Gibson's albatross and white-capped albatross in the Auckland Islands 2019–20

Kalinka Rexer-Huber, Graeme Elliott, Kath Walker, David Thompson and Graham Parker

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Department of Conservation, Conservation Services Programme project POP2017-04 Seabird population research: Auckland Islands 2019-20

Breeding female Gibson's albatross with recently-attached satellite tracker (aerial just visible behind head)

Gibson's albatross and white-capped albatross in the Auckland Islands 2019–20

Final report to Department of Conservation, Conservation Services Programme

10 June 2020

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Summary

This report details the mark-recapture methods and findings for Gibson's albatross and white-capped albatross at the Auckland Islands. We present data on the size of the Gibson's albatross nesting population on Adams Island in 2020 and update estimates of survival, productivity, recruitment and foraging range to help identify causes of current population size and trends. For white-capped albatrosses we focus on estimating adult survival and document tracking methods and device recoveries.

Gibson's albatross. Nesting success was 56%. The survival rate of adult females and males is once again similar, having recuperated from the dramatically low female survival recorded 2006–08. However, at 90% the survival rate for both sexes remains 6% lower than before the population crash in 2005, and is probably incompatible with population recovery given ongoing limited chick production. The total estimated number of breeding pairs of Gibson's wandering albatrosses showed slow improvement 2008–13, but these gains appear to have stalled. In 2019–20 the island-wide breeding population (3,861 pairs) was the lowest recorded since the years following the crash (2008–10). In the study area 96 albatross pairs bred in 2019–20. This is the first time nest numbers there have fallen below 100 since the crash 2006–08. There were only seventeen new recruits into the study colony (new breeding birds banded). Breeding and non-breeding/failed females have different survival rates. Satellite tracking in 2019 showed breeding birds foraging largely in the Tasman Sea, while those that had failed moved further west into the Great Australian Bight. Together, survival, breeding numbers and recruitment show the slow Gibson's albatross population recovery recorded over the decade 2007–16 has stalled.

White-capped albatross. Banded white-capped albatrosses were resighted at a rate of 0.26 in the study colony of 679 banded birds. Four GLS tracking devices were retrieved, and one further bird which had lost its GLS (or had it removed) was resighted. Adult survival is estimated as 90% (95% CI 86–93), taking into account different detection rates of nesting birds and those not on nest during colony visits.

Keywords: Adams, Disappointment, mark-recapture, survival, productivity, population trend

Contents

Introduction

Assessments of the risk of commercial fisheries to seabird populations (e.g. Richard and Abraham 2013) can be affected profoundly by uncertainty in population size and uncertainty in demographic rate estimates, particularly adult survival (Walker et al. 2015). To reduce uncertainty or bias in estimates of risk from fishing, robust information is needed on key aspects of biology (survival, productivity, recruitment, trends). Long-lived, slow-breeding seabirds that are vulnerable to accidental capture in commercial fisheries are the focus here: Gibson's albatross *Diomedea antipodensis gibsoni* and white-capped albatross *Thalassarche steadi*. Both are species of high conservation concern (Robertson et al. 2017; BirdLife International 2018a, b).

Gibson's wandering albatrosses are endemic to the Auckland Island group. About 95% of the population breed on Adams Island, with small numbers on Disappointment Island and a handful on main Auckland Island (Elliott et al. 2020). They forage largely in the Tasman Sea, but also along the continental shelf off southern and south eastern Australia and off eastern New Zealand (Walker and Elliott 2006). Gibson's albatross survival, productivity, recruitment, and population trends have been monitored during annual visits to Adams Island since 1991. In the 1990s the population slowly increased following a major, presumably fisheries-induced, decline during the 1980s (Walker and Elliott 1999; Elliott et al. 2020). However, between 2004 and 2006 there was a sudden 68% drop in the size of the breeding population, from which recovery has been very slow. The Gibson's wandering albatross population is still less than half of its estimated size in 2004, having lost the gains slowly made through the 1990s (Walker et al. 2017; Rexer-Huber et al. 2019).

The white-capped albatross is also endemic to New Zealand, with ~95% of the population breeding on Disappointment Island (Baker et al. 2014). White-capped albatrosses are caught as incidental bycatch in commercial fisheries in New Zealand, and caught in substantial numbers in fisheries off South Africa despite substantial reductions in captures since the late 1990s (Ryan et al. 2002; Watkins et al. 2008; Francis 2012; Rollinson et al. 2017). Mortality in high seas fisheries remains largely unknown.

A white-capped albatross study area was established on Disappointment Island in January 2015 (Thompson et al. 2015) and data suitable for estimating demographic parameters like adult survival and for population trend assessment has been collected annually since then (Parker et al. 2017; Rexer-Huber et al. 2018, 2019). Estimates of white-capped albatross numbers have so far been based on aerial photographs interpreted to estimate the number of nesting birds present, starting in 1985 then most years since 2006 (Baker et al. 2014, 2018; Walker et al. 2020). Tracking data are also collected at the Disappointment Island study area to build on existing knowledge about the at-sea range of white-capped albatrosses (Thompson and Sagar 2008; Thompson et al. 2009; Torres et al. 2011).

In 2019–20 this work continued on behalf of the Department of Conservation's Conservation Services Programme (CSP), collecting information to estimate key demographic parameters for modelling and understanding the species' conservation status. Here we report on the following specific aims and objectives:

- Gibson's albatross research aimed to build on estimates of survival, productivity and recruitment at Adams Island, and provide information on the size and trend of the population. Foraging range data are also explored (note this was not part of the CSP contract).
- The white-capped albatross component focused on collecting resight data from the study colony on Disappointment Island and estimating adult survival.

Methods

Timing and logistics

Seabird research in the Auckland Islands took place over the period December 2019–February 2020, conducted by the same two-person team throughout. Seven weeks were spent on Adams Island (25 December–11 February), mainly for Gibson's albatross research focusing on population monitoring and tracking. During that time, one and a half days were spent on Disappointment Island 21–23 January for research on white-capped albatross.

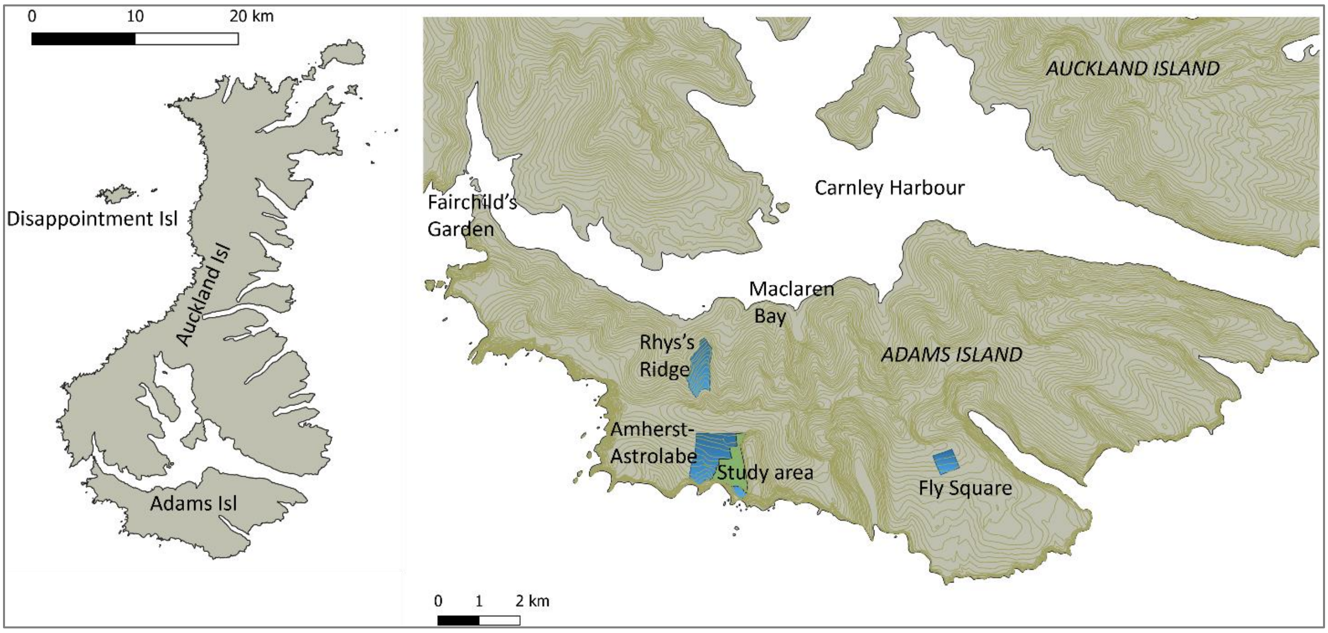

Figure 1. Auckland Island group (left) with inset of with Adams Island at right. Areas in blue are representative nest-count blocks for Gibson's albatross, and the Gibson's study area is shown in green

The MV *Tranquil Image* brought us from Bluff to the Auckland Islands, delivering us to Adams Island on 25 December. Work on Disappointment Island was enabled by the MV *Awesome*. We were collected from Maclaren Bay on 21 January at 9am and transferred to Disappointment Island and returned to Adams Island on 23 January around noon. *Awesome* also picked us up for return to Bluff by 13 February.

Gibson's albatross

Mark-recapture study

Each year since 1991 a 61ha study area on Adams Island (Fig. 1) has been visited repeatedly to leg-band nesting birds and collect resightings of already banded birds. The wider areas around the study area (within a kilometre) are visited less frequently and any banded birds are recorded. All birds found nesting within the study area have been double-banded with individually numbered metal bands and large coloured plastic bands, and since 1995 most of each year's chicks have also been banded. The proportion of chicks that are banded each year depends on the timing of the research field trips which in turn is dependent on the availability of transport. In 24 of the last 30 years researchers have arrived at, or soon after, the time at which the first chicks fledge and more than 90% of the chicks were still present and were banded. In the other six years researchers arrived late and as many as 45% of the chicks had already fledged and were not banded.

