above, it appears that penguins on the Antipodes Islands are experiencing a continued decline, as several colonies seem to have disappeared since the last full survey on the island in 2011.

**A total of 81 Erect-crested penguin colonies were surveyed with drones in 2022.** Three colony locations could not be visited or identified and their current status, therefore, remains unconfirmed. 26 Erect-penguin colonies last surveyed in 2011 are no longer present. 21 penguin colonies have vanished between 1978 and 2011 (Figure 22).

Although data are only preliminary and need careful analysis, **it appears as if about one-third (36%) of Erect-crested penguin colonies have disappeared over the course of the last 44 years.** About one-fifth of the penguin colonies (19%) have been lost in the past decade which may suggest an accelerated decline of the species on the Antipodes Islands.



**Figure 22.** Past and present Erect-crested penguin colony distribution on the Antipodes Islands.  
Note that these data are preliminary and subject to change.



*Penguin GPS tracking – preliminary results*

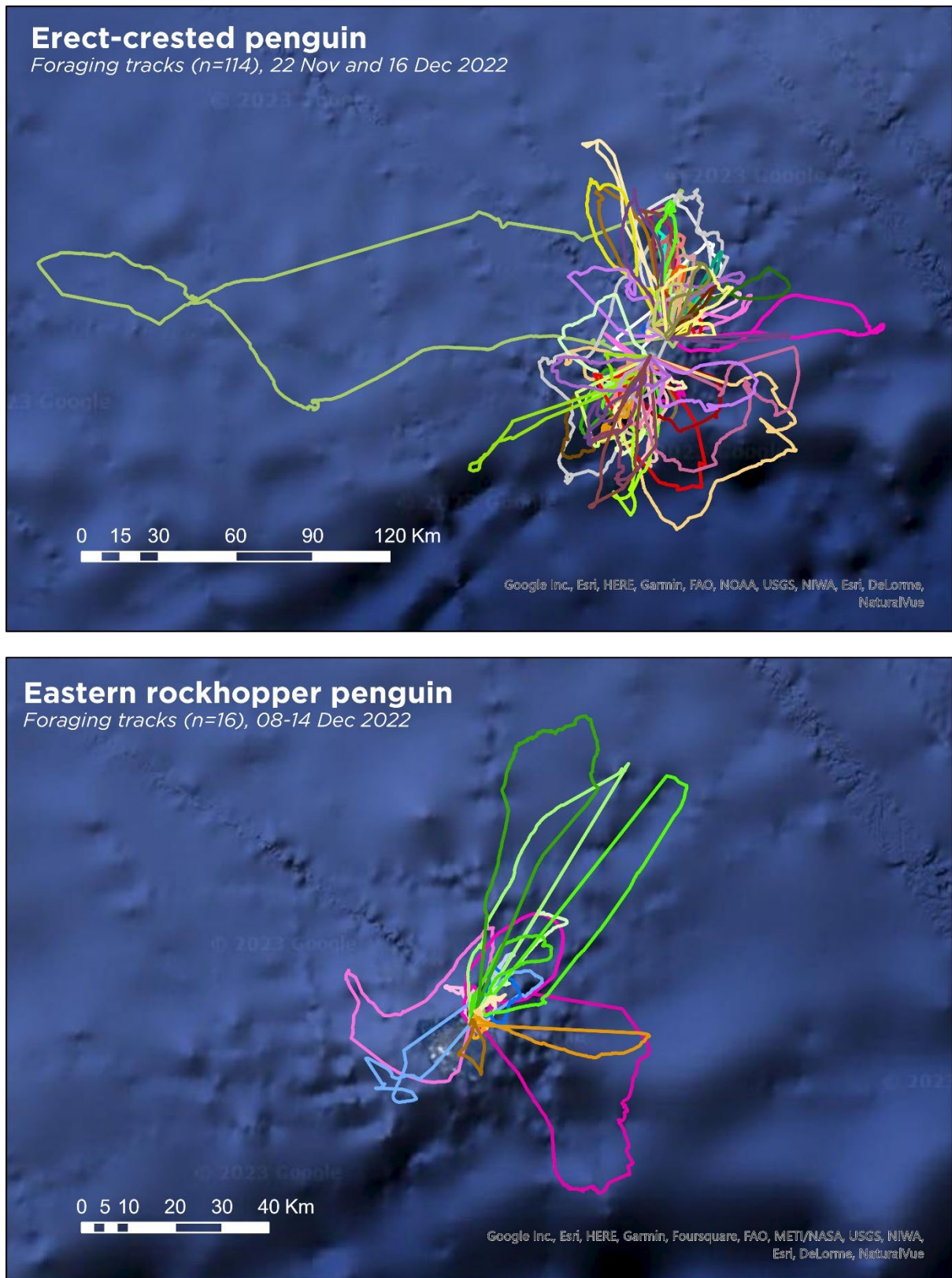
**The 25 deployments of GPS dive loggers on Erect-crested penguins, yielded data representing 114 individual foraging trips** (Figure 23 – top panel).

