White-capped albatross population study: February 2023

Graeme Elliott, Kath Walker, Kalinka Rexer-Huber, Graham Parker

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Graeme Elliott[1], Kath Walker[1], Kalinka Rexer-Huber[2] and Graham C. Parker[2]

[1] Department of Conservation, Private Bag 5, Nelson, New Zealand
[2] Parker Conservation, 126 Maryhill Terrace, Dunedin, New Zealand

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SUMMARY

White-capped albatross (*Thalassarche steadi*) are a significant bycatch in commercial fisheries in New Zealand and off South Africa and, to an unknown extent, in the high seas. To determine the impact this is having on the species, a mark/recapture study was established on Disappointment Island, the main breeding ground for white-capped albatross, in 2015. Subsequent brief annual visits to the island focussed on banding and re-sighting banded birds to measure survival and productivity, and recently, to investigate the potential to census the population using drones. This report describes the results of the field programme in 11–15 February 2023.

Banded white-capped albatross were re-sighted at a rate of 0.25 in the study colony of 643 banded birds. Adult survival was 0.92, a little higher than estimated last year. Nine of ten trail cameras monitoring the last half of the 2022 breeding season and the start of the 2023 breeding season gave some data, and seven cameras continued functioning for the full 12 months, though only two stayed upright long enough for the outcome of all the nests in the frame to be determined. Seven of the nine 2022 season cameras drooped over time, probably because the island's soft peat was so wet it was not strong enough to support the waratahs the cameras were attached to.

Chick success, or the survival of a chick from hatching to fledging, was 66% (22 out of 33 nests). Chicks fledged ~26 July (range 17 June–20 August), and adults returned to the colony from around 10 October (earliest 20 September). Camera images supported earlier findings that white capped albatross is predominantly a biennially-breeding species. This means cameras placed to capture clear views of a cluster of nests being used one season seldom capture many in the next, at least when chick success is reasonably high and nest density only moderate. Reliable information on nest failure rates between laying and hatching will be difficult to obtain without a late November visit to Disappointment Island to position cameras on clusters of nests with confirmed eggs.

An additional 24 unbanded birds were banded and darvic bands were added to three already metal-banded birds. A few feathers were collected from each of these birds for determination of sex, and

GLS dataloggers were attached to the leg bands of 26 of them to follow their movements at sea. Blood samples were collected from 20 of these birds for analysis of the levels of mercury pollution.

A comprehensive ground count was made of birds nesting in part of the eastern Castaway Bay colony. The eastern and the western Castaway Bay colony were then photographed from the air by drone twice. There was great variability in the number of non-breeding birds present on the ground between counts (36-106), depending on conditions, which would make it difficult to get an accurate count of breeding birds from drone photographs. Any whole island drone-based census of nests will need to be accompanied with simultaneous ground truthing.

Before a reliable drone-based whole island census can be made, the following is required:

1) trials to determine whether the vertical orthomosaics which have so far only been tested on gentle ground, will work on the steep cliffs and narrow gullies which characterise the western and northern colonies, or whether more complicated 3D models of the steep slopes need to be constructed.
2) Purchase of ~25 batteries and possibly 2 drones (if batteries no longer available for existing drones).
3) Purchase of an improved digital elevation model.

INTRODUCTION

White-capped albatross (*Thalassarche steadi*) are endemic to New Zealand, with ~95% of the population breeding on Disappointment Island (Baker et al. 2014; Walker et al. 2020). They are caught as incidental bycatch in commercial fisheries in New Zealand, and caught in substantial numbers in fisheries off South Africa despite considerable reductions in captures since the late 1990s (Ryan et al. 2002; Watkins et al. 2008; Francis 2012; Rollinson et al. 2017).

A white-capped albatross study area was established on Disappointment Island in January 2015 (Thompson et al. 2015) and data suitable for estimating key demographic parameters such as adult survival and population trend assessment was collected annually thereafter (Parker et al. 2017, 2022; Rexer-Huber et al. 2018, 2019) except for 2021 when there was no field trip to the island.

Estimates of the size of the white-capped albatross population breeding on Disappointment Island have so far been based on counts of birds seen in aerial photographs taken from a helicopter, with photographs taken sporadically and opportunistically from 1985, then most years in 2006 to 2017 (Baker et al. 2023; Walker et al. 2020). Aerial photographs were also taken in 2019 from a helicopter but these have not yet been analysed (Rexer-Huber et al. 2019), and drones were tested as a replacement for aerial census in 2022 (Parker et al. 2022).

During the breeding season (November-June) New Zealand white-capped albatross occur throughout coastal New Zealand, especially from Cook Strait south, and across the Tasman Sea to south-east Australian waters. After breeding most birds remain in Australasian waters, but about 20% of adults migrate across the Indian Ocean to seas off South Africa and Namibia (Sagar 2013). Knowledge of the at-sea range of white-capped albatross (gathered by Thompson & Sagar 2008; Thompson et al. 2009; Torres et al. 2011) has been supplemented since 2020 by geolocator dataloggers attached to birds breeding in the Disappointment Island study area.

Breeding success remains essentially unknown for white-capped albatross. Observation in a pig-free portion of the South-West Cape colony on Auckland Island in the 2006/07 breeding season found 62% nest success between early incubation and mid chick rearing (Thompson & Sagar 2007). However, a trial of nest cameras on Disappointment island in 2018 suggested that chick success may be worryingly low, with only 29% of chicks fledging (Rexer-Huber et al. 2019).