Survival is estimated from the banded birds with maximum likelihood mark-recapture statistical methods using the statistical software M-Surge (Choquet et al. 2005). For the models in M-Surge, adult birds are categorised by sex and by breeding status: non-breeders, successful breeders, failed breeders, and sabbatical birds taking a year off after a successful breeding attempt. Birds in each of these classes have quite different probabilities of being seen on the island but similar survival rates, so the models estimate resighting probabilities separately for each class, but survival is estimated separately only for males and females, and for breeding and non-breeding birds.

Population size is estimated by multiplying the actual counts of birds in each class by the re-sighting probability produced when estimating survival. The survival estimates assume no emigration which is appropriate because wandering albatrosses have strong nest site fidelity, a pair's separate nesting attempts are rarely more than a few hundred metres apart, and birds nesting at new sites within a few hundred metres of the study area are detected during the census of surrounding country (Walker and Elliott 2005).

Nest counts in representative blocks

Since 1998, all the nests in three census areas (Fig. 1) have been counted each year. The three areas support about 10% of the Adams Island albatross breeding population and represent high density nesting habitat (Fly Square), medium density (Astrolabe to Amherst including the 61 ha mark-recapture study area) and low-density habitat (Rhys's Ridge).

Counts are carried out between 23–31 January just after the completion of laying, and as close as possible to the same date at each place in each year. A strip search method is used where two observers walk back and forth across the area to be counted, each within a strip about 25 m wide programmed on a GPS, and count all the nests with eggs in their strip. Every bird on a nest is checked for the presence of an egg, and each nest found with an egg is marked by GPS and counted. All non-breeding birds on the ground are also counted, and they and most breeding birds on eggs are checked for leg bands, the number and location of which are recorded. Once the whole block has been counted, the accuracy of the census is checked by walking straight transects at right angles to the strips, marking all nests within 10–15 m of the transect by GPS and checking later to ensure the nest has been counted.

Counts are corrected to take account of any eggs not laid or any failed nests at the time of counting. These corrections are based on the repeated monitoring of nests in the study area.

Total number of nests on the island

The number of pairs of Gibson's wandering albatross nesting on the whole of the Auckland Islands was estimated from a whole-island population count done in 1997, followed by repeated counts of parts of Adams Island, including the count in 2020. The proportion of the total population in 1997 that was nesting in those parts of the island that were subsequently repeatedly counted was used to estimate the total population using the following formula:

$$\hat{t}_i = \frac{t_{1997}}{p_{1997}} \times p_i$$

Where

$\hat{t}_i$ is the estimated total number of pairs nesting in year i ;

t_{1997} is the total number of pairs counted nesting in 1997;

p_{1997} p_{1997} is the number of pairs counted nesting in 1997 in those parts of the island that were subsequently repeatedly counted; and

p_i p_i is the number of pairs counted nesting in year *i* in those parts of the island that are repeatedly counted.

This estimate assumes that the proportion $\frac{t_i}{p_i}$ is constant from year to year, which is true when the pattern of distribution of nests remains the same from year to year, as confirmed on Adams Island (Elliott et al. 2016).

Foraging range

To identify where Gibson's albatrosses might be interacting with fishing vessels, new GPS positioning data were collected by deploying twelve satellite-transmitting GPS trackers (Lotek's 'Pinpoint' tags) on breeding birds in the study area in January 2019. These complement geolocator loggers (GLS, Migrate Technology), which archive light data until device recovery, that have been deployed and retrieved since 2009 to monitor foraging range. This season we resighted six of the satellite-tracked birds, all of which had moulted off their trackers, and recovered nine GLS.

Analysis of new GLS data is outside the scope of this report but will be progressed separately. Daily GPS location data received via the Argos satellites were groomed to remove any anomalous positions by Samhita Bose of DOC's marine science unit and uploaded to the Albatross Tracker app (built by DOC and MPI; https://docnewzealand.shinyapps.io/albatrosstracker). We updated these positions with the birds' final breeding status, determined via colony inspection at the end of the breeding season, before mapping the albatrosses' movements (QGIS 3.4).

White-capped albatross

Mark-recapture study

Resightings of banded white-capped albatrosses were collected at the study colony in Castaways Bay on Disappointment Island (Fig. 1). All white-capped albatross nests and loafing birds in the study area were checked for bands. Nesting birds checked were marked with stock marker on the breast. Birds also carrying a GLS tracker were captured to remove the tracker. Incubating white-capped albatross are flighty, so we maintained best-practise release techniques (Rexer-Huber et al. 2018). A buffer of ~50m around the study area was checked in case banded birds had moved outside the study area. No new birds were banded to add to the study since on the single day available for banding, it was raining too heavily to remove birds from nests.

Survival of white-capped albatrosses in the study area is estimated with maximum likelihood mark-recapture statistical methods similar to those used for Gibson's albatross but implemented in the software package MARK via the R package RMark (White and Burnham 1999; Laake 2013; R Core Team 2019). The data 2015–20 are suitable for estimating survival in the standard CJS model (Test2+Test3 in program RELEASE; Burnham et al. 1987); see goodness-of-fit and overdispersion statistics in the Results. However, exploratory analyses showed that the data are not yet adequate for estimating time-varying annual survival rate. That is, if survival is modelled by year, some survival estimates are at the boundary (i.e. 1) indicating that the dataset does not yet cover a long enough time period for such a long-lived species. Models therefore held survival constant when testing the influence of other parameters (resighting probability, state).

White-capped albatrosses are semi-biennial (Francis 2012) which likely affects the probability of seeing a bird at the colony, as for Gibson's albatrosses. Visits to the white-capped albatross colony have been too short to allow breeding status to be determined for all marked birds resighted. For example, some 'loafing' birds standing in the colony will have been non-breeders, but others may in fact have been breeding birds just recently changed incubation at the nest from their mate. Therefore, state categories are limited to the observed state: S birds sitting on a nest with egg or chick and L birds standing in the colony whose breeding status is unknown. To assess whether state is useful for modelling white-capped albatross survival we used multistrata models (Brownie et al. 1993). We expect that white-capped albatrosses in each of these states (sit and loaf) have different resighting probabilities but similar survival rates.

Results

Gibson's albatross population parameters

Population size estimate from mark-recapture

Mark-recapture resighting probabilities and survival estimates are used to correct the actual counts of birds in the study area to estimate the full study area breeding population. The population in this area was increasing up until 2005, but between 2005 and 2012 the population declined rapidly. Since 2012 the decline has slowed, but both female and male populations show continued gradual decreases (Fig. 2).

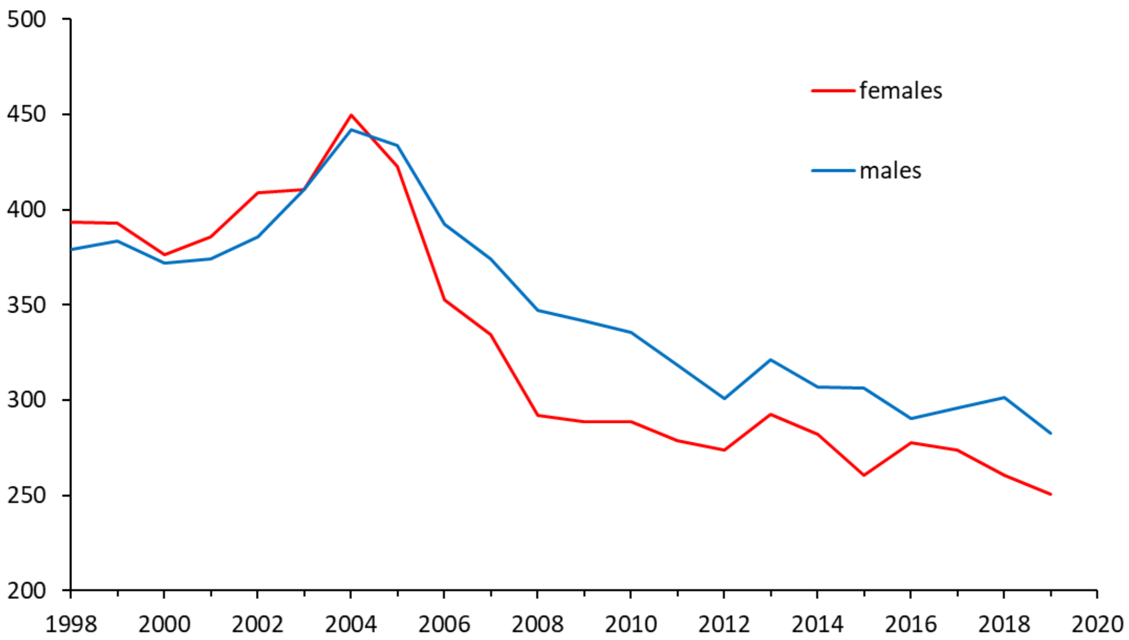

Figure 2. The number of breeding Gibson's albatrosses in the Adams Island study area estimated by mark-recapture. Note: mark-recapture population estimates are not reliable in the last year of data collection, so we show only results up to 2019

The size of the total population including pre-breeding birds (as opposed to the total number of breeders) can be estimated using the modelling techniques of Francis et al. (2015), but this is beyond the scope of this report.

Survival

Adult survival varied around a mean of about 96% up until 2004 and during this period male and female survival were not notably different. Survival dropped substantially after 2005, with female survival reaching catastrophic lows 2006–08 (Fig. 3). Female survival has improved substantially since then, and though the survival rate of the sexes is different each year, female survival is now on average about the same as male survival. However, with survival of 93% for both sexes in 2018 and 90% in 2019, survival remains markedly lower than the average prior to the crash.