A total of 59,488 dive events were recorded during which the penguins dived to an average depth of 31.9m. The maximum depths reached by the individual birds averaged 104.5m, with the deepest dive recorded going down to 141.1m. Trip durations ranged between 3.3-148.0 hours (mean: 22.9 hours), during which the birds covered distances of an average 42.3km with the longest trip going over 240km covered over course of five days. Except for one bird that travelled about 160km to the west of the island, birds stayed on average within 20km of the island.

There seem to be notable differences in some of the foraging parameters between penguins from Anchorage Bay and the south coast with the latter group showing greater foraging effort by diving deeper and travelling further afield during their trips while still maintaining comparable trip duration. However, this requires more detailed analysis in the coming months.

**Five GPS logger deployments on Eastern rockhopper penguins resulted in data for 16 different foraging trips** (Figure 23 – bottom panel).

7,087 dive events were recorded with penguins reaching dive depths of an average 26.1m reaching individual maximum depths of a mean 84.1m with the deepest dive recorded at 88.4m. The birds stayed at sea for an average 26.0 hours (range: 8.7-54.7 hours) during which they remained within 20km from their colony (mean 12.2 km), and covered travel distances of 62.8km, the shortest trip being 17.2km, the longest 144.5km.



**Figure 23.** Foraging tracks generated from GPS data recorded on Erect-crested and Eastern rockhopper penguins in November and December 2022, Antipodes Island.



## Notes on logistics

### *Gear transfer at Antipodes Islands*

Prior to the expedition's departure it was unclear whether it would be permitted to use the flying fox in Hut Cove to transfer gear from the Evohe to the hut. Health and Safety concerns required inspection of the tripod structure before its use was green lit. Fortunately, this was the case so that the flying fox could indeed be rigged.

There are two ways to rig the flying fox.

Traditionally, the end of the flying fox wire is rigged to a rock on the pebble beach inside Hut Cove. This method requires gear to be dropped on the beach from the dinghy shuttling between Evohe and Hut Cove. Gear is stashed on the beach and eventually hauled up to the hut via flying fox. We employed this method on arrival (Figure 24).



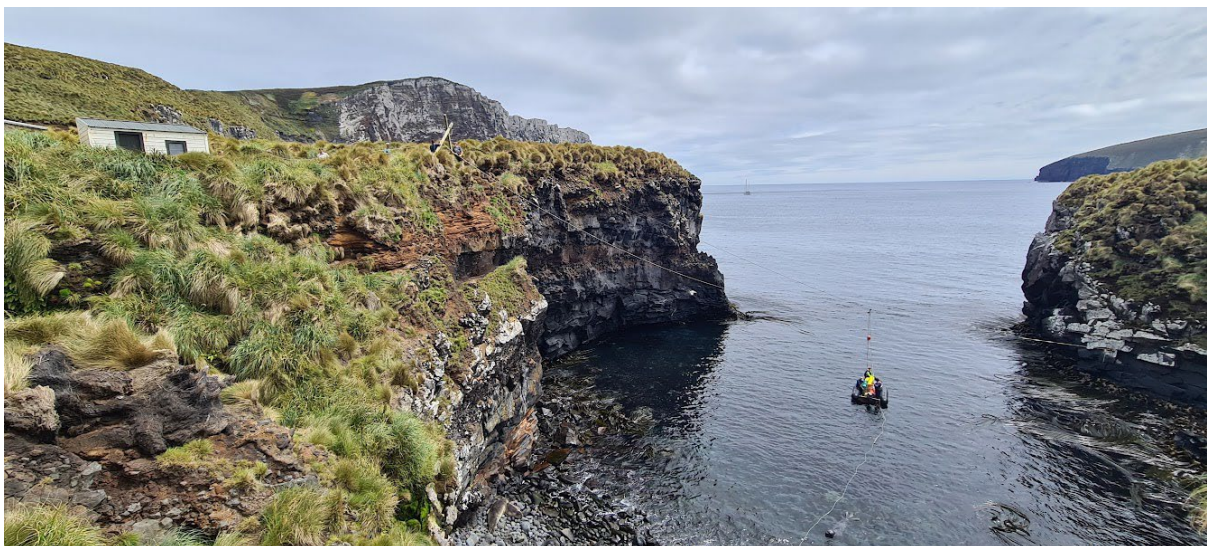
**Figure 24.** *Hauling gear up to the hut via flying fox rigged to rock on beach, 16 November 2022*