The primary objectives of this study are to measure survival, productivity and other key demographic parameters and to describe the at-sea distribution of white-capped albatross to reduce uncertainty or bias in estimates of their risk from commercial fishing. Secondary objectives undertaken during 4 days on Disappointment Island between 11—15 February 2023 were to assess the potential for census of the population using drones, and to collect blood and feather samples for a Pacific-wide mercury pollution study.

METHODS

Mark recapture study

Banded white-capped albatross were searched for during two comprehensive and one smaller survey of the area in and around the study area, which lies within a larger eastern Castaways Bay colony (Fig. 1). During these surveys all white-capped albatross nesting and loafing within the study area were checked for bands, and all nesting birds were counted and marked with stock marker on the breast so that they would not be disturbed on subsequent checks. Any banded birds sighted opportunistically whilst in the study area at other times were also recorded.

Twenty-four of the birds nesting within the study area which were unbanded, were banded with both a uniquely numbered metal and a coloured plastic band (darvic), and a darvic band was applied to three birds previously banded only with a metal band.

The survival of banded birds was estimated using multistate models (Brownie et al. 1993) which can estimate separate survivorship and detectability for 2 states: breeding and loafing birds. Multi-state survival analysis was carried out using RMark (Laake 2013), the same methods as used for previous estimates for white-capped albatross on Disappointment Island (Parker et al. 2022). Three mark-recapture models were used and compared using AICc:

1. survivorship different for every year and state (breeding or loafing),
2. survivorship different between years, but the same for the two states.
3. survivorship constant between years and states.

All models had detectabilities and transitions that varied with both state (loafing/nesting) and time.

Timing of nest checks and breeding timetable

The first survey was lengthy, taking 2 observers 7 hours (between 7–9pm on 11/2/23 and 10.30am–3.30pm on 12/2/23) to search both the study area and a substantial area on its north-east and south-west edges for re-sights of banded birds and for a count of all nests present. The second survey was shorter taking 2 observers 4 hours (between 1–5pm on 14/2/23) and was confined to the study area. A third survey by one observer between 1.30–2.30pm on 15/2/23 checked only the central part of the study area. During the first survey on 11 February a small number of birds were still incubating eggs while most of the breeding birds were guarding small chicks, and several larger chicks had been left unguarded. By 15 February, the number of unguarded chicks had risen substantially to about 10%.