Within sexes, survival often differs between breeders and non-breeders (Fig. 4). Non-breeding females generally have had lower annual survival rates than breeding females, particularly since 2013. In contrast, non-breeding males have generally had similar or slightly better survival than breeding males (Fig. 4). It is important to note that the best-supported model for Gibson's albatross survival remains the male-female model, which has lower AIC (males and females: 40525.718) than the one distinguishing between breeders and non-breeders (males and females x breeders and non-breeders: 40581.601). Despite this, it is valuable to consider those years when breeding females have vastly different survivorship than non-breeding females.

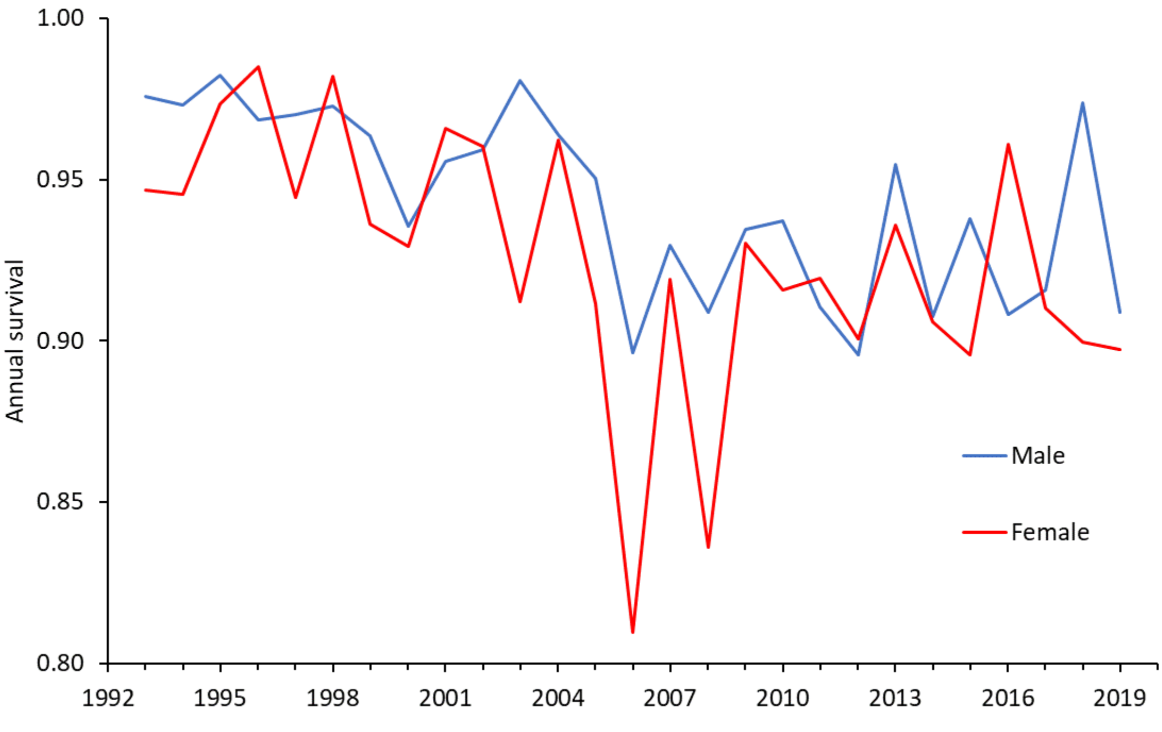

Figure 3. Annual survival of Gibson's albatross in the Adams Island study area since 1993, estimated by mark-recapture. Mark-recapture estimates of survival for 2020 are unreliable so not presented

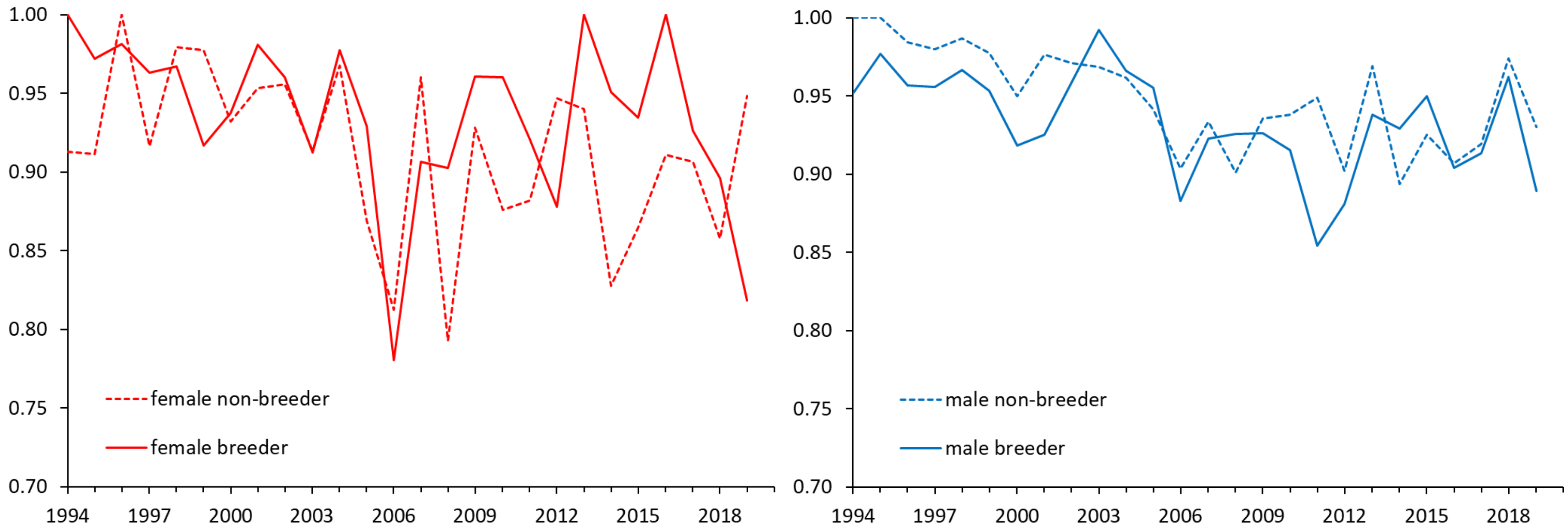

Figure 4. Survival estimated separately for breeding and non-breeding female (left) and male (right) Gibson's albatrosses, estimated by mark-recapture

Productivity and recruitment

Breeding success was estimated as 56% in 2019. This is slightly down from the 57–67% of the previous three seasons, but still healthy compared to the productivity range of 40–50% recorded 2011 to 2015 (Fig. 5, blue line). Nesting success is now comparable to levels before 2005 (pre-crash), but the number of chicks produced remains lower than pre-2005 since fewer birds are breeding (Fig. 5, orange line).

The number of birds breeding for the first time in the study area has been slowly and erratically rising, following the big decline in 2005–06, but these gains appear to have reversed with slight declines since 2016 (Fig. 6). This season is the first year since 2006 where both female and male recruitment was in the single digits (8 and 9, respectively). Many of the birds recruiting to the breeding population now were chicks fledged since the population crashed in 2006. Thus, even if young birds have high survival rates, the number of birds reaching breeding age will be low because of the low numbers of birds breeding since 2006.

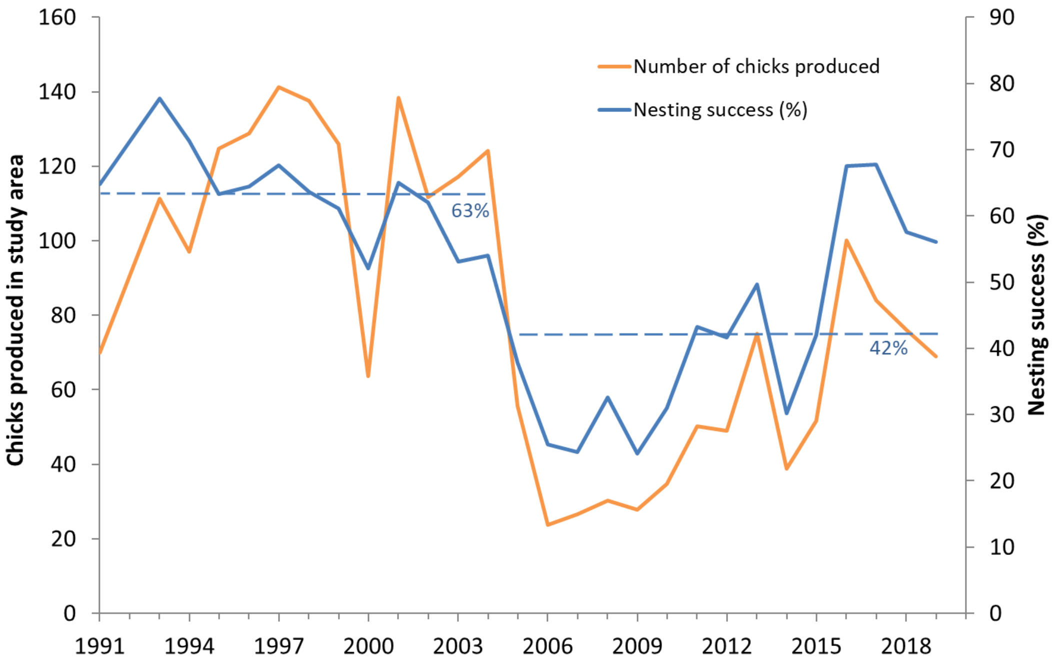

Figure 5. Gibson's albatross nesting success and the number of chicks fledged from the study area on Adams Island since 1991. Dashed lines indicate average nesting success in two periods, 1991–2004 and 2005–2019

