Population studies of southern Buller's albatross on The Snares

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Executive summary

This report presents a summary of the results of demographic studies at three study colonies of southern Buller's albatrosses *Thalassarche bulleri bulleri* breeding at The Snares from 27 March to 13 April 2022.

Demographic studies at the three study colonies on North East Island have been undertaken annually from 1992 to 2022, with the exception of 2018 and 2021, and so this report incorporates some of these data in the current analysis. Estimates of the numbers of breeding pairs, made by recording the contents (chick, egg or egg fragments) of each nest mound, increased in two of the three colonies to over the numbers recorded during 2020 to be at all-time highs for the 30-year duration of the study. With the assumption that the combined total number of breeding pairs in the three study colonies was representative of North East Island as a whole, and notwithstanding the maximal counts in two of the study colonies recorded in 2022, then the breeding population probably peaked around 2005-2006 and has since undergone marked annual variations.

A total of 379 birds were recaptured that had been banded previously in the study colonies as breeding adults of unknown age. A further 137 breeding birds were banded in the study colonies - these are presumed to be first-time breeders – during the latest 2022 survey. Estimates of annual survival of birds banded as breeders continued to decline, with estimates close to 0.9, or lower, in recent years. During the period 1992-2004 all chicks that survived to near-fledging in the study colonies were banded and their survival to return to the study colonies in subsequent years has been monitored. In 2022, 139 of these birds were recaptured, with birds from cohorts banded from 1996 to 2004 being recaptured for the first time. This demonstrates the long-term monitoring required to obtain reliable estimates of survival of such known-age birds. Of these recaptured 139 known-age birds, 11 were found breeding for the first time, and so were recorded as being recruited to the breeding population. In addition, three birds that had been banded as near-fledging in the study colonies during September 2013 and September 2014 were also recaptured for the first time.

In 2020 50 Global Location Sensing (GLS) tags were attached to the metal leg bands of breeding birds in the Mollymawk Bay study colony; of these, 31 were retrieved, and a further 7 recorded as being lost, during the 2022 field season.

Twelve trail cameras were deployed at breeding colonies during the 2022 fieldwork: 11 set to record one photograph every hour during daylight, and one set to record 30 seconds of moving images daily, until they are retrieved in April 2023.

1 Background

This project was funded by the Conservation Services Programme, Department of Conservation (CSP, DOC: project POP201904). The primary purpose of the project was to continue the demographic study at three study colonies at Tini Heke or the Snares Islands ('the Snares') of breeding southern Buller's albatrosses *Thalassarche bulleri bulleri*, which had been initiated in 1992 and continued annually to 2022, with the exception of 2018 and 2021. The specific objectives of the project were to:

1. Determine the numbers of pairs breeding in the three established study colonies.
2. Estimate annual survival of banded birds from recapture data.
3. Retrieve 50 Global Location Sensing (GLS) tags deployed on birds in 2020.
4. Deploy 12 trail cameras in colonies to record activities at nests over a full 12-month period.

This report describes the field work completed from 27 March to 13 April 2022 at the Snares under contract POP2019-04 to the DOC in accordance with Wildlife Act Authority 96049-FAU and Entry Permit 97913-LND.

Fieldwork centred on the population dynamics of southern Buller's albatross, particularly population size, adult survival, breeding frequency, and recruitment of known-age birds in three long-term study colonies on the Snares. Demographic data of southern Buller's albatrosses in these study colonies at The Snares were recorded annually in 1992-2017 and 2019-2020.

2 Methods

2.1 Logistics

Transport to The Snares was provided by the vessel FV *Awesome* (skipper, plus two crew). The field team (comprising David Thompson (field leader, NIWA), Paul Sagar (NIWA) and David Sagar (DOC)) were dropped off at Boat Harbour, North East Island, at 08:00 on 27 March 2022. After weather and sea conditions caused several cancellations of the pick-up by the FV *Awesome* the field party was eventually returned to Invercargill by helicopter on 13 April, five days after the scheduled pick-up date.

The Snares (48°01'S, 166°36'E) comprise North East Island (280 ha) and Broughton Island (90 ha), plus numerous islets and stacks (Figure 2-1). The laying period of southern Buller's albatrosses at The Snares extends from late December to the end of February, with most eggs laid by late January (Sagar & Warham 1998). Hatching occurs from mid-March with a peak in the first week of April. Therefore, in 2022 the timing of population counts was scheduled to occur close to the end of incubation, when most birds sitting on a nest were assumed to have shorter incubation stints, and so change-overs at the nests were more frequent and allowed a greater proportion of partners to be captured/recaptured. Capturing a greater number of breeding birds reduces the uncertainty around estimated mean annual survival rates, and so allows greater confidence in the data.