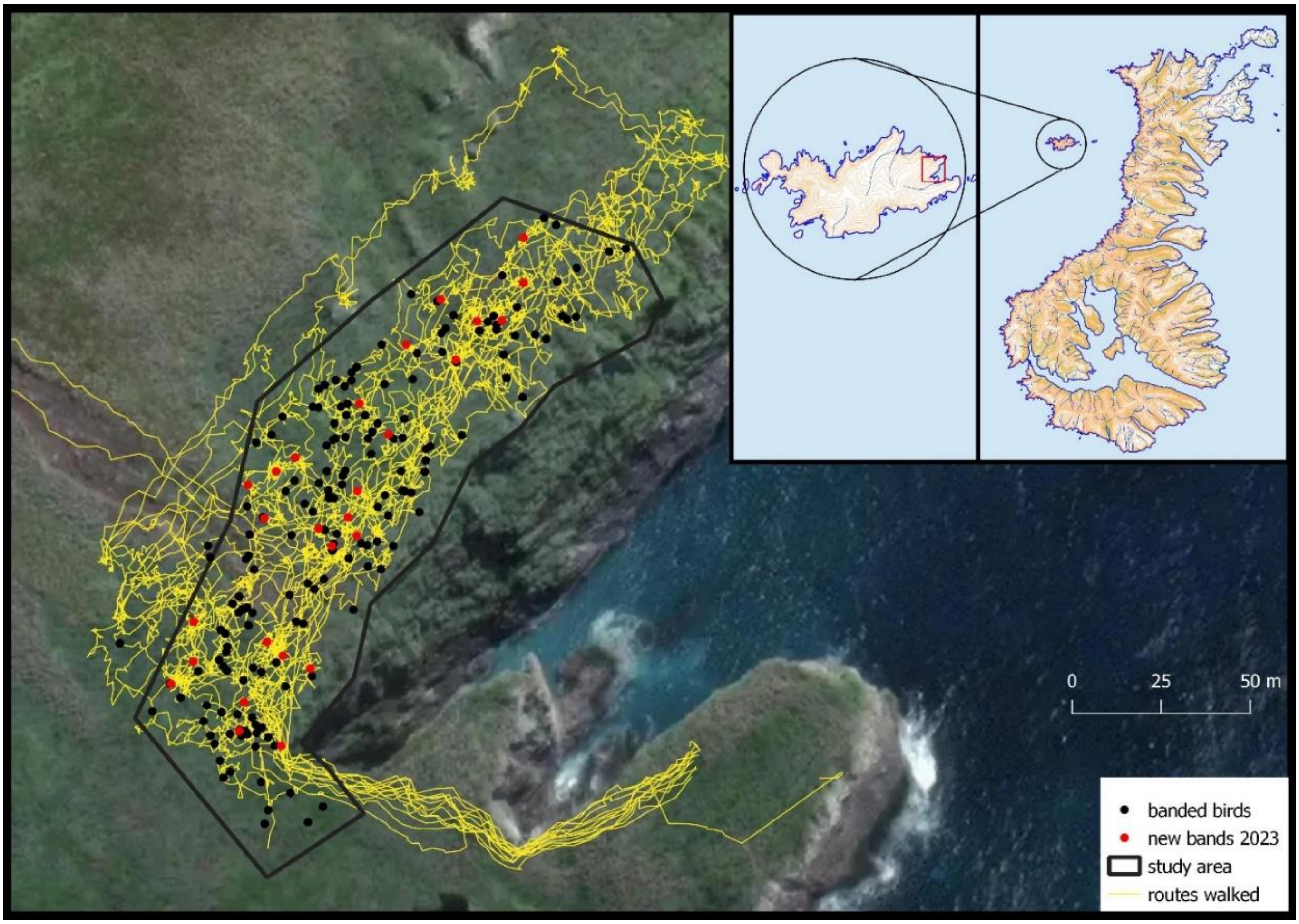

Figure 1. Routes walked, already banded birds re-sighted and birds newly banded in the study area in the Castaways Bay eastern colony, Disappointment Island in February 2023.

At sea distribution

Geolocator loggers were attached to the newly applied metal leg bands of 26 adult white-capped albatross whilst they were being handled for banding. A few feathers were collected from each for determination of sex. All were caught within the study area. Twenty-four of them were guarding young chicks, while one was on a nest with a dead chick and one other was a previously metal-banded bird which was not breeding but was being handled to attach a darvic band.

Taking blood and feather samples

Between 11am and 9pm on 13 February blood and feather samples were collected from 20 birds nesting in the study area for investigations into the levels of mercury pollution in seabirds across the Pacific being undertaken by researchers at the University of Tsukuba. To avoid disturbing more birds than necessary, the 20 birds from whom blood and feathers were collected were part of the 25 birds caught for banding and attachment of GLS described earlier. Birds to sample were selected by the position of their nests, as described by Rexer-Huber et al. (2018) who found local topographical features could increase the probability of birds settling back onto nests after handling.

Measuring productivity

Ten Bushnell Enduro trail cameras deployed at seven sites in the study colony in February 2022 to monitor nesting success were retrieved and an analysis of the photos was undertaken. Ten new cameras were installed at approximately the same sites but with their field of view changed to maximise the number of active nests that each camera monitored. Cameras were set up to record time-lapse images, at hourly intervals during daylight hours as had been done in February 2022.

Counting the number of breeding pairs

This work aimed to continue development of ways to count nesting white-capped albatross from aerial photographs taken by drone, and for those counts to be corrected to account for the presence of variable numbers of pretend-breeders (birds sitting on empty nests) which could not be distinguished from nesting birds from the air.

Trials in February 2022 (Parker et al. 2022) had shown that white-capped albatross can safely be counted from the air with a drone, despite the extensive aerial seabird activity present, and that it was best undertaken using orthomosaic images constructed from photos taken by drones flying 30–70m above the ground. However, it had been found that loafing birds (birds in colony not on a nest pedestal) could not reliably be distinguished from apparently nesting birds, and that orthomosaics needed to be accurately georeferenced to facilitate matching aerial counts with ground-truth counts.

Although drone flight at a constant height above sea level worked in the block tested in 2022, that block only had an elevation range of 40m (60-100m asl). Flying at a constant height above sea level would not work in steeper parts of the island where white-capped albatross nest in blocks which have an elevation range of 200m. That would mean that albatrosses in the highest parts of the block would be photographed from 30m whereas those at the lowest parts of the block would be photographed from 230m and might be too small to identify in the photographs. Drone flying needed to be undertaken with the drone tracking the contours of the land in order to fly at a constant height above ground level.

To try and resolve these issues, in February 2023 the following drone-related work was undertaken in the same block as in 2022 (i.e., Castaway Bay colonies) on Disappointment Island:

1. Testing of methods to ensure that drones flew at a constant height above ground.
2. Establishment of temporary ground control points to allow aerial counts to be matched with ground truth counts.
3. Testing methods for estimating the ratio of non-breeding to breeding birds from matched aerial photos and ground truth counts.
4. Estimating the number of nests in the calibration area.

No time was available to test whether flying drones at a constant height above ground and taking vertical images would work in very steep country.

RESULTS

Mark-recapture study

In total 159 already banded birds were re-sighted (Fig. 1) in three rounds of the study area, and 24 un-banded nesting birds were banded to add to the pool of birds to use for future mark-recapture survival estimates (Table 1). The re-sighting rate of previously banded birds was lower than in previous years, despite the trip being longer than previous trips (Table 1). This was probably mostly because no new birds had been banded in the last three years, leading to a decline in the number of banded birds available to be resighted.

Table 1. White-capped albatross banded and re-sighted on Disappointment Island 2015-2023.

	2015	2016	2017	2018	2019	2020+	2021	2022	2023	Total
Banded	150	83	160	128	122	0	0	0	24	667 (703*)
Resighted from previous years		32 of 150	53 of 233	130 of 393	191 of 521	175 of 643	-	173 of 643	159 of 643	
% Resighted		21%	23%	33%	37%	27%	-	27%	25%	
Duration of trip (days)	3	2.3	2.3	2.5	2.5	1.5	-	2	4	
Timing	31 Dec–11 Jan	8–12 Jan	13-16 Feb	16–19 Jan	5–7 Feb	21–23 Jan		15–16 Feb	11–15 Feb	

*Total banded when 36 birds banded in the study area in 1993 and 2008 are included
+ slip through study area in late 2019, killing some birds & removing white-capped albatross nesting habitat

Comparison of three models for estimating survivorship (Table 2) indicated no support for differentiating the survivorships of breeding and loafing birds (model 3 in Table 2), though it did support separate survivorships for years (model 1 in Table 2). However, one of the estimated survivorships in this model had confidence intervals of 0 and 1, so the best plausible model was one with a constant survivorship for all years and both breeding and loafing birds (model 2 in Table 2). Estimated survivorship was 0.92 (95% confidence interval 0.90– 0.93) which is higher than estimated last year (0.89, 95% confidence interval 0.86–0.91, Parker et al. 2022).