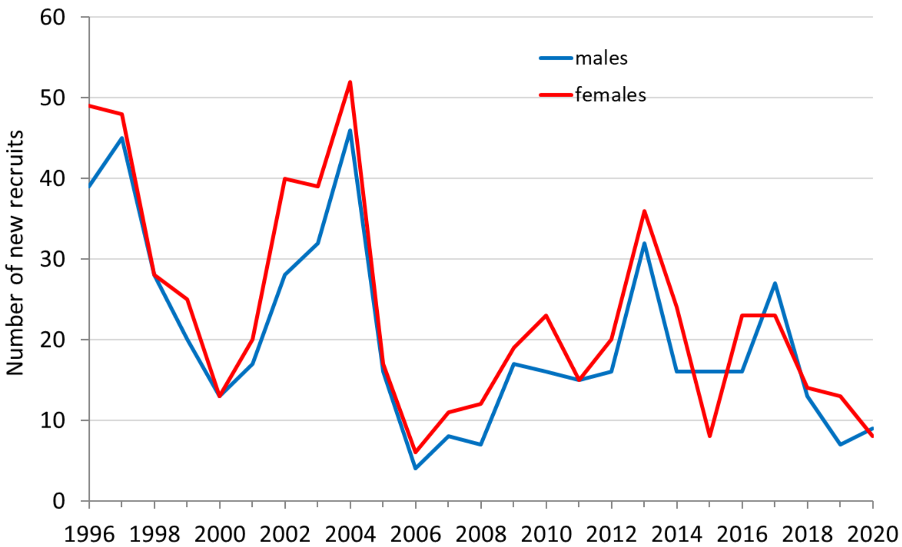

Figure 6. Recruitment: number of Gibson's albatross breeding for the first time in the study area on Adams Island since 1996

Nest counts and whole-island breeding pair estimate

The three blocks in which nests have been counted since 1998 were counted again in late January 2020, from which the total number of breeding pairs on the island were estimated. Counts were corrected to take account of as-yet unlaid eggs and nest failures at the time of census (Elliott et al. 2016).

After the number of breeding pairs dropped sharply 2004–06 by about 46%, we have seen slow growth 2007–16 with annual breeding population growth rate or lambda of 1.4 (Fig. 7 and 8). Since then recovery in breeding pair numbers has stalled (Fig. 7, 8). The whole-island breeding population is now 3,861 pairs (Fig. 8, Table 1). This is the first time the overall population has dipped below 4,000 pairs since 2010 (Fig. 8, Table 1).

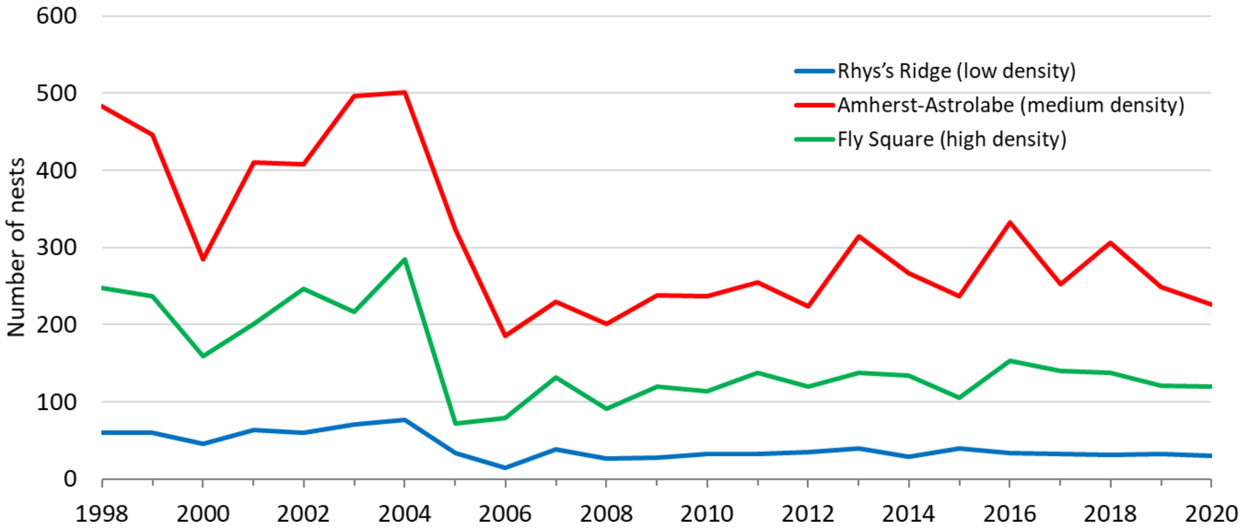

Figure 7. The number of Gibson's wandering albatross nests in three census blocks on Adams Island 1998–2020

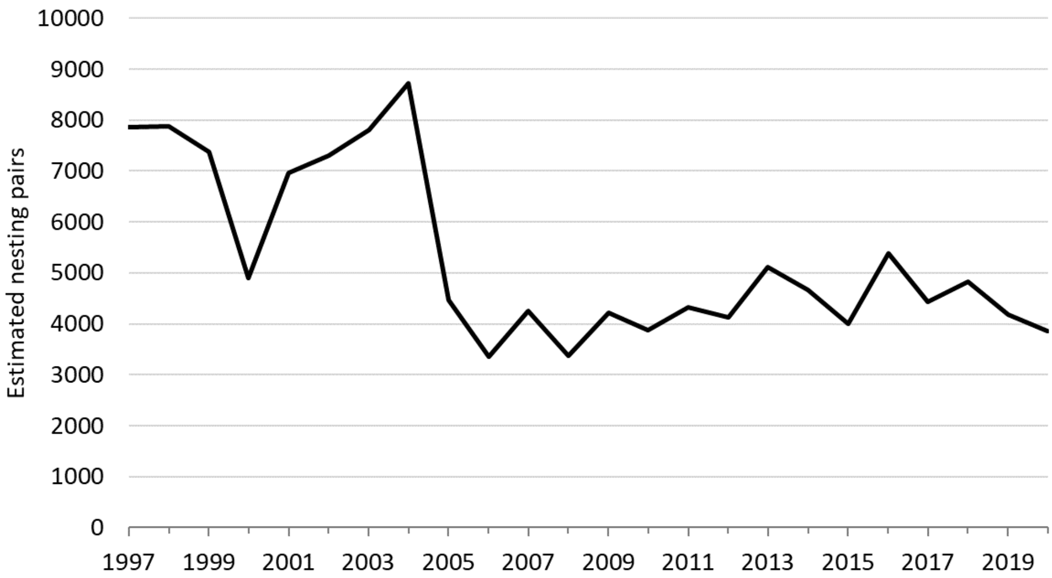

Figure 8. Breeding population size of Gibson's albatross 1997–2020. The estimated number of nesting pairs on the island is based on annual counts in the three census blocks corrected by the proportion of the total population in 1997 that was nesting in those three counted blocks

Table 1. Gibson's wandering albatross nests with eggs in late January in three census blocks on Adams Island, 1998–2020. Corrected total is the estimated number of nests in the three blocks taking account of the number of failed and unlaid nests at the time of counting. Estimated total is the estimated number of nests on the island, based on the proportion nesting in the three counted blocks relative to island-wide totals in 1997 when the last whole island count was undertaken

Year	Rhys's Ridge (low density)	Amherst-Astrolabe (medium density)	Fly Square (high density)	Total No. of nests	Corrected total	Estimated total
1997					796	7857
1998	60	483	248	791	798	7875
1999	60	446	237	743	746	7367
2000	45	284	159	488	497	4904
2001	64	410	201	675	706	6969
2002	60	408	246	714	740	7303
2003	71	496	217	784	791	7809
2004	77	501	284	862	884	8728
2005	34	323	72	429	452	4467
2006	15	185	79	279	341	3363
2007	38	230	132	400	430	4245
2008	26	201	91	318	341	3371
2009	28	238	120	386	426	4211
2010	32	237	114	383	392	3872
2011	33	255	137	425	438	4323
2012	35	224	120	379	418	4131
2013	39	315	138	492	519	5120
2014	29	267	134	430	473	4669
2015	39	237	105	381	406	4010
2016	34	332	153	519	545	5385
2017	32	252	140	424	448	4424
2018	31	306	138	475	489	4827
2019	33	249	121	403	423	4180
2020	30	226	120	376	391	3861

Gibson's albatross foraging range

Gibson's albatross tracked in 2019 were separated into those whose breeding attempt failed during the tracking period, and those that continued incubation and chick provisioning throughout. Failed breeders—four females and two males—covered a broad area from the Australian Bight to beyond the Chatham Islands and throughout the Tasman Sea in between (Fig. 9). The foraging range of these failed breeders is largely the same as the known distribution (Walker and Elliott 2006; Walker et al. 2017). All flights made by birds wearing satellite transmitters in 2019 are shown, by individual, in the appendix.

Breeding females (n=6) mainly foraged in the Tasman Sea (Fig. 10), as expected from tracking to date, although one female also foraged well into the Australian Bight, which is the range more associated with failed breeders and non-breeders (Walker et al. 2017).