2.2 Study colonies

Each of three study colonies (Upper Punui Bay, Lower Punui Bay and Mollymawk Bay) on North East Island was visited 4-6 times; Upper Punui Bay and Lower Punui Bay on 27 and 31 March and 4, 5, 7

and 10 April 2022, and Mollymawk Bay on 28 March and 2, 6 and 9 April 2022. On the first visit to each colony, all nests were inspected, and the contents (chick, egg or egg fragments) recorded. Band numbers of all adult birds associated with these nests were recorded and any unbanded birds incubating were captured and fitted with a uniquely numbered stainless-steel leg band. All adult birds recorded on this first visit were marked with blue raddle (a temporary stock marker) so that they were not recaptured, and disturbed, on subsequent visits. On the second and subsequent visits to each colony, all nests were checked again, and any birds not marked with raddle were captured and band numbers recorded, or leg bands applied, as appropriate. In addition, on each visit an attempt was made to recapture as many as possible of the banded non-breeding birds that were loafing in the colonies.

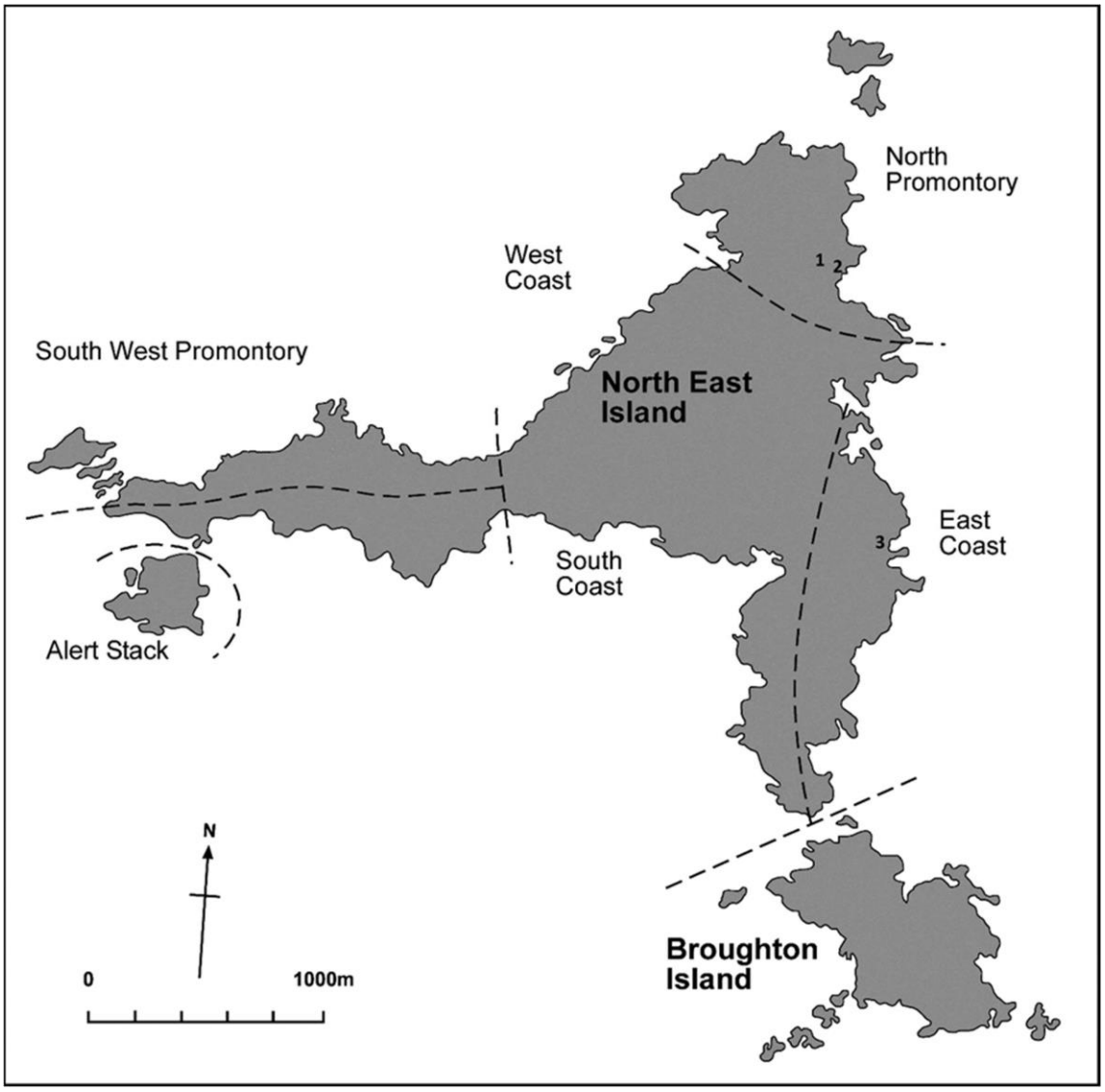

Figure 2-1: Tini Heke the Snares, with locations of study colonies on North East Island. 1, Upper Punui Bay; 2, Lower Punui Bay; 3, Mollymawk Bay. Dashed lines indicate boundaries of areas for whole-island counts of breeding pairs of southern Buller's albatross (although such counts were not undertaken in 2022).