Table 2. Model selection table for three models of white-capped albatross survival. All models have detectability's and transitions that vary with both state (loafing/nesting) and time.

Model	npar	AICc	ΔAICc
1. Survival varies with time	37	4653.48	0.00
2. Survival constant	31	4654.49	1.01
3. Survival varies with time and state (loafing/nesting)	45	4663.12	9.64

Taking blood and feather samples

Two of the first three adults removed from their nest on 13 February for sampling failed to settle back on to their nest after handling, and flew off, leaving the chick alone. Neither bird had returned after an hour, but both unattended chicks were still alive several days later. Subsequently only birds guarding very young chicks were sampled, as it was found they had stronger drive to brood, and with careful handling to encourage nest return, all 17 safely settled back on their nests. Unguarded chicks noticeably increased in the following few days, and it was concluded the ideal time to handle this rather flighty species is the first 10 days in February when most eggs have hatched but chicks are still being brooded.

Measuring productivity

Of the 10 cameras deployed in 2022 to monitor the outcome of 61 nesting attempts, one was so wet and damaged that no images could be retrieved from its SD card. Two cameras stopped recording early (1/5/22 and 25/11/22), but the remaining seven cameras continued recording for the full 12 months. However, seven of the nine 2002 season cameras drooped so much over time that many of the nests originally in view were no longer visible. The soft peat which the waratahs holding the cameras were pushed into was probably not strong enough to support the weight, and each camera-holding waratah needed to be braced. The slippage problem was not detected until the images were processed in May 2023, so the 10 new cameras deployed in February 2023 to monitor the outcome of 93 nesting attempts are likely to suffer similar problems. In 2022 only two cameras stayed close to the vertical long enough for the outcome of all the nests in the frame to be determined, but fortunately one of these had many nests in view.

Some data on chick success was gained from eight of the cameras. From 33 nests, 22 chicks clearly fledged (mean date 26 July; range 17 July–20 August) and another three chicks almost certainly fledged (camera tipping led to three nests with chicks close to the mean fledging date no longer being visible) and six nests failed. One failure on 6/3/22 may have been caused by an attack by a giant petrel, or the petrel scavenged a chick which had just died. The first brief visits of adults returning to the colony varied between 20 September and 31 October with the mean date 10 October (six cameras).

Chick success, or the survival of a chick from hatching to fledging, at 66% from 33 nests (76% chick success if including the three chicks which almost certainly fledged) is much higher than the 29% recorded from 17 nests in the 2018 breeding season However, both are overestimates of breeding success as they don't include the failures which will have occurred between egg laying and hatching. Few nests could be seen clearly enough in camera images taken in November 2022 at the start of the 2023 breeding season for certainty as to whether an egg had been laid. As a result, the continued presence of a bird (and later a chick) at a spot was the only available evidence for most new nesting attempts in the 2022/2023 summer. This meant nests which failed early could not be distinguished from birds visiting the colony but failing to lay, limiting the ability of cameras to provide robust nesting success data.

From the small number of nests (17) monitored closely by camera from February 2022 to February 2023, 73% (11 of 15 pairs) which successfully fledged a chick in 2022 did not breed again the following season, though birds from seven of these nests briefly visited at various times in November and December 2022. The remaining four (26%) successful 2022-season breeders re-nested in the 2023 season, as did the two pairs whose 2022 season nests failed during early chick rearing.

All nine cameras provided data on the timing of the end of chick guarding by parents. The end of guard ranged from 16–28 February, with 67% of chicks alone on the nest by 24 February. On some occasions an adult would return after 24–48 hours of the chick being alone and guard it for another 12–24 hours, presumably being the second parent, whose brooding drive had yet to subside.

Drone Trial

Flying at a constant height above ground

There is software that enables drones to be flown automatically at a constant height above the ground if there is a digital elevation model of the land being flown over. UGCS software was used for drone flights in February 2023, but the digital elevation model of Disappointment Island provided by the software was found to be inaccurate. There is no digital elevation model for the Auckland

Islands available from Land Information New Zealand (LINZ, the normal source in New Zealand), but we were able to build one from the contour lines for the Auckland Islands which are available from the LINZ website. This digital elevation model was not a substantial improvement on the one provided by UGCS as the LINZ-provided contours were clearly inaccurate (see Figure 2). We were however able to shift the digital elevation model so that its coastline lined up with the coastline in aerial imagery available from the LINZ website, and this enabled flight at approximately a constant height above ground. However, this shift of digital elevation model to match land was only possible for the small area flown, not for the whole island.