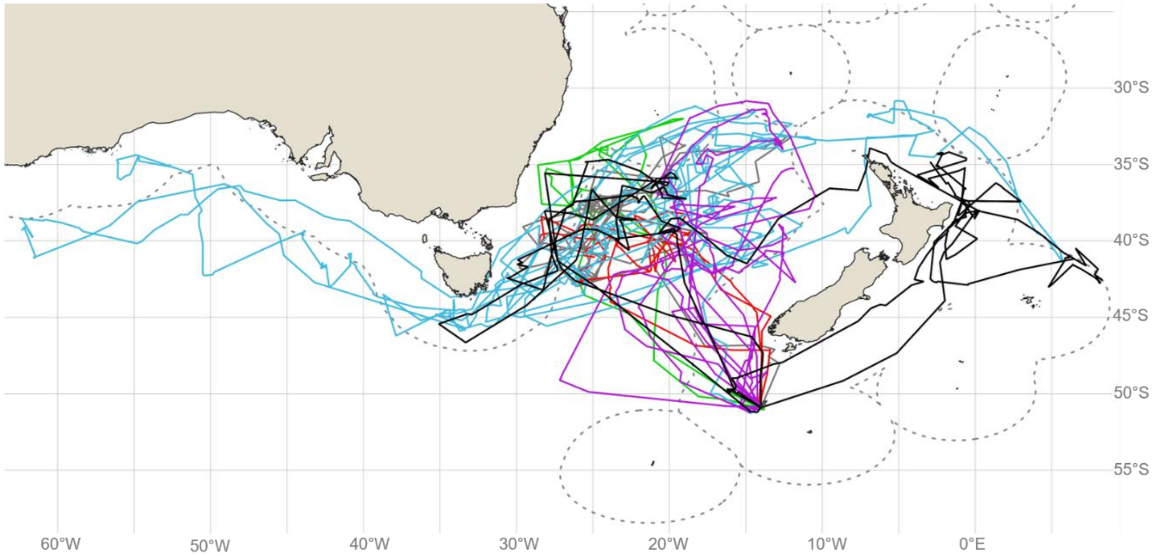

Figure 9. Foraging range of Gibson's albatross whose breeding failed during the tracking period Feb–Sept 2019. Males are grey and black (n=2) and females coloured (n=4)

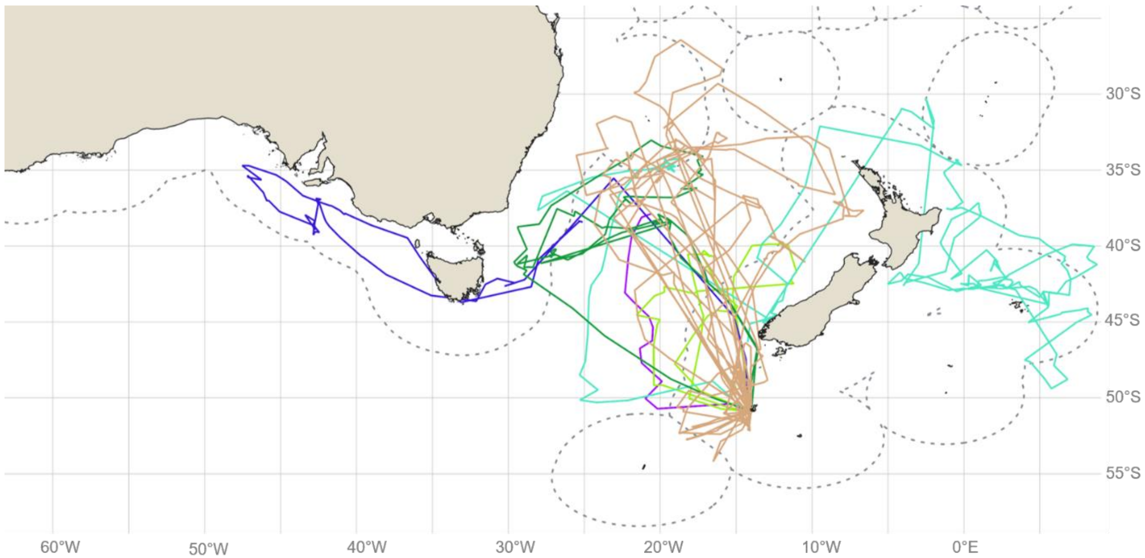

Figure 10. Foraging range of breeding Gibson's albatross tracked Feb–Sept 2019. All six are female

White-capped albatross

Mark-recapture study

A total of 175 banded white-capped albatrosses were resighted over the 1½ day visit to Disappointment Island in 2020. The resighting rate was 0.26, which is lower than the last two visits (Table 2) largely because of time-limited effort: just 11 human-hrs possible in 2020 compared to 48 human-hrs in 2019 (Table 2). The short visit also made the interval between nest checks even shorter than usual, so there were few changeovers at the nest to contribute to the tally of resighted birds. No banded birds were seen outside the original banding area.

No new albatrosses were banded to add into the study because on the day available for banding it was too wet to handle birds, and handling would have exposed pipping eggs and new chicks. We were then picked up earlier than planned, by a new vessel operator with no experience of the area, since winds arrived at the islands sooner than predicted. Together, these aspects meant we had just 5½ hrs in the colony during the 1½ day visit. Banding was limited to giving metal-only birds a numeric darvic band, leaving just 64 birds banded with only metal bands. The study colony has had 679 birds banded, including the 36 birds banded in the study area in 1993 and 2008 (Fig. 11).

On arrival we found that a large slip ~25m wide had cut through the study colony near the western end. White-capped albatrosses, white-chinned petrels and sooty shearwaters were caught in the slip and killed. Two of the white-capped albatross corpses inspected were leg-banded. Given the number of dead animals visible at the surface of the slip, the overall mortality from the slip must have been substantial. The slip must have occurred sometime since September when both white-capped albatrosses and white-chinned petrels have returned to the island.

Four GLS tracking devices were retrieved from breeding and loafing white-capped albatrosses. One albatross that should still have carried a GLS was resighted with no logger. The GLS mount may have failed, since loggers were fitted in 2016, or the bird may have been caught and had the tracker removed. Data recovery by the manufacturer yielded 712–1058 days data from the GLS recovered, bringing the total to 20 datasets from this population. Analyses of these tracking data is outside the scope of this report but will be progressed separately.

Table 2. White-capped albatrosses banded and resighted in subsequent years on Disappointment Island 2015–2020

	2015	2016	2017	2018	2019	2020	Total
Banded	150	83	160	128	122	0	679
Resighted from previous years	na	32 of 150	56 of 233	130 of 393	191 of 557	175 of 679	
% resighted	na	21%	24%	33%	34%	26%	
Duration of work (days)	3 †	3 †	2.5	2.5	2.5	0.5	

† Duration includes ground-truthing work

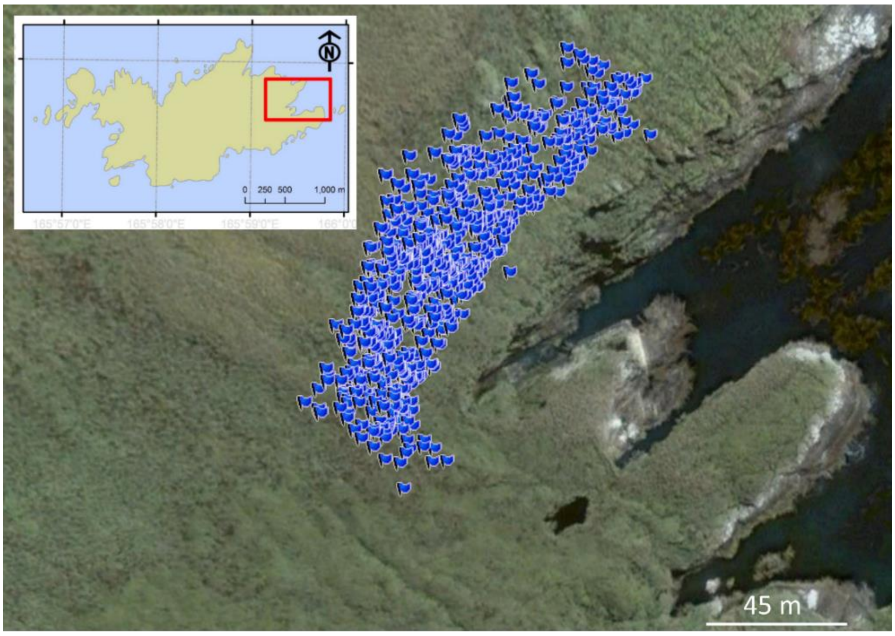

Figure 11. White-capped albatross study area in Castaways Bay, Disappointment Island. Blue flags are banding locations of white-capped albatrosses 2015 to present.

Survival estimates

Models showed good fit to the data (GOF p=0.26) and little overdispersion ($\hat{c}$=1.21), indicating that the standard time-dependent CJS model is a good fit to the data. However, time-varying annual survival rate estimates are not yet possible: survival estimates for some years hit a boundary (i.e., 1), indicating that the data have not been collected for long enough yet, given the species' longevity, for estimates of annual survival to be time-varying. Therefore, survival rate was held constant in subsequent models, estimating annual survival from the whole period. The best-supported model estimated annual survival with resighting probability varying over time. Under this model, estimated annual survival was 0.92 (95% CI 0.88–0.95) for the period 2015–20, with detection probability varying 0.25–0.45 among years.

White-capped albatrosses in the colony are seen in different states (S sitting on egg or chick; L loafing or standing in colony). The best supported multi-state model showed that survival rate is the same for both states but that resighting probability differs between states and over time, and the probability of transitioning from one state differs between states but is constant over time. Estimates from this model, accounting for the differing resighting probabilities of states (Fig. 12), give annual survival as 0.90 (95% CI 0.86–0.93). The transition probability for L to S—the probability that a bird moves from state loaf to sit in the following year—was 0.65, and transitioning S to L was 0.69. The remainder do not move state (i.e., transition S to S), so from this we can infer that the probability of breeding birds to breed again in the following year is 0.31.