GLS devices were deployed on 50 breeding birds in the Mollymawk Bay study colony on 15 March 2020. During 2022, as birds on these nests were recaptured, any GLS tags were also retrieved.

A total of 12 trail cameras were deployed with each camera attached to either a warratah or a suitable branch so that it overlooked 4-6 breeding birds. Three cameras were deployed in the Upper Punui Bay and Mollymawk Bay study colonies, three were deployed in a colony on the south side of Punui Bay and two were deployed in a colony on the north side of Punui Bay. Each of these cameras was programmed to take a still image every hour during daylight. The final, twelfth camera was also deployed in the colony on the south side of Punui Bay, but was programmed to record moving video imagery for 30 seconds at midday, daily.

2.3 Banded birds outside study colonies

When traversing the island to and from study colonies, as many birds as possible were checked for leg bands. In most years, banding of birds was restricted to the three study colonies, but breeding birds have on occasion been banded at colonies in relatively proximity to the study colonies. This information will be used to estimate the dispersal rate of birds banded in the study colonies and could also be used to explore movements of birds into the study colonies.

2.4 Survival estimation

Survival was estimated from resight information captured from banded birds, using the mark-recapture programme Mark 9.0 (White & Burnham 1999) and a relatively simple Cormack-Jolly-Seber model. The model was run using data from 1992 to 2022, noting that 1993 was the first year for which a survival estimate was calculated, and fixing the encounter probability for the years 2018 and 2021 to zero when no visit was made to the island. All estimates of annual survival from 1993 to 2022 have been presented in this report, even though the error estimates for years 2018, 2019, 2021 and 2022 are relatively large, due to the absence of data collection in 2018 and 2021. Overall, this data set comprised 1737 birds banded across all years (1992-2022).

3 Results

3.1 Number of occupied nests

Totals of 94, 59 and 150 nests with a chick or an egg were counted in the Upper Punui Bay, Lower Punui Bay and Mollymawk Bay study colonies, respectively (Figure 3-1). Included in these totals were five nests in Mollymawk Bay each containing an abandoned (cold) egg or egg fragments indicating an egg that had been laid but broken earlier that season. In Lower Punui Bay one nest contained an abandoned egg and another had the remains of a broken egg, while at Upper Punui Bay there were no indications of abandoned or broken eggs.

The 2022 totals represent increases, relative to numbers counted in March 2020, in the Mollymawk Bay and Upper Punui Bay study colonies of 11.1% and 22.1%, respectively, and a decrease of 10.2% in the Lower Punui Bay study colony.

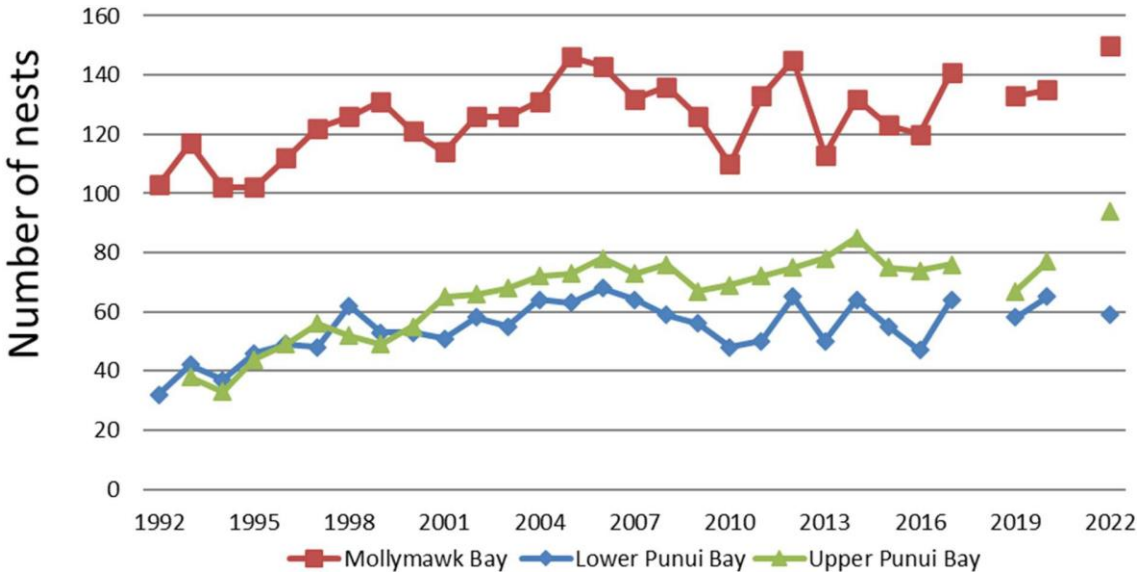

Figure 3-1: Number of breeding pairs (nests) of southern Buller's albatrosses counted annually at three study colonies, Tini Heke the Snares 1991-2022. No check was made of the study colonies in 2018 and 2021, hence the gaps in the time-series data.