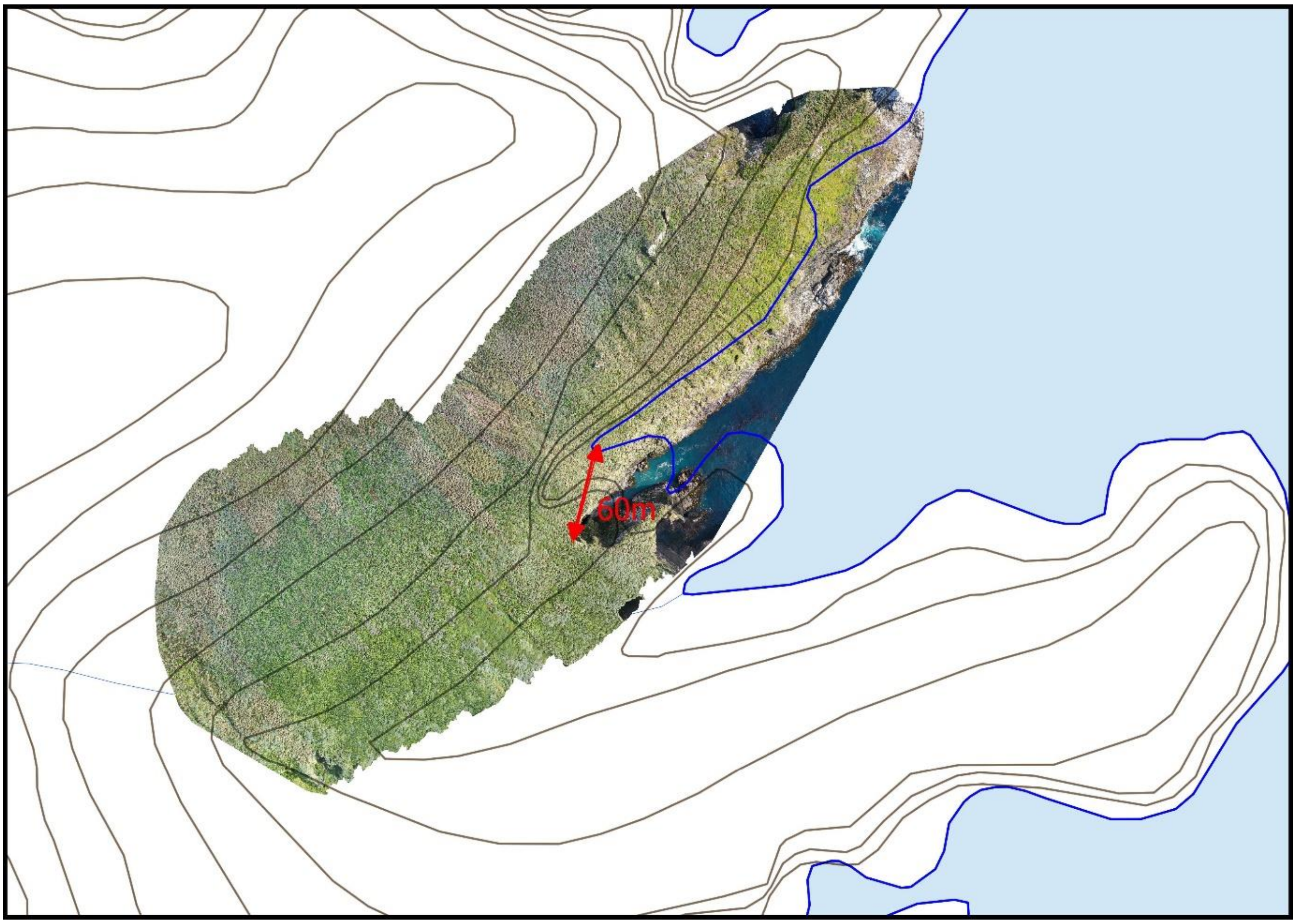

Figure 2. The coast edge (blue line) and contours (black lines) of the Castaway Bay sector of Disappointment Island according to LINZ data, overlain by a geo-referenced orthomosaic of the land which illustrates the inaccuracy of the LINZ data.

Testing ground control points

To enable matching of the orthomosaic images and ground counts, (geo-referencing), six temporary ground control points were established around the periphery of the area in which the detailed ground count of white-capped albatross had been undertaken (calibration block, Fig. 3, 4). At each of the six ground-control points a 50x50cm square of blue closed-cell-foam was tied to the ground in a position where it would be visible from the air (Fig. 3). The position of each control point was measured twice with a GPS; once when the foam squares were put out and 2 days later when they were retrieved.

Figure 3. Ground control points on Disappointment Island (solid black circles), overlaid over an orthomosaic produced from drone photography, overlaid over adjusted aerial imagery from LINZ.

Estimating the ratio of breeding to non-breeding birds

On 11 and 12 Feb 2023 all the nests with eggs or chicks, loafing birds, and birds on empty nests were counted (from the ground) in a calibration block (0.7 ha) shown in Fig. 4, and their location marked using a GPS. All the tracks walked through the albatross colony to complete this search were also recorded on GPS and used to define the boundaries of the calibration block which was the area within which all nests were certainly detected. There were 281 nests with eggs in the calibration block, very few loafing birds present and the ratio of birds: nests was 1.128 (Table 3).