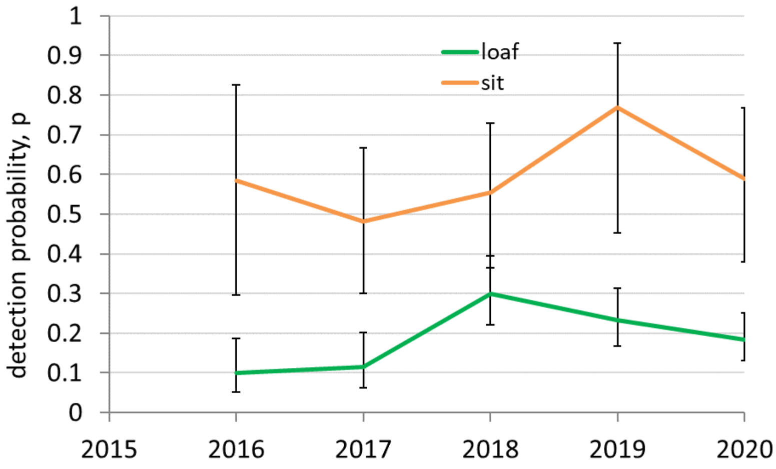

Figure 12. Detection probability over time for white-capped albatross states sit (bird sitting on an egg or chick) and loaf (seen standing in colony, breeding status unknown). Bars span 95% confidence intervals

Discussion

Gibson's albatross

The demography of Gibson's albatross had showed gradual improvement following the population crash in 2006, but some of these gains have now levelled out.

Adult survival of 90% remains substantially below the average pre-crash survival rate, and is very low for such a K-selected species (Weimerskirch and Jouventin 1987; Verán et al. 2007). In addition, numbers of breeding birds in the study population continue to slowly decline and fewer than normal new recruits entered the breeding population this year. This season is the first time since the crash 2006–08 that nest numbers in the study area have fallen below 100, and nest numbers were low across the island. It has been more than a decade since the breeding population on Adams Island was this small (2008–10, in the years just following the crash). On the positive side, nesting success has been at or above pre-crash levels for the last four years, and survival of adult females has returned to rates similar to those of males, after a period of markedly lower female survival recorded during the crash.

Together, survival, recruitment and productivity shed some light on the slow increase then stasis in the number of breeding birds on the island. Although nesting success has recovered, the number of chicks produced remains much lower than it used to be, since annual adult mortality remains higher than before 2005 and the breeding population is still substantially smaller. Wandering albatrosses start breeding at about 12 years old, so most birds joining the breeding population now were produced during a period when chick production was very low. Further, the trend to recruiting at a younger age may have already depleted the pool of birds available to recruit. Along with adult mortality remaining high, this is likely to continue to limit population recovery.

What is unclear is what has changed in the last three to four years to stall the (albeit slow) population recovery recorded over the decade 2007–16, other than diminishing recruitment from a small pool of birds.

Why do breeding numbers and adult survival remain depressed? The southern oscillation index (SOI) may have had an influence, since a lower proportion of the population choose to breed during La Niña (Elliott et al. 2018) and moderate La Niña conditions persisted for much of 2016–18 (Bureau of Meteorology 2020). However, this is not the whole explanation, since in 2019 the SOI reverted to a moderate El Niño under which a higher proportion should choose to breed, yet particularly low breeding numbers were seen.

Another possibility is some change in overlap of Gibson's albatross at sea with fishing fleets giving greater risk of mortality. This could occur, for example, if the foraging range shifts into a heavily fished zone, or if fishing effort increases in the albatross foraging areas. However, our tracking data here from 2019 showed little clear change in foraging range compared to the known distribution (Walker and Elliott 2006; Walker et al. 2017), and if there has been a change in mortality in this period, the change is subtle. Subtle effects can be masked by pooled data, so we estimated survival separately by breeding status. In recent years non-breeding females have had markedly lower annual survival rates than breeding females. Tracking data here showed the foraging range of breeding and non-breeding females is different, but followed only a few non-breeding females for less than a year. The much larger sample of birds tracked by GLS could be valuable to assess where the range of non-breeding females has differed from breeding females over time – particularly those years when breeding females have vastly different survivorship than the non-breeders. Analysis of GLS data was outside the scope of this report but has potential to provide insight into why population recovery has stalled. Concurrently, it would be useful to assess changes in fishing effort in the central Tasman Sea and Australian Bight, where Gibson's albatross forage. We have not done a full assessment of fishing effort relative to bird foraging range here but took a critical look at flightpaths of individual birds for signs of bycatch problems (per Elliott and Walker 2020). For birds whose breeding failed and have not been seen since their transmitter stopped, we compared the last fix from the tracker with the location of fishing vessels available from Global Fishing Watch (https://globalfishingwatch.org/map). Only one bird of the twelve tracked met these criteria (Red-575) but the nearest boats were 150 km away when the tracker stopped. However, most loggers stopped before the winter shift of the fishing fleets southwards begins, when most of the likely interactions between wandering albatrosses and fishing vessels occur (Elliott and Walker 2018), so interaction between albatrosses and vessels are less likely to be detected.

A final possibility is that nothing has changed: the population has declined continually since 2004, as illustrated by mark-recapture estimates, and apparent improvements in nest counts were simply an artefact of nest counts being a less-powerful method to detect population change than mark-recapture estimates (Bakker et al. 2018; Elliott and Walker 2020).

While the conservation status of Gibson's wandering albatross remains of concern, monitoring the size of the population and its structure and trend on Adams Island remains a priority.

White-capped albatross

The current survival rate estimates for white-capped albatross (0.90, 95% CI: 0.86–0.93) is low for albatross species (Verán et al. 2007). Compared to the only other estimate for white-capped albatross (0.96, 0.91–1; Francis 2012) the current estimate is lower but more precise, with greater precision indicated by a smaller confidence interval range. This makes sense considering the underlying data. The Disappointment data comprise five resighting visits to a study colony of 643 banded birds, while Francis (2012) drew on four resighting visits to the small SW Cape colony with 122 birds banded. The precision of survival estimates is expected to improve with successive resighting visits and increasing numbers of banded birds in the study, as illustrated by exploratory modelling and simulation for white-capped albatrosses (Roberts et al. 2015; Rexer-

Huber et al. 2018). In fact, real data from six consecutive visits gave a slightly more precise estimate here than was predicted by simulation modelling for six visits.

Survival estimates assume no emigration which is appropriate because buffer-area checks show no sign of white-capped albatross moving to nest in new sites outside the study area, and recapture locations between years indicate that white-capped albatrosses appear to have strong nest site fidelity. A goal of this study is to estimate population size (N) and population rate of change (lambda), which also require that there be no emigration and that the study area does not change in size.

However, exploring models with time-varying annual survival rates showed that resighting data have not yet been collected for long enough, relative to how long white-capped albatross live, to estimate time-varying demographic parameters. This is not unexpected, since population dynamics of long-lived slow-breeding animals logically requires longer time periods. It is premature to estimate annually time-varying parameters like population size and trend from these data. To detect and follow changes over time in survival, population size and trend requires a longer dataset than is currently available.

As for Gibson's albatross, the probability of resighting a marked white-capped albatross at the island is different for birds on nest and birds standing in the colony or loafing, but their survival rates are the same irrespective of state. White-capped albatross states should be accounted for when modelling demographic parameters (Francis 2012), as for Gibson's. However, short visits to the study colony mean that unlike Gibson's albatross, the breeding status of loafers remains uncertain. Loafing birds may in fact be breeding, so until we can be present at the island for long enough (a full changeover interval) to be sure that both mates have been checked on all nests, we cannot infer that loafers present are not breeding. At late incubation/brood-guard, the changeover interval is at its shortest in albatrosses, so the extra time on island required may not be significant.

Slips occur regularly on wet Disappointment Island, with scars from old slips visible all over the island (Walker et al. 2020). Over six annual visits we have twice found recent slips. This year's slip was large (~25m wide, compared to the 5–10m of slips found in 2016) and caused substantial mortality. Adult albatross, white-chinned petrel and sooty shearwater corpses were found across the surface of the slip, with an unknown proportion buried. This is simply unfortunate timing; this year's slip must have occurred sometime after seabirds were back at the island for the breeding season.

Recommendations

Gibson's albatross

The gradual improvements in the demography of Gibson's albatross over more than a decade following the crash in 2005–06 appear to have stalled. The slowly increasing number of birds nesting on the island 2006–16 are decreasing again, down to numbers not seen since 2005–10, and recruitment has also dropped. With particularly low nesting numbers recorded this year, more than a decade of low chick production, and annual mortality remaining very high for such a K-selected species (and higher than it used to be), the conservation status of Gibson's wandering albatross remains of concern. Monitoring the size of the population and its structure and trend on Adams Island remains a priority.

White-capped albatross

A resighting rate of 26% in 2020 is lower than achieved in previous years, the result of a short island visit cut to just 5½ hours in colony by unworkable weather. Future visits should take place in early February when mate changeovers are most frequent, over at least five days to increase resighting rates and provide some contingency for poor weather. Since birds' state appears to be useful for parameter estimates, longer visits would help improve survival estimates by improving the confidence in assigning breeding/non-breeding states to birds seen.

Exploratory analyses showed that while the data are suitable for point estimates of survival, time-varying annual survival rates are not yet possible. More resightings needed to allow estimation of time-varying annual parameters like survival rates, population size and population rate of change.

To assess how our very brief resighting visits affect demographic parameter estimates, we suggest that data from other densely-colonial biennially breeding *Thalassarche* could be useful. Where comprehensive resighting data exist, the comprehensive dataset could be sub-sampled to mimic brief island visits and assess the impact of effort on parameter estimates.

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Author contributions: GCP and KRH conducted fieldwork and wrote the report. GE and KRH analysed the data. KW and GE provided logistical support for the Gibson's albatross study, and DT for the white-capped albatross study. All authors contributed to this report.