3.2 Adult survival

A total of 379 birds were recaptured that had been banded previously as breeding adults of unknown age in the study colonies. This total comprised breeding birds, non-breeding birds, and failed breeders. In addition, a further 137 breeding birds (i.e. birds that were incubating or brooding a chick) were banded within the study colonies in 2022. Because birds breeding in the study colonies have been checked annually, and any new birds banded since 1992, we assumed that any birds captured that are not banded are first-time breeders in the study colonies, and so likely to be 10-12 years old, the average age of first breeding (Francis & Sagar 2012).

All banding data (newly banded birds plus recaptures) have been submitted to the Banding Office, DOC, Wellington.

Estimates of annual survival are presented in Table 3-1 and plotted in Figure 3-2. Annual survival was relatively high prior to 2012, with values generally in excess of 0.95, from which point estimates tended to decline and were generally less than 0.92 through to 2020 (Table 3-1, Figure 3-2).

Table 3-1: Estimates of annual survival, and the associated standard error, for southern Buller's albatrosses at Tini Heke the Snares, 1993-2022.

Year	Survival Estimate	Standard Error
1993	0.972	0.01
1994	0.976	0.01
1995	0.928	0.01
1996	0.981	0.01
1997	0.957	0.01
1998	0.971	0.01
1999	0.974	0.01
2000	0.959	0.01
2001	0.934	0.01
2002	0.941	0.01
2003	0.957	0.01
2004	0.956	0.01
2005	0.944	0.01
2006	0.934	0.01
2007	0.920	0.02
2008	0.956	0.02
2009	0.943	0.02
2010	0.913	0.02
2011	0.951	0.02
2012	0.907	0.02
2013	0.937	0.02
2014	0.917	0.02
2015	0.924	0.02
2016	0.903	0.03
2017	0.895	0.03
2018	0.921	13.85
2019	0.920	13.84
2020	0.858	0.03
2021	0.820	17.78
2022	0.891	17.51

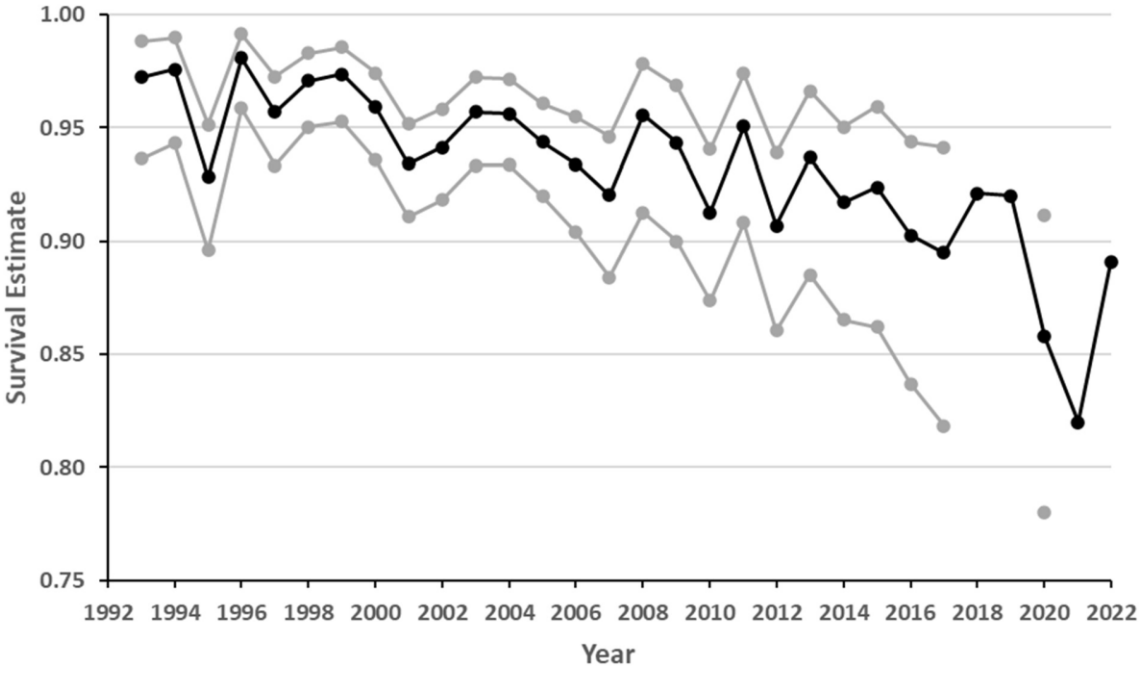

Figure 3-2: Plots of estimated annual survival, and upper and lower 95% confidence intervals, for southern Buller's albatrosses at Tini Heke the Snares, 1993-2022. Survival estimates are shown by black dots joined by black lines, with confidence intervals shown by grey dots joined by grey lines. For clarity, 95% confidence intervals for 2018, 2019, 2021 and 2022 are not shown due to their large size.