While this method greatly facilitates gear transfer to the hut, using the beach to unload proved to be a substantial health and safety hazard as it required the shore party to wade into the surf to receive gear from the dinghy. Occasionally, larger waves would roll in making this a difficult if not dangerous task. Moreover, carrying heavy

gear from the drop-off site to the lower end of the flying fox also proved treacherous due to the slippery nature of the beach.

A second method recently devised by Graeme Elliot and Kath Walker rigs the flying fox in a rock crevice in the wall on the other side of the bay (Figure 25). Although this is a bit more difficult to set up, our experience is that this method is far superior as it allows much safer gear transfer for all involved.

For one, no gear needs to be unloaded from the dinghy onto the beach or lugged to the flying fox, greatly reducing the risk of injury for the shore party. Moreover, with the dinghy operating in the centre of the cove it is easier to negotiate incoming swells which was the case during the departure.



**Figure 25.** *Hauling gear up to the hut via flying fox rigged to rock wall across the Hut Cove, 18 December 2022*

Therefore, in our opinion, the latter method should be the preferred way to transfer gear to the hut. As such, ensuring that the flying fox structures are maintained to meet DOC Health and Safety requirements should be a priority going forward.



### *Camp on the south coast*

To allow GPS tracking of penguins breeding on the southern end of the island, it was necessary to establish a camp as a base of operation. The walk across the island (Figure 26) will take a fit team around 3 hours, although 4-5 hours are more realistic for most people. The easiest route is via the Mt Galloway summit and the western ridge of Mt Waterhouse, using largely vegetation-free landslips as principal causeways up and down the mountains. On the plains it is advisable to walk across areas dominated by *Carex ternaria* and avoid tussock and fern, even if it means deviating from the direct route.



**Figure 26.** Best route from the hut to the southern camp site. GPX file of the route can be downloaded via <https://bit.ly/antips-south>



The camp was established in a tussock gully close to Erect-crested penguin colony SCW-001 (tent location: -49.7058396°, 178.7472978°). The site is suitable as it is reasonably close to the study site, but out of sight and acoustic range of the penguins and has a running stream nearby which provides good drinking water (Figure 27).



**Figure 27.** *Camp at the south coast*

The site has very inquisitive Antipodes parakeets (Figure 28) so that it is advisable to keep the tent always closed. Also, no food or lightweight gear should be left unsupervised as the birds tend to steal items and drag them away into the tussock. The vestibule area of the tent was also frequently visited by the parakeets and therefore is not a suitable area to store food. Also be aware that the parakeets have no fear of humans and may interfere with cookers and pots while in use.



**Figure 28.** *Parakeet interacting with cooker at south coast camp.*



### *Hut maintenance*

A new mount for the Starlink system was installed on the hut roof using a quick release adapter that was fixed in the old mounting pole of the old satellite dish. With the old satellite technology now obsolete, all devices (routers, telephones, cables) as well as the big satellite dish were removed from the island and have since been dropped off at an eWaste collection centre in Dunedin.

The hut and dangerous goods shed were washed and painted (Figure 29a-d). Exterior window frames and sills were also painted. We planned to do the same for the toilets, but misty and drizzly conditions did not allow this task to be completed before our departure.



**Figure 29a.** Antipodes Hut before and after paint job. Note: principal painter Dave Houston shown in lower panel. Also note Starlink mount on roof.