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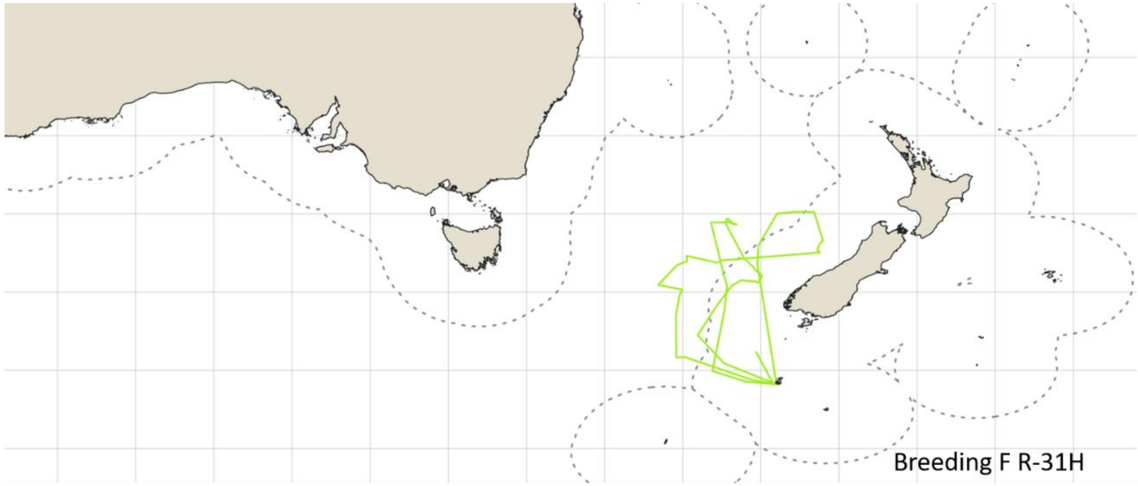
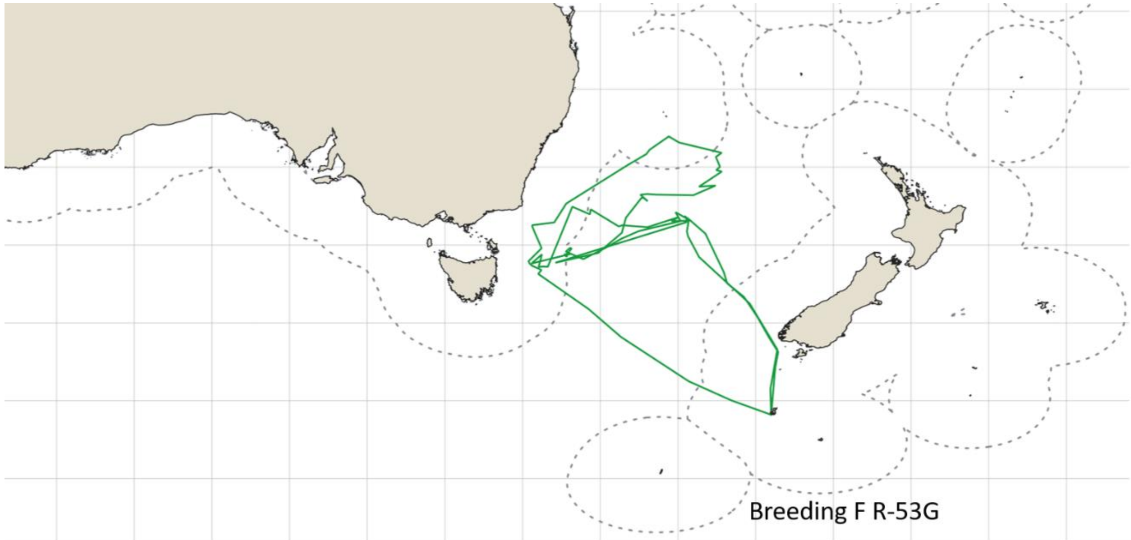
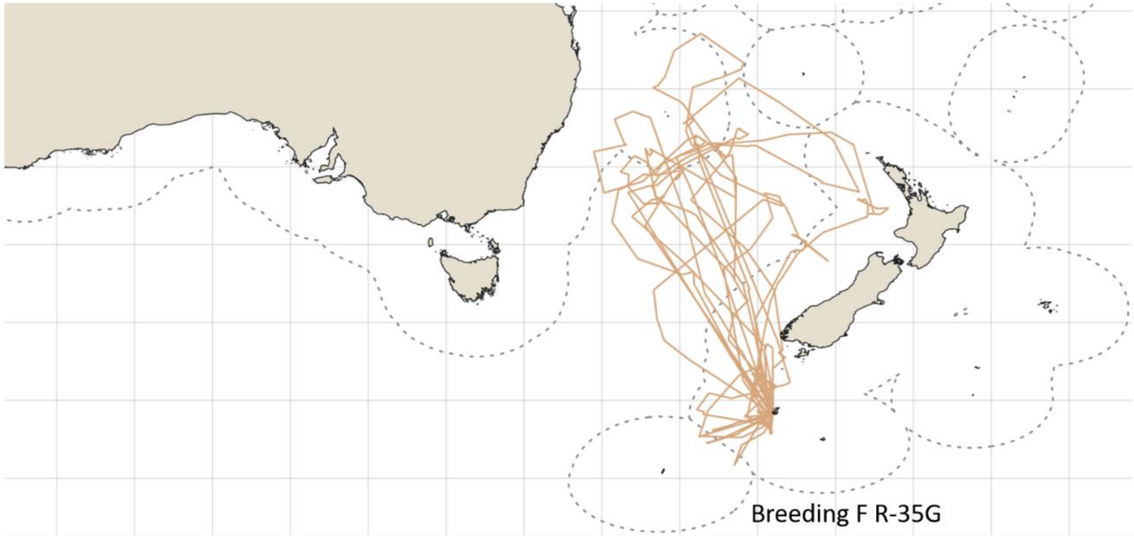
Appendix

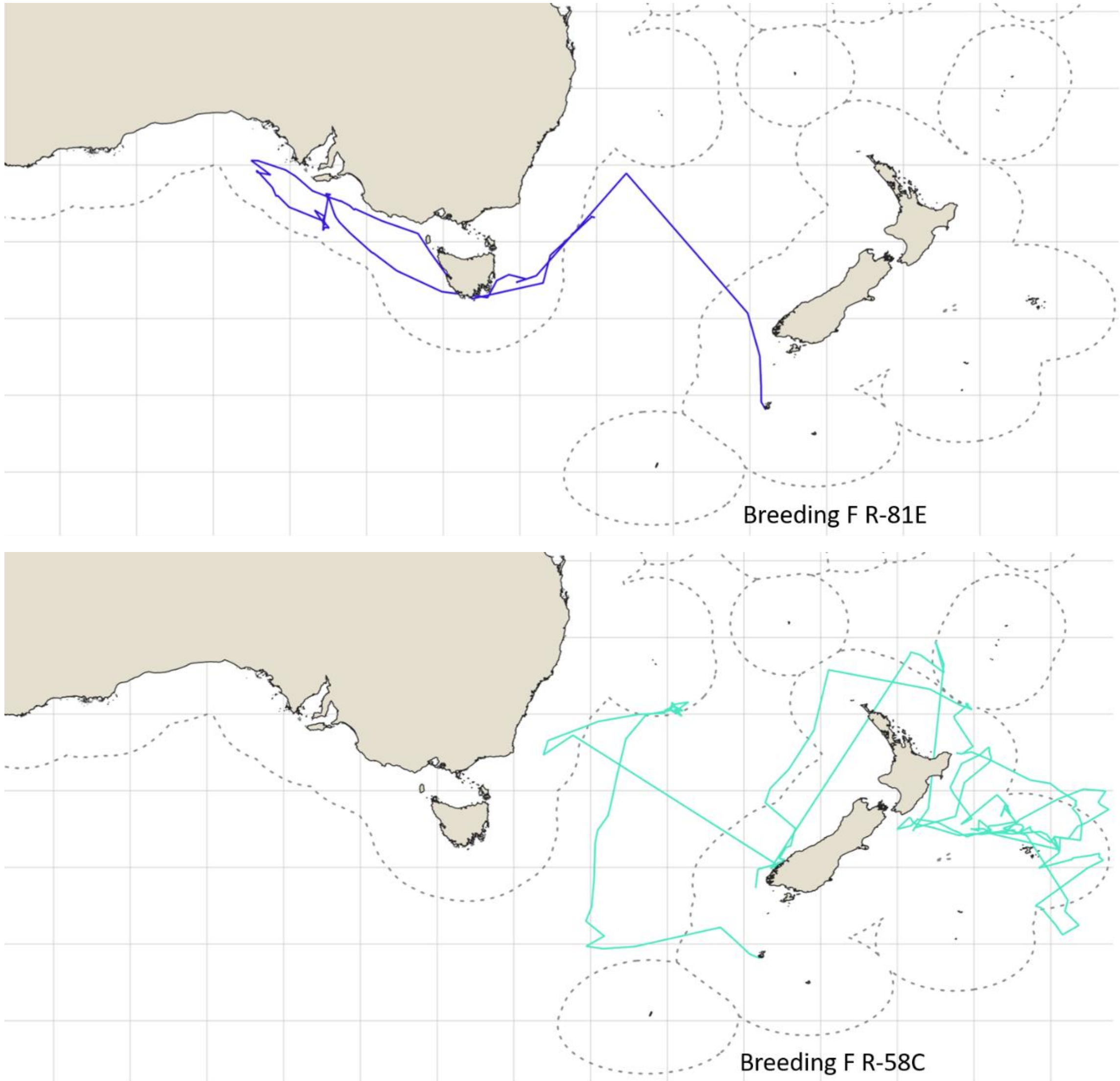
Gibson's albatross satellite tracking for 12 adults tracked from February to September 2019, grouped by status. Breeding: breeding continued throughout the tracking period; Failed-breeding: breeding attempt failed during the tracking period.