3.3 Return rate of known-age birds

The return rate of known-age southern Buller's albatrosses is the proportion of a cohort of chicks that is recaptured several years after banding. Of the 2765 birds banded as chicks near fledging in the study colonies and adjacent colonies between 1992 and 2004, 139 were recaptured during March-April 2022. These birds were from cohorts banded between 1996 and 2004. The oldest known-age birds recaptured in the three study colonies for the first time were from the 1996 cohort, and so were 26 years old. This indicates that many more years of recapture effort are required to obtain reliable estimates of the survival of these known-age birds.

Of the 1991 birds banded as chicks near fledging in the study colonies during the period 1992-2004 (which would now be at least 18 years old), 577 (29.0%) have been recaptured. The lowest rate of return (14.9%, 16 recaptured from 107 banded) is for the 2003 cohort in Punui Bay (Lower and Upper Punui Bay study colonies combined) and the highest rate of return (44.3%, 27 recaptured from 61 banded) from the 1995 cohort was in these same colonies (Table 3-2).

With just one bird recaptured in the three study colonies during March-April 2022 from the 1992 to 1998 cohorts banded it is unlikely that many further birds from these cohorts will be recorded. A plot of the overall return rate (all three study colonies combined; Figure 3-3), shows that the percentage of banded known-age birds returning to the study colonies varied from 26.7% (1996 cohorts) to 39.3% (1995 cohort) for the cohorts banded from 1992 to 1999. Currently, the return rate of cohorts banded 2000-2004 varied from 20.9% (2001 cohort) to 33.0% (2004 cohort), indicating that more birds from these cohorts have yet to be recaptured.

Table 3-2: Number (with % of total banded in brackets) of southern Buller's albatrosses, banded as well-grown chicks in 1992-2004, returning to Tini Heke the Snares. Data are presented by study colony of provenance, with Upper and Lower Punui Bay colonies combined.

Colony/ cohort	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mollymawk Bay	19 (27.1)	28 (31.8)	26 (37.1)	6 (26.1)	19 (22.4)	19 (20.0)	32 (39.5)	31 (35.2)	25 (28.1)	17 (21.0)	22 (23.2)	30 (31.6)	27 (27.3)
Punui Bay	18 (39.1)	13 (22.4)	17 (39.5)	27 (44.3)	21 (32.3)	29 (38.7)	21 (27.3)	12 (23.5)	20 (23.8)	17 (20.7)	23 (24.5)	16 (14.9)	35 (39.3)

One of 40 birds banded as chicks near fledging in the study colonies during September 2013 was recaptured; the second bird from this cohort to be recaptured back on the island (the first was in 2020). In addition, two of 83 birds banded as chicks near fledging in the study colonies during September 2014 were recaptured; the first birds from this cohort to be recorded back on the island.

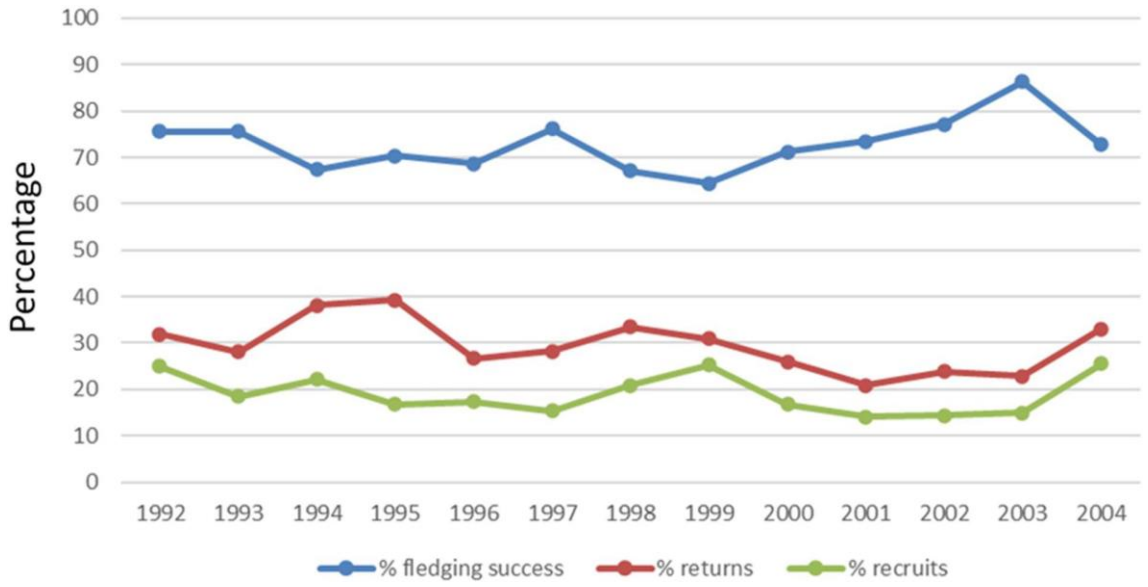

Figure 3-3: Fledging success and return and recruitment rates of southern Buller's albatrosses banded as chicks in three study colonies at Tini Heke the Snares, 1992-2004.

3.4 Recruitment rate of known-age birds

The recruitment rate of known-age southern Buller's albatrosses is the proportion of a cohort of chicks that is recaptured as breeding adults several years after banding: the recruitment rate is invariably less than the return rate because of mortality in the years between returning and the first breeding attempt.