Table 3. Drone and ground-based counts of white-capped albatrosses in a calibration block in the eastern Castaways Bay colony on Disappointment Island. Birds/nest is the ratio of breeding to non-breeding birds (Total birds and nests/Nests)

Type of count	Date	Calibration block Nests	Birds on empty nests	Birds not on nests	Total birds and nests	Birds/ nest	Estimated nests
Ground	11-12/2/23	281	21	15	317	1.128	
Aerial	13/2/23	-	-	-	302		268
Aerial	15/2/23	-	-	-	387		343

Nests in the calibration block

At 9am on both 13 February and 15 February a drone (DJI Mavic 2 pro) was flown over a larger area (8 ha including both the western and eastern Castaway Bay colonies) which included the calibration block. The drone flew a pre-programmed series of parallel flight lines at a height of approximately 40m above ground level, with side and forward overlaps of 75% giving a ground resolution of 1cm per pixel. The flight was planned and controlled using UGCS software and used the digital elevation model of part of the island constructed from the contour lines. A series of aerial photos were taken from the drone from which an orthomosaic was generated using WEBODM software.

Birds which appeared on the orthomosaic to be nesting inside the calibration block (i.e., inside the line shown on Fig. 4) were counted, and the results compared to the number found to be nesting there in the 11/12 February ground search. To enable matching of the othomosaic images with the calibration/ground count nest map generated from GPS points, the temporary ground control points (the blue squares) and the georeferencing tools in QGIS were used to accurately geo-reference the orthomosaic image. On the orthomosaic birds on eggs or chicks could not be distinguished from birds on nests without eggs or chicks, and sometimes not even from birds not on nests. Counts from the aerial photos were simply of birds.

The number of birds counted in the calibration block varied considerably between the three counts (one ground and two aerials, Table 3). This variation is attributable to variable numbers of non-breeding birds on the ground. The arrival on the ground of many non-breeding birds appeared to be associated with weather and time of day, as noted in ground truthing work in 2015 and 2016 but may also have to do with the stage in the breeding cycle.

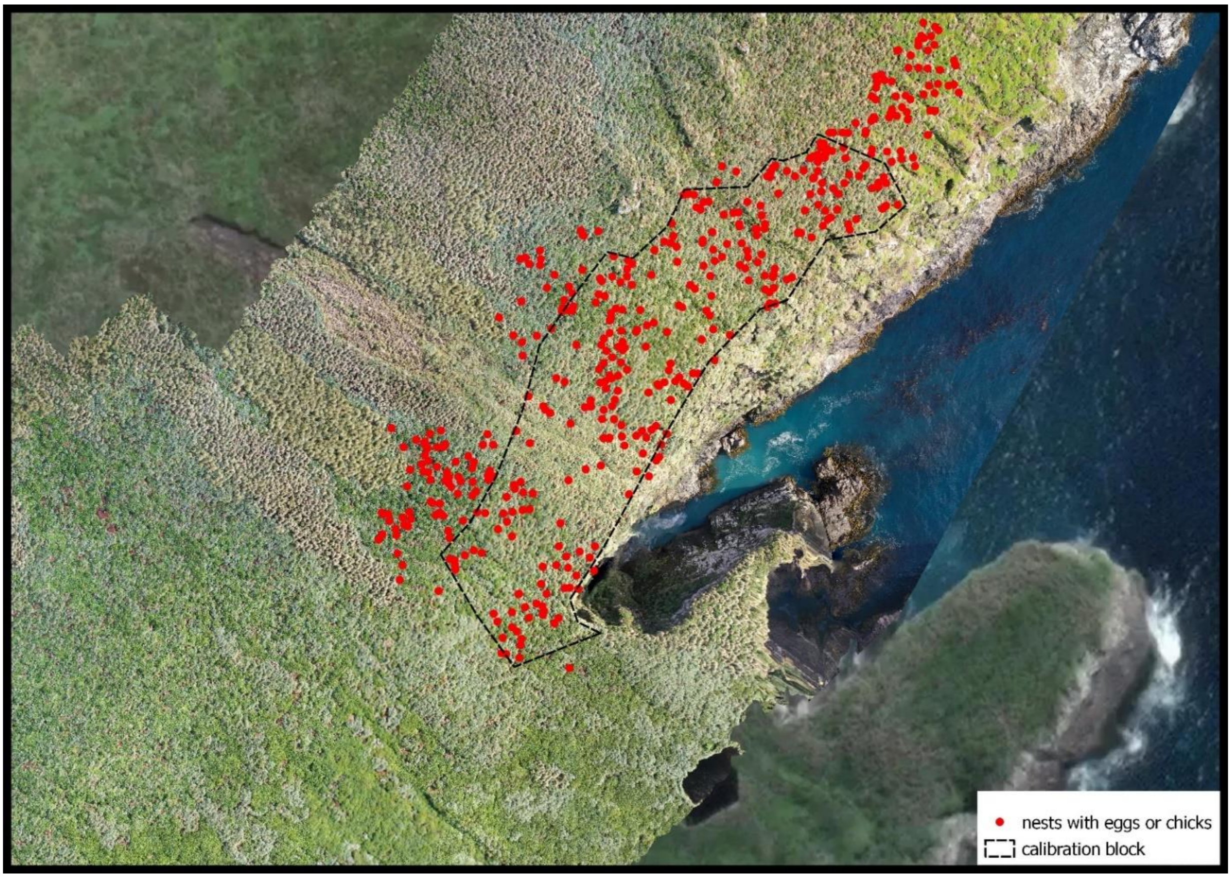

Figure 4. The area used to calibrate nest counts from drone photos with nest counts from on ground nest checks. Dashed black lines indicate the area on Disappointment Island in which all parts were searched on foot and the location of all nests found (red dots) recorded on a GPS.