**Figure 29b.** *Dangerous good shed with fresh coat of paint. Note: shed requires new hinges.*



**Figure 29c.** *Painted hut seen from the west.*



**Figure 29d.** *Painted hut seen from the east.*



## Historic assets

“In 1969, two stone structures thought to possibly be old sealers’ fireplaces were found on the south-west coast of the Antipodes Island [...]. Because they lacked obvious chimneys their utility was uncertain; one suggestion was that they were parts of rock and tussock shelters built in 1893 by the survivors of the wreck of the *Spirit of the Dawn*.” – R. Taylor (2006), “Straight through From London”, *Heritage Expedition Publications*, page 53.

The two structures we found (Figures 30 & 31) appear to be in the same condition as pictured in Taylor (2006).



**Figure 30.** Presumed sealer’s fireplace on south coast (-49.705508, 178.743509)



**Figure 31.** Second fireplace on south coast (-49.705547, 178.743305)



“In 1894, the Marine Department placed 65 finger posts in prominent positions on the southern islands pointing to [castaway] depots. [...] Eight [posts] were put up at the Antipodes.” – R. Taylor (2006), *“Straight through From London”, Heritage Expedition Publications*, page 126.

The Alert Bay finger post (Figure 32a & b) is the only one we encountered while roaming the island in November and December 2022.



***Figure 32a.*** Finger post in Alert Bay.



***Figure 32b.*** Detail of Alert Bay finger post.



“In a shallow cave on the cliffs of Anchorage Bay there is a cache of tightly rolled penguin skins dating from the sealing days. They were probably left there in 1880 when another 3,500 penguin skins were loaded [...] onto the sealing schooner *Alert* by a gang who found no seals during a six-week stay ashore” – *R. Taylor (2006), “Straight through From London”, Heritage Expedition Publications, page 53.*



**Figure 33.** Cache of rolled penguin skins in Anchorage Bay



## Detailed trip timeline

<b>7 November 2022</b>	Quarantine of expedition gear and briefing of the team at DOC Southland's Quarantine Store. Transport of quarantined gear to Dunedin and load onto <i>RV Evohe</i> .
<b>8 November 2022</b>	Depart from Dunedin with destination Bounty Islands
<b>10 November 2022</b>	Arrival at Bounty Islands around midday. First landing on Proclamation Island and rigging of guide ropes to top of the island in the afternoon. First drone missions flown to survey Proclamation, Ranfurly, Spider, Tunnel and Depot Island (incomplete).
<b>11 November 2022</b>	Landed on Proclamation Island around 8.30am. Between 9am and 3pm drone missions for Lion, Penguin, Ruatara, Depot and Proclamation. The latter two missions were repeats due poor light conditions the previous day. Blood sampling of Erect-crested penguins for stable isotope analysis and disease screening (the latter for DOC). First day of penguin ground counts on Proclamation Island. Installed six time-lapse cameras.
<b>12 November 2022</b>	No landing possible due to inclement weather. Evohe cruised northwards to wait for better conditions.
<b>13 November 2022</b>	Back at Bounty Islands in the morning. Seas too rough for landing. Anchored south of Depot for 4 hours before returning to anchorage off Proclamation Island.
<b>14 November 2022</b>	Landing possible around lunch time. Continued drone surveys (Castle, Coronet, Funnel, Prion and Depot).



	Finished Proclamation ground counts and blood sampling. Maintenance of time-lapse cameras.
<b>15 November 2022</b>	Cruised to East Group to fly drone missions for Molly Cap and North Rock from the <i>Evohe</i> . Depart Bounties with destination Antipodes Islands around 10am.
<b>16 November 2022</b>	Arrived at Antipodes just after midnight. Cruised to Bollons to fly drone missions for Archway Island and Bollons from the <i>Evohe</i> . First group goes ashore in Hut Cove around 11am. Flying fox rigged by midday. Transfer of gear from <i>Evohe</i> to beach and then up to hut via flying fox takes rest of the day.
<b>17 November 2022</b>	Maintenance work around hut. Installed holder for Starlink satellite dish, cleared tracks around the hut with weed eater, repairs of toilets (one toilet door blown off by storms), installation of solar panels. Visits to Anchorage Bay and Stella Bay penguin colonies. Drone missions covering Anchorage Bay East flown. <i>Evohe</i> and NZ Geo team depart Antipodes in the afternoon.
<b>18 November 2022</b>	Recce trip to South Coast (Thomas, Hannah, Jeff, Robin) to look for suitable study suite and drop off camping gear. Very misty. Detour via Orde Lees to fly an incomplete drone mission. Continued south after lunch but only made it to Mt Waterhouse ridge. Stashed gear and returned to hut. First Erect-crested penguin eggs hatched at Anchorage Bay colony. Ground counts of Anchorage Bay eastern colonies (HTC-002).