In March-April 2022, 12 known-age birds, banded as chicks in the study colonies 1992-2004, were found breeding for the first time in the study colonies, i.e., they had recruited to the breeding population. Of these, four were aged 18 years (banded as chicks in 2004), one was aged 19 years (banded as a chick in 2003), one was aged 20 years (banded as a chick in 2002), three were aged 21 years (banded as chicks in 2001), one was aged 23 years (banded as a chick in 1999), and two were aged 24 years (banded as chicks in 1998).

A plot of recruitment rate, by cohort, of birds banded as chicks in the period 1992-2004 (Figure 3-3) shows an apparent decline throughout most of this period. However, given that the mean age of first breeding of southern Buller's albatrosses at The Snares is 10-12 years (Francis & Sagar 2012), more birds from the later cohorts are likely to be recorded as breeding in the future. Therefore, it is probably prudent to estimate recruitment only for the 1992-1999 cohorts, i.e., birds aged between 20 and 27 years. Currently, these estimates range from 8.4% for the 1997 cohort from Mollymawk Bay to 32.6% for the 1992 cohort from Punui Bay (Table 3-3). In addition, there is considerable variation in the recruitment rate both between years and between colonies in the same year (Table 3-3).

Table 3-3: Numbers (with % of total banded in brackets) of known-age southern Buller's albatross recruits (i.e. returning to breed) to Tini Heke the Snares. For cohorts banded 1992-1999, by colony of provenance and with Upper and Lower Punui Bay colonies combined.

Colony/ cohort	1992	1993	1994	1995	1996	1997	1998	1999
Mollymawk Bay	14 (20.0)	19 (21.6)	15 (21.4)	2 (8.7)	11 (12.9)	8 (8.4)	17 (21.0)	24 (27.3)
Punui Bay	15 (32.6)	8 (13.8)	10 (23.3)	12 (19.7)	15 (23.1)	18 (24.0)	16 (20.8)	11 (21.6)

A plot of the overall recruitment rate (all three study colonies combined; Figure 3-3), shows that the percentage of banded known-age birds from the 1992 to 1999 cohorts that returned and survived to breed varied from 15.3% (1997 cohort) to 25.2% (1999 cohort). Currently, the recruitment rate of known-age birds banded from 2000-2004 varies from 14.1% (2001 cohort) to 25.5% (2004 cohort), with more birds likely to be recorded from these cohorts in the future.

Despite searches for banded birds being made in other colonies adjacent to the three study colonies, some birds, particularly females, will have settled to breed elsewhere on North East Island (Sagar et al. 1998), and so the percentage returns from each cohort should be considered as a minimum (see also section 4.3 below).

At the Snares, breeding birds were banded during studies in 1948, 1961 and in most years between 1967 and 1977. No birds from these years were recorded during March-April 2022. In addition, 859 well-grown chicks were banded at a large number of colonies distributed over much of North East Island during August 1972 (Sagar et al. 1998). None of these birds was recorded during March-April 2022 despite repeated searches made of the breeding sites of the three remaining birds from this cohort recaptured during 2019 and 2020.

3.5 GLS deployment

GLS tags were attached to the metal band of 50 birds breeding in the Mollymawk Bay study colony on 15 March 2020. Of these, 32 were banded as adults of unknown age 1992-2020 and 18 were banded as chicks 1994-2004. From measurements of these birds it was estimated that 29 were male, 11 were female and 10 could not be assigned with confidence. Three of the birds had been tracked during a previous deployment of GLS tags in 2008-2010.

During March-April 2022 31 of these loggers were retrieved and the loss of a logger by each of a further seven birds was recorded. Of the loggers retrieved, 18 were on known males, six on known females, and seven of unknown gender. Thirteen of the loggers were retrieved from known-age birds.

All details of the GLS tag deployment have been submitted to the Banding Office, DOC, Wellington. The geolocation data await analyses and are not considered further in this report.

3.6 Placement of long-term trail cameras

Most of the birds within the study colonies breed on sloping ground under the canopy of *Veronica elliptica* and *Olearia lyalli*, and so there are few sites suitable for the placement of cameras to record the year-round activity at a number of nests within the breeding colonies. No suitable sites were available at the Lower Punui Bay study colony. However, suitable sites were found in the adjacent North and South Punui Bay colonies and the Upper Punui Bay and Mollymawk Bay study colonies.

Cameras were placed so that four to six nests were in view (Figure 3-5), and so overall these trail cameras should allow over 50 nests to be monitored through to the retrieval of the cameras, planned for April 2023.

Figure 3-4: South Punui Bay, showing an area where up to six pairs of breeding southern Buller's albatrosses could be monitored by camera. Note the two cameras side by side: one camera has been programmed to record still images, whereas the other has been programmed to record moving video images.