The ground count indicated that more than half of the loafing birds (that is, not on an egg or chick) were none-the-less sitting on a nest, and these birds, as well as some of those not on nests, are not distinguishable from breeding birds from the air. Using the single birds/nests correction of 1.128 from ground counts, drone counts of total bird numbers gives nest estimates of 268–343 nests in the calibration block (Table 3). Compared to the 281 active nests actually present (ground counts), this shows that the power to detect trends in nest numbers using aerial counts is greatly reduced by the variability of counts but could be substantially improved if each aerial count had a simultaneously estimated birds/nests correction factor.

DISCUSSION

Survival

The most-recent survival rate estimates for white-capped albatross (0.92 95%CI 0.90– 0.93) is low for an albatross (Véran et al. 2007). The only other estimates for white-capped albatross are from this population a year ago (0.89, 95% CI 0.86-0.91, Parker et al. 2022) and from South West Cape on the main Auckland Island between 2005 and 2009 (0.96, 0.91–1) (Francis 2012). Given the relatively large confidence intervals of these estimates and the likely high inter-annual variation in survival, reading too much into these estimates should be avoided. The lower number of birds resighted in the last two years is probably related to the absence of new-bird banding since 2019, as new-bird banding was de-prioritized to make time for nest cameras, drone trials and diet and health studies. Next season, banding should be a high priority to ensure the core mark-recapture study is not compromised, as continuation of the gradually improving precision of survival estimates is reliant on it.

Productivity

Chick success at 66% of 33 nests monitored by camera in 2022 (76% if three "probable" fledglings are included) was much higher than measured in 2018 from a smaller sample (29%, from 17 nests) (Rexer-Huber et al. 2019). For a more reliable result the number of nests monitored needs to increase, which is reliant on overcoming camera stability issues. Bracing the waratahs to which the cameras are tied should be trialled next summer. The wet peat into which the waratahs were pushed is soft and weak, and with pressure on them by strong winds, sealions and—less likely—albatrosses, they probably can't stay upright without bracing. The problem of waratah lean did not occur in the original trial of 6 cameras in 2018, either because it was a drier winter, or because by chance they were placed in a site with drier deeper peat.

It had been hoped that robust estimates of nesting success, rather than just chick success, could be obtained by combining the observed nesting success before hatching from one year's cameras with nesting success post-hatching from the next years cameras. However, while nesting success was able to be calculated in this way for Salvin's albatross which nest annually at very high density on the bare rocks of Bounty Islands (Rexer-Huber et al 2021), this may not be achievable for white capped albatross nesting biennially at lower density in deep tussock and megaherb vegetation amidst dissected topography on Disappointment Island. Analysis of the 2022 breeding season photographs showed it was very difficult to be sure an egg had been laid as the nests were mostly too distant or obscured to see nest details. With chick success relatively high, camera sites which were chosen for their high density of nests with eggs/chicks in view in February 2022 inevitably had fewer nests in the immediate field of view in February 2023 as about 75% of successful breeders do not re-nest the following season (Thompson & Sagar 2008). The only way the existence of a nesting attempt could be assumed by camera photos alone was by the uninterrupted presence of a bird over time. Disappearance of a bird from a spot could mean either that it did not in the end lay, or that an egg had been laid and the nest subsequently failed. If it was the latter, breeding success will be overestimated.

To try and overcome this problem, cameras could be set up on more exposed ground which is covered in a low sward of *Leptinella plumosa* north-east of the study area. The relative openness of this ground means it attracts more loafing birds which would complicate interpretation, and the peat is relatively thin, increasing the difficulty of stabilizing the cameras, but nest visibility is better (Figure 5). The alternative is setting up cameras near nests with confirmed eggs in November at the start of incubation; an expensive option requiring an additional landing on Disappointment Island.

Figure 5. (top) Characteristic vegetation (tall *Poa foliosa* tussock and megaherb *Anisotome antipoda*) where cameras are currently set up to record breeding activity of white capped albatross, and (below) a small meadow of *Leptinella plumosa* on the edge of the study area which could provide clearer camera sight lines.

Further support that white capped albatross are predominantly biennial breeders was provided by 17 nests monitored closely by camera from February 2022 to February 2023. Most of those which successfully fledged a chick in 2022 did not breed again the following season (73%), a similar proportion (76%) to that reported by Thompson & Sagar (2008).

Timing

The camera footage provided more information on the timing of both chick fledging and breeder return to Disappointment Island. The timing of this visit 11-15 February was very similar to the previous year and appears to be nearly optimal for banding and resighting work in white-capped albatross colonies. Turnover of birds was high, maximising the chance of seeing bands. However, the chick guard stage was nearing its end, so conducting re-sighting surveys any later means that too few parents will be present to be re-sighted, as cameras showed that by 24 February many chicks were left unguarded.

Future drone-based white-capped albatross counts

There are about 120ha of white-capped albatross colonies on Disappointment Island (Walker et al. 2020). The Castaway Bay colonies where all the drone trials have been carried out is not only the most accessible white-capped albatross colony but also one of the easiest colonies to move around in as it is not as steep and dissected as some colonies at the western end of the island (Fig. 6, 7). The programmed flight path methods of droning used successfully on the relatively even ground of the study area may not work as well in the high narrow gullies and cliff shelves common on the western and north-western sides of the island.

Trials are needed to determine whether the orthomosaics constructed from photos taken vertically at Castaways Bay, will work on the steep cliffs and gullies elsewhere on Disappointment. If they do not work, more complicated 3D models of the steep slopes will need to be constructed.