<b>19 November 2022</b>	Foggy day. Slow day spent mostly with analysis of Bounty Island data.
<b>20 November 2022</b>	Southern team (Jeff & Robin) leaves 9.30am up Mt Galloway and south to collect gear from Mt Waterhouse. Reaches south coast by 12.30pm and pitches tent in a tussock gully close to Erect-crested penguin colony SCW-001 (tent location: 178.7472978°E 49.7058396°S). Team returns to hut by 6pm. Hut team completes drone missions to cover all of Anchorage Bay, Reef Point and Stella.
<b>21 November 2022</b>	Misty in the morning. First ground counts of Reef Point penguin colony. Also flown drone mission over Reef Point shortly after ground counts completed. Ground counts of larger Anchorage Bay colony located on sloping rock platform. First deployments of GPS dive loggers on three Erect-crested penguins tending small chicks in Anchorage Bay. Wind picks up in afternoon and rain sets in at night.
<b>22 &amp; 23 November 2022</b>	Misty & rainy, hut days.
<b>24 November 2022</b>	Sunny. Two teams depart hut, one to conduct recce trip to Northwest Coast and Mirounga Bay (Jeff, Robin, Bianca, Klemens), the other (Dave, Thomas, Hannah) to walk to Orde Lees to fly drone missions. First team back at hut in the afternoon; deploys five more GPS dive loggers on Erect-crested penguins on rock platform below ladder to Anchorage Bay. Orde Lees team returns exhausted by 7pm.



<b>25 November 2022</b>	Clear day with westerlies. Drone missions flown at Crater and Alert Bay. Ground counts of penguins at Stella Bay and Reef Point.
<b>26 November 2022</b>	Southern team (Jeff & Robin) leaves in the morning to reach south camp for device deployments and arrives there around lunchtime. Eight GPS dive loggers deployed on penguins from colony SCW-001; ground counts of colonies SCW-001 to SCW-008. Second team walks to Mirounga Bay to fly several drone missions that cover the entire length of the bay.
<b>27 November 2022</b>	Misty & rainy. Southern team returns after lunch. Recovery of first two GPS dive loggers in Anchorage Bay.
<b>28 November 2022</b>	Two teams leave to conduct drone missions along Northwest Coast and to re-do Crater Bay. In the afternoon deployment of two camera loggers on Erect-crested penguins in Anchorage Bay.
<b>29 November 2022</b>	Southern team (Thomas & Hannah) leaves hut around 11am; arrives at southern camp early afternoon. Drone missions of south coast colonies flown in the afternoon. Recovery of one camera logger as well as redeployment of GPS dive loggers on two penguins in Anchorage Bay. Stella Bay ground counts repeated.
<b>30 November 2022</b>	Southern team flies drone missions over South Bay and the western colonies of the south coast. Heads back towards the hut around 2pm and arrives around 6pm. Second camera logger recovered. GPS dive logger deployed on another penguin from Anchorage Bay.

<b>1 December 2022</b>	Hut day. Painted dangerous goods shed. One GPS dive logger recovered in Anchorage Bay.
<b>2 December 2022</b>	Drone missions flown at several sites of the West Coast. Recovery of four GPS dive loggers at the Anchorage Bay study site.
<b>3 December 2022</b>	Southern team (Jeff & Robin) leaves around 10am, arrives south coast around 2pm. Recovers five GPS dive loggers and deploys six more loggers on penguins before nightfall. Drone team walks to Ringdove Bay to fly drone missions. Five GPS dive loggers recovered in Anchorage Bay.
<b>4 December 2022</b>	Strong winds and rain. Hut day for northern party. Clears up in the afternoon allows ground count repeat in Stella Bay. Southern team recovers sixth device with two birds still missing. Decide to stay another night in the camp.
<b>5 December 2022</b>	Southern team has no luck recovering missing two devices and returns in the afternoon in stormy and rainy conditions. Ground count repeat of Reef point colony.
<b>6 December 2022</b>	Sunny but breezy. Drone mission to cover all of Anchorage Bay flown at great altitude. Finished just before winds got too strong.
<b>7 December 2022</b>	Sunny with cold southerly breeze. Southern team (Thomas & Hannah) heads south around 11am via the eastern route past Ringdove Bay and arrives at camp around 5pm. First deployment of GPS dive logger on