4 Discussion

4.1 Study colonies

Overall, information from the three study colonies suggests that the breeding population of southern Buller's albatrosses peaked during 2005-2006, then trended downward until 2010 and subsequently has been variable in the Lower Punui Bay and Mollymawk Bay study colonies, with marked annual increases and decreases, whilst numbers in the Upper Punui Bay colony have tended to increase in most years. The numbers of breeding pairs in the Mollymawk Bay and Upper Punui Bay study colonies in 2022 were higher than those recorded in any previous year since the study began in 1992. In contrast, the number of breeding pairs in Lower Punui Bay study colony showed a slight decrease over that recorded in 2020. However, the latter may be explained by the extensive growth of *Veronica elliptica* throughout the colony (Figure 4-1), which may prevent birds from occupying their previous nest mounds. It remains to be seen whether birds that are displaced from their nests sites by *Veronica elliptica* growth move to alternative sites within the Lower Punui Bay study colony or move further afield.

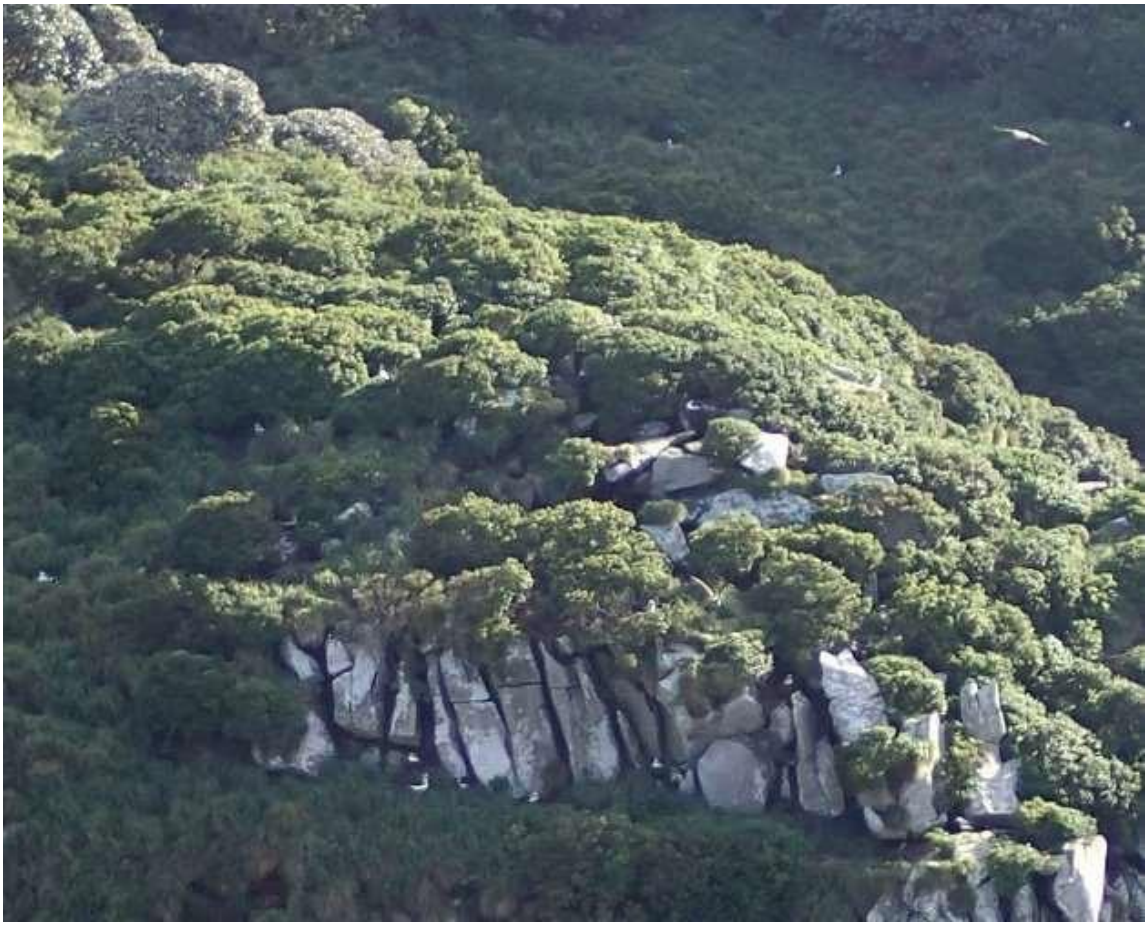

Figure 4-1: Lower Punui Bay study colony, March 2022, showing extensive growth of *Veronica elliptica*.

The trends in the numbers of breeding pairs in the study colonies until 2007 (see Figure 3-1) broadly reflect changes in annual adult survival (Sagar et al. 2000; Francis & Sagar 2012), with higher annual adult survival rates from 1992-2004 (Sagar et al. 2000) followed by declines through to 2022 (Francis & Sagar 2012; Sagar et al. 2017; Table 3-1 and Figure 3-2). Since 2012 the recruitment rate

(calculated from the numbers of newly banded birds and recaptures of known-age birds) increased from 10-11% to 16-21%, which led Sagar et al. (2017) to suggest that this is likely sustaining the breeding population and without it the population would decline. This suggestion is further supported by the results of the current trip, with a further 137 breeding birds of unknown age banded in the study colonies.