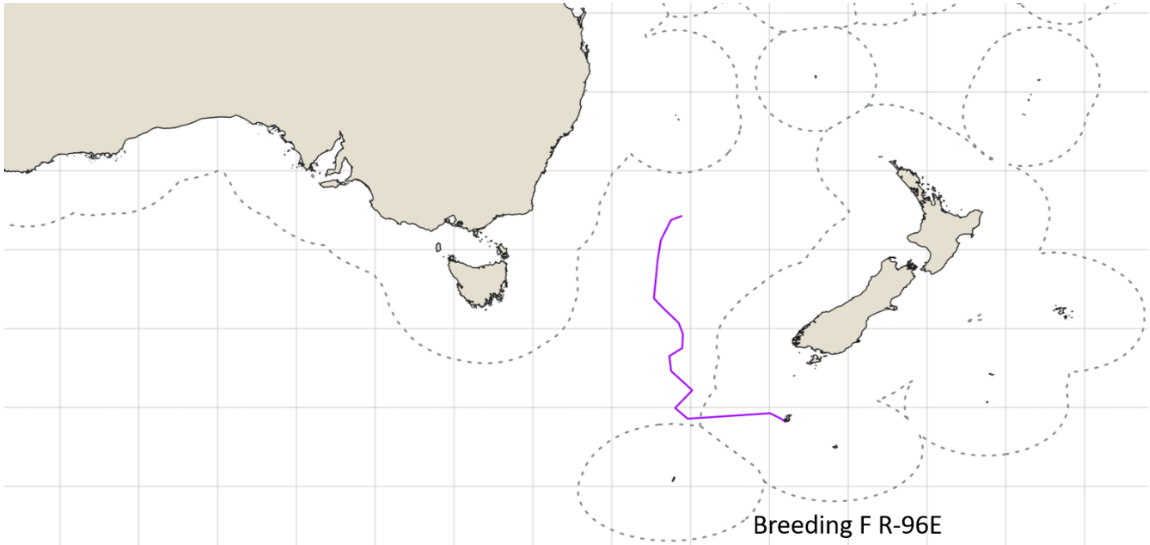
Breeding females



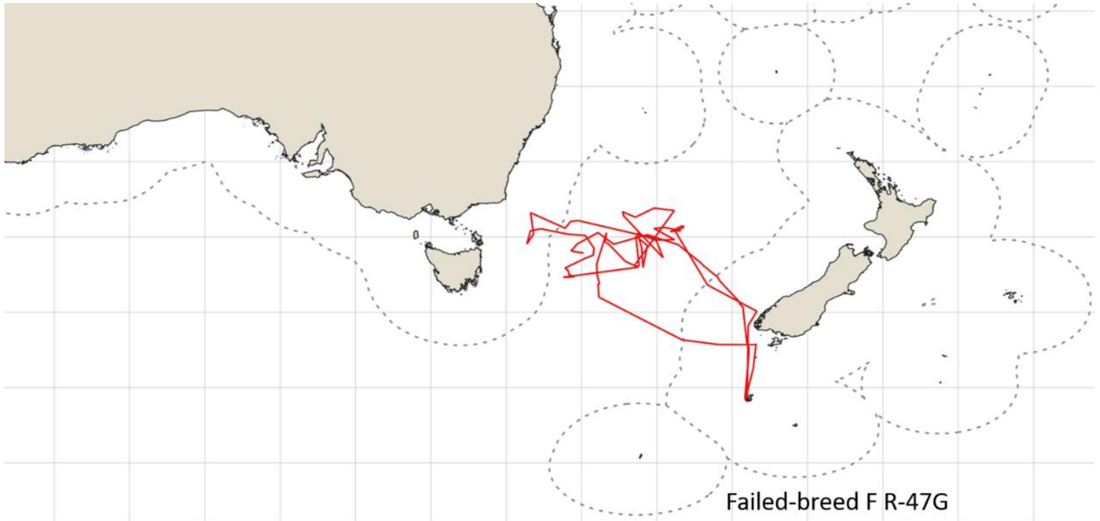

Breeding F R-53G

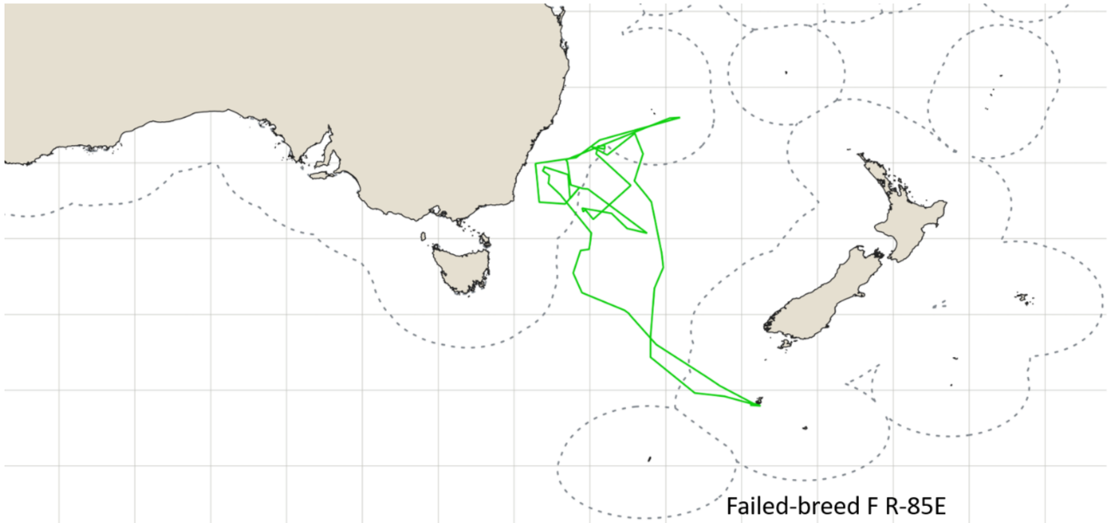

Breeding F R-35G

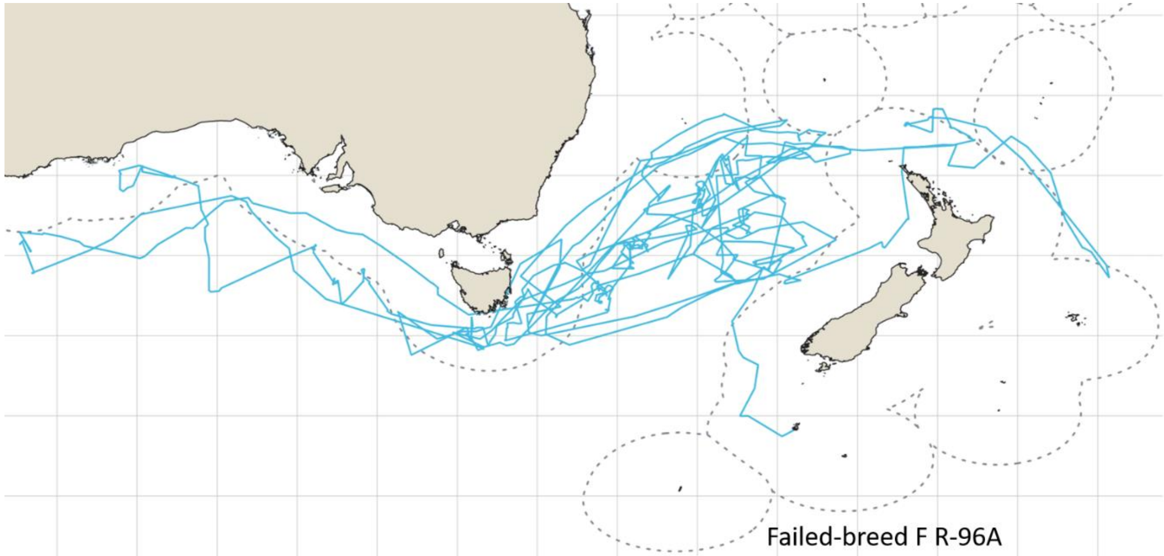

Breeding F R-81E
Breeding F R-58C

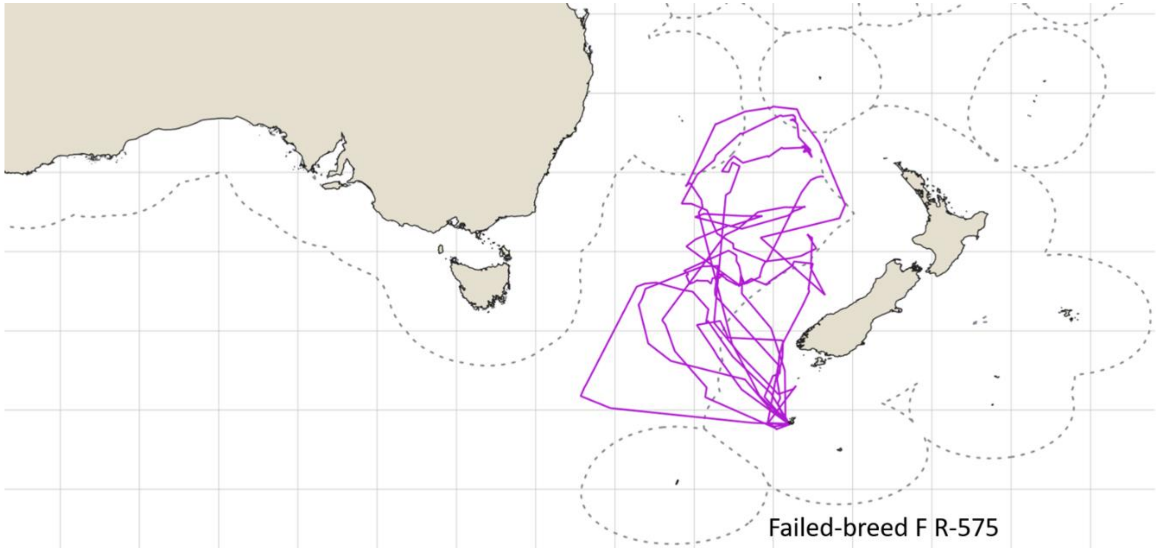

Breeding F R-96E

Failed-breeding females






Failed-breed F R-96A


Failed-breed F R-575

Failed-breeding males