	<p>Rockhopper penguin from nests close to the ladder to Anchorage Bay. Deployment of one GPS dive logger and three camera loggers on Erect-crested penguins in Anchorage Bay.</p>
<b>8 December 2022</b>	<p>Southern team flies drone missions over Stack Bay and finished up missing areas in South Bay and South Coast West. Deployment of 4 GPS dive loggers on Rockhopper penguins and one Erect-crested penguin in Anchorage Bay. Two camera loggers recovered.</p>
<b>9 December 2022</b>	<p>Southern team experienced stormy night which snaps one of the tent poles. The team spends the first half of the day waiting for the potential return of the missing logger birds. But no sign. Journey back to hut around 1pm in strong gusty winds and arrive at 4.15pm. Last three GPS logger deployments on Rockhopper penguins at Anchorage Bay. Recovered last camera logger.</p>
<b>10 December 2022</b>	<p>Southern team (Jeff &amp; Robin) leave for south coast to recover last devices and complete blood sampling. Leave around 11am and arrive 2.30pm. Recover two GPS dive loggers in the afternoon. Hut team focusses on computer work.</p>
<b>11 December 2022</b>	<p>Misty, drizzly conditions. Southern team managed to recover another two devices, one more to go. The two missing devices from the first deployment round are considered lost as both males have now abandoned nests. In the afternoon, Thomas &amp; Dave walk over to Alert Bay to see if drone missions are possible but are</p>

**12 December 2022**

drenched by horizontal flying rain. Back at the hut by 4.30pm.

Clear morning. Dave, Thomas & Hannah leave 11am to walk to east coast to complete drone missions of southern Alert Bay and east coast. Several missions flown before controller battery dies. Back to hut by 5pm. Klemens & Bianca repeat ground counts of eastern Anchorage Bay. Southern team recovers last GPS logger around lunchtime. Decides to spend another night to finish up blood sampling.

**13 December 2022**

Cloudless, windless day. Ideal conditions for drone missions at Albatross Point. Cruise ship visits Anchorage Bay in the morning with eight tenders shipping passengers to the penguin colonies. Thomas & Hannah leave hut around 10.00am and reach Ringdove Bay 1.5 hours later. Fly missions of northern Albatross Point from there before continuing to the point itself. Reach top of southern tip of the Albatross Point by around 1pm. Fly missions of South Coast East colonies and southern half of Albatross Point. Clouds start to roll in by 2pm. Leave for home by 2.30pm and arrive at hut by 6.30pm. Cruise ship spotted in Ringdove Bay in the afternoon. Southern team returns to hut in the afternoon. Recovery of four GPS dive loggers before the end of the day.

**14 December 2022**

Fog and drizzly. Hut day with hourly checks for logger birds. Recovery of two devices at lunchtime, no other



**15 December 2022**

birds return. Finish blood sampling of Eastern Rockhopper penguins.

Misty, Thomas, Hannah, Jeff, Robin walk to Orde Lees to maintain time lapse cameras, conduct ground counts of Rockhopper colony, and to fly drone mission to assess suitability of this method during crèching. Team leaves hut around 9.30am and arrives at the colony 11am. Fog lifts a bit occasionally so that brief drone missions can be flown. Team heads back around 3pm, back at the hut just after 5pm.

**16 December 2022**

Start packing gear for departure. Hourly checks for final logger bird from morning. Device recovered around 2pm. This means, except for the two lost devices in the south, all data loggers could be recovered successfully.

**17 December 2022**

Evohe arrives in the morning but swell too high to even attempt a landing in Hut Cove. Shore party conducts two hourly checks and times frequency of large rollers the whole day. By 3pm everyone settles in for another night on the island. Unexpectedly DOC hut inspector arrives at the hut having managed to jump ashore at Reef Point and trek through fur seal colony to hut. A determined man.

**18 December 2022**

Still rollers coming in frequently, but conditions improve by lunchtime. Flying fox rigged to cliff wall, and transfer of gear directly from the dinghy starts by lunchtime. Takes about four hours to get Parker Conservation gear to the hut and our expedition gear



to the Evohe. Team leaves island from Anchorage Bay rock platform and is on the Evohe by 4pm. Cruise around northwest coast and East Windward Island to fly final drone missions. Leave Antipodes by 7pm.

**21 December 2022**

Arrive Dunedin 6am.