4.2 Estimated annual survival

The continued decline of the estimated annual survival rates of birds banded as breeding birds of unknown age is concerning. Since 2011 the estimated annual survival has been relatively low (<0.94), possibly, perhaps likely, at a level which is insufficient to maintain a stable population over the long-term. The estimates of 0.86, 0.82 and 0.89 for 2020, 2021 and 2022, respectively, are the lowest three values recorded during the entire 30 years of the current study, notwithstanding the relatively high levels of uncertainty around these recent estimates.

It is also noteworthy that while the estimates of the standard error of the annual survival estimates have ranged from 0.01 to 0.03 during most years, the effect of missing a year of recaptures increased the standard error to >13 in both the year of no recaptures and the subsequent year. Thus, while the relatively low estimates of annual survival noted above are in keeping with the declining trend in this parameter since 2011, additional recapture data would be required in order to reduce uncertainty in these most recent estimates.

4.3 Return and recruitment rates

The return and recruitment rates of known-age birds banded from 1992-2004 shows considerable variation both within colonies between years and between colonies within the same year. Although future field work is likely to increase both the return and recruitment rates for the cohorts 2000-2004, few new birds are likely to be recaptured from cohorts banded 1992-1999 inclusive.

In this report we refer to return and recruitment *to the study colonies* and have noted the ages of birds banded as chicks and which were encountered (returned or recruited) in the study colonies for the first time. It is possible that some birds encountered for the first time in the study colonies could have been present, or present and breeding, elsewhere on the island prior to recapture within the study colonies. Sagar et al. (1998) reported that of 86 birds recaptured as breeders from 859 birds banded as near-fledged chicks in 1972, 57 (66%) were within 100 m of their natal nest site. The remaining 29 birds had dispersed over distances ranging from 100 to 2,430 m, with a median distance of 520 m. Furthermore, of those birds that could be sexed based on morphology, 15 of 17 (88%) of males were within 100 m (and the remaining two males were within 200 m) of their natal nest sites, whereas only five of 15 (33%) females were within 100 m of their natal nest sites, indicating that of birds which moved more than 100 m from their natal nest site, females were more likely to do so compared to males.

As noted above (section 4.1) it will be important to monitor recruitment rates for birds joining the breeding population over the last ten years or so, if, as we suggest, increased levels of recruitment currently offset the effects of declining annual survival in maintaining the southern Buller's albatross population at the Snares. Furthermore, a pattern of increasing recruitment will likely also result in a reduction in the age of first breeding, and so it will be interesting to see if this is observed in recruiting birds banded as chicks in 2013 and 2014.

4.4 Trail cameras

Despite all the years that southern Buller's albatrosses have been studied at the Snares, beginning with Lance Richdale in 1948, the only season when breeding was followed from start to finish was in

1971-72 when Carol Horning diligently visited the Mollymawk Bay study colony daily at key times through the breeding cycle; so that is the only season for which we have both laying dates and fledging dates to calculate breeding success. Laying dates are available from the 1968-69, 1969-70, 1970-71, 1974-75 and 1976-77 seasons, but there are no fledging data from those seasons. For our current study, which began in 1992, we have estimated breeding success from 1992 to 2004 from the numbers of eggs estimated to have been laid and the numbers of chicks banded near fledging. Consequently, deployment of the trail cameras will provide further information about such key events as the timing of return of adults to the breeding colonies, estimated breeding success and the timing of departure from the breeding colonies.

5 Recommendations

It seems reasonable to conclude that estimates of adult survival for southern Buller's albatross at the Snares over the last ten years or so are relatively low, and that the overall stable population trend,

with annual fluctuations, since about 2006-06 is possibly being maintained by increased levels of recruitment from the 'pool' of non-breeding birds. It would therefore be prudent to continue acquiring recapture data for breeding birds at the three study colonies to confirm that adult survival is indeed at levels that would, over the long-term, result in a declining population trajectory, and to reduce the uncertainty around recent estimates of adult survival resulting from no recapture data for two years when the population was not visited. Perhaps a more comprehensive modelling approach could be applied to the entire data set to estimate parameters other than adult survival. Such modelling could follow that undertaken by Francis & Sagar (2012), which used NIWA's 'SeaBird' model and incorporated data up to and including those from 2007. However, a comprehensive re-modelling of southern Buller's albatross data would be beyond the scope of this project and would ideally require a separate project that could incorporate 'new' data from 2008-2023 when this project is completed. A re-run of the modelling undertaken by Francis & Sagar (2012) would additionally be beneficial for future iterations of the spatially explicit fisheries risk assessment: for example, the most recent seabird risk assessment (Richard et al. 2020) incorporated annual survival values from 0.93 to 0.98 for southern Buller's albatross, which, on the basis of data presented in this report, may over-estimate current adult survival.

6 Acknowledgements

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