A new and accurate digital elevation model of the whole is required for both the construction of orthomosaics or 3D models. Satellite imagery can be used to construct such digital elevation models

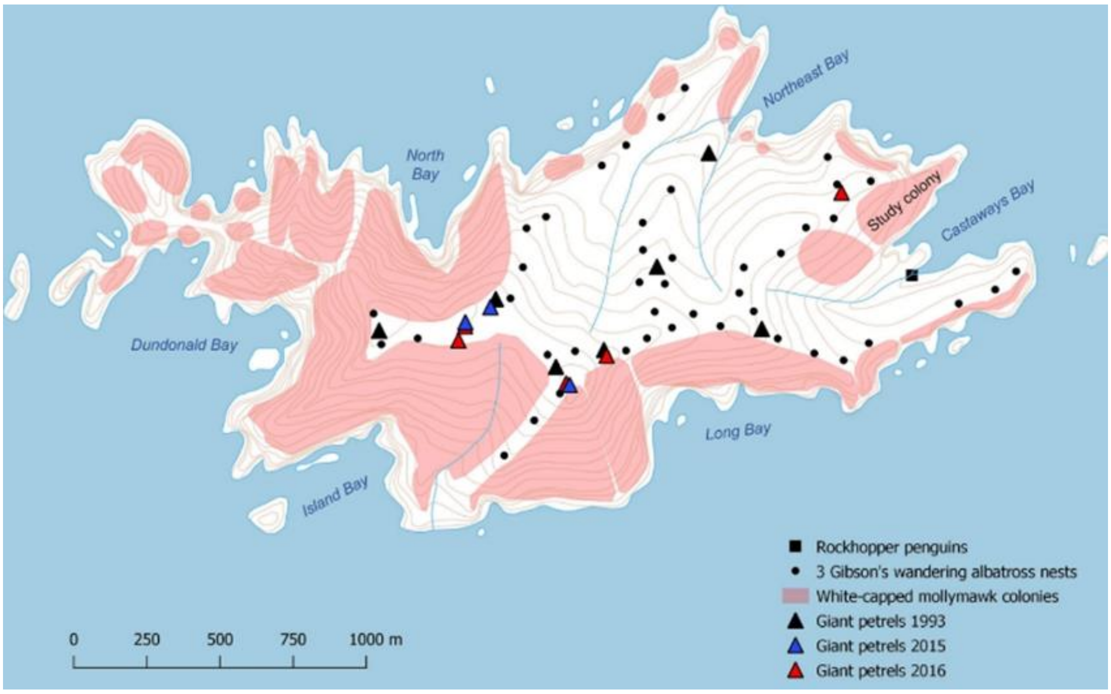

Figure 6. The location of white-capped albatross colonies (pink shading) on Disappointment Island, with most on steep dissected ground at the western end of the island. Drone trials have so far only been undertaken in the Castaway Bay study area colony (map reproduced from Walker et al 2020).

Figure 7. White-capped albatross nesting at the western end of Disappointment Island in Jan 1993, with one of the steep cliffs visible on the left, which are likely to require different drone techniques to those trialled so far. (Note for scale 2 people on lower right)

and the Department of Conservation's National Eradication Team recently had one produced for most of the Auckland Islands, but not Disappointment Island.

Drone flights must be planned to allow for concurrent ground-truthing since the number of non-breeding (loafing) birds on the ground varies between colonies (Thompson et al. 2015, Parker et al. 2017). Full counts of matched calibration blocks, as here and last year, would be implausible in the steep cliffs at the northern and western parts of the island, but transects to sample the birds/nests ratio in a given area while it is being overflown are feasible, even in difficult terrain (Parker et al. 2017). Ground-truthing is such an essential part of a reliable count of white capped albatross that comprehensive, concurrent ground-truthing transects should be built into planning.

Depending on the outcome of the trials described above, about 25 batteries and several dry, relatively calm, clear days to drone all the white-capped albatross colonies may be sufficient to photograph the whole island using a DJI Mavic 2 Pro drone or similar. Given the weather is frequently windy, wet, and misty, it is likely to take double that time to obtain enough "drone-able" weather. Travel time carrying enough batteries to the western-most portion of the island to drone all the cliffs there would also need to be factored in. A small generator and some fuel to re-charge batteries whilst on the island would be required, The DJI Mavic 2 Pro drone used in February 2023 is no longer manufactured and extra batteries might be difficult to source. A new, but similar, drone (DJI Mavic 3) has a longer battery life and readily available spare parts.

RECOMMENDATIONS

Survival and Productivity

- Robust estimates of survival and productivity of white-capped albatross requires continued and longer annual trips to Disappointment Island and given so many birds are still being caught in fisheries, such trips are a priority.

- The optimal time for mark-recapture study is early February when mate changeovers are most frequent and desertion due to disturbance or absence of adults at the end of chick guard stage is rare.

- In addition to prioritizing effort to re-sight banded birds, renewed effort (time) is needed to build on the banded study population.

- Solving the problem of camera stability should be a high priority to increase the length of time known nesting attempts can be followed.

- To obtain more robust estimates of productivity, a brief visit to Disappointment Island in late November/early December to set up cameras on active nests is desirable.

- Funding for in-depth examination of any improved camera image series should be set aside to allow calculation of daily nest survival using the techniques of Dinsmore et al. (2002).

Aerial Census

Drone census of nesting birds on the island is feasible but will require an improved digital elevation model of the island, trials to work out how the drone should be flown on very steep slopes to maintain a constant distance from the ground, and planning for ground-truthing transects to be undertaken at the same time as areas are droned.

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