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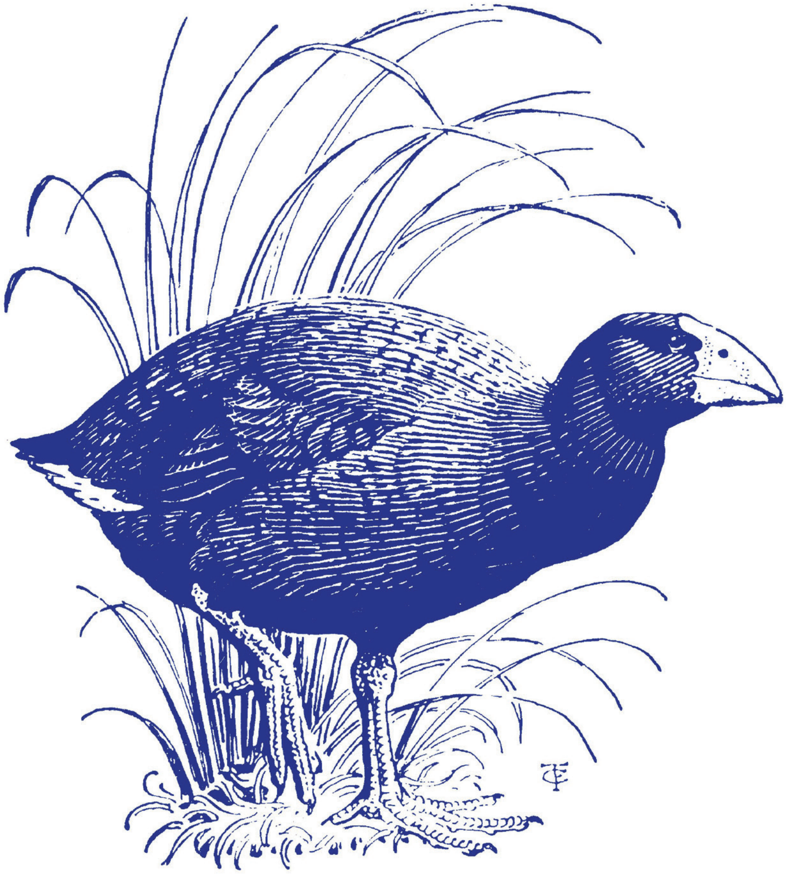

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North Island kokako (*Callaeas wilsoni*) recovery update: 2000 to 2023

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Abstract: This paper describes North Island kokako (*Callaeas wilsoni*) recovery actions and outcomes since 2000 at 11 sites with relict populations, and at 12 other mainland and three offshore island sites to where they have been translocated. Populations are now secure on pest-free Te Hauturu-o-Toi / Little Barrier Island and Kapiti Island, and Tiritiri Matangi Island is a valuable advocacy site. Maungatautari is a large (3,300 ha) pest-fenced and pest-free site that has demonstrated rapid kōkako recovery. All other sites are unfenced and require ongoing control of key pests. The national total of kōkako pairs has increased from *c*. 458 in 2000 to *c*. 2,327 in 2023; however, latest counts indicate populations at seven sites have declined. Future kōkako recovery will be assisted most by improved, large-scale pest control tools for unfenced mainland sites, and by sustained effective pest control in large key relict populations (Pureora, Te Urewera, Rotoehu, Mapara, and Mokaihaha).

Innes, J.; Bradfield, P.; Brown, K.; Bryden, D.; Burns, R.; Carpenter, J.; Corkery, I.; Flux, I.; Jansen, P.; Parker, K.A.; Rogers, A.; Speed, H.; Thurley, T.; Wills, S. 2024. North Island kokako (*Callaeas wilsoni*) recovery update: 2000 to 2023. *Notornis 71(4)*: 129–145.

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INTRODUCTION

This paper documents the methods and outcomes of management undertaken to increase North Island kokako *Callaeas wilsoni* abundance and distribution in the 24 years after 2000, within the context of previous research and management. The programme is widely regarded as successful, but how was this achieved and what more is there to learn and improve?

North Island kokako (henceforth kōkako) were widespread throughout the North Island at the time of European settlement but declined rapidly thereafter, especially in the seven decades before 1950 (Salvador *et al.* 2019). This is consistent with the observation that in New Zealand 'deep endemic' bird species declined as human impacts increased (McDowall 1969). Formerly found "on all the ranges of the North Island forests" (Reischek 1886), kōkako were confined to scattered forests in the northern two-thirds of the North Island by 1970 (Lavers 1978). Hypotheses for their decline include forest clearance, predation, and food competition with introduced pest mammals (Williams 1976; Lavers 1978). Detailed studies from 1978 to 1984 of kōkako use of forest habitat at Pureora (Waikato) and Puketi (Northland), prompted by logging controversies in native forests, revealed key aspects of the species' biology, including year-round territoriality, diverse diet, and poor nesting success (Hay *et al.* 1985; Powlesland 1987; Best & Bellingham 1991). As a precaution, kōkako were translocated successfully to pest-free offshore islands, including Te Hauturu-o-Toi / Little Barrier Island (from 1981, henceforth Hauturu), Kapiti Island (from 1991), and Tiritiri Matangi Island (from 1997).

Research during 1989–1997 verified that mainland declines were primarily due to predation of eggs and chicks, and occasionally adults during nesting, by ship rats (*Rattus rattus*), brushtail possums (*Trichosurus vulpecula*), swamp harriers (*Circus approximans*), and, more rarely, stoats (*Mustela erminea*). Kōkako food supply was considered an important secondary factor (Innes *et al.* 1999).

Subsequent control of pest mammals sustained kōkako recovery in some relict populations, from which birds would later be harvested for reintroduction to parts of their former mainland range (Innes & Flux 1999; Innes *et al.* 2013). Such translocations sought to establish or sustain populations at Puketi Forest (Northland); Hunua and Waitākere Ranges / 'Ark in the Park' (Auckland); Maungatautari and Pirongia (Waikato); Otanewainuku, Manawahe, and Whirinaki (Bay of Plenty); Ngapukeariki (East Cape); Boundary Stream (Hawke's Bay); Parininihi, and Pouiatoa (Taranaki); and Pukaha / Mt Bruce (Wairarapa, Fig. 1). Of the 26 sites with current populations, Hauturu, Tiritiri Matangi, and Kapiti are pest-free offshore islands; Maungatautari is a large (3,300 ha) pest-fenced ecosanctuary, and all others are unfenced 'mainland islands' with constant mammal pest reinvasion from surrounding land (Innes *et al.* 2019).

During 2011–2014 translocations to new sites were suspended while the Kōkako Recovery Group (KRG) addressed genetic issues about whether populations should be mixed by translocation and how many genetic founders there should be in new populations. This work culminated in national prioritisation of kōkako populations, with the highest ranking going to relict (not translocated) populations that had never had fewer than 40 individuals (Te Urewera, Pureora, Mapara, Mokaihaha, and Rotoehu; Emily Weiser, unpubl. report, 2015). It also established guidelines for the minimum number of founder individuals from which new populations should be started, and the maximum number of individuals that could be harvested from source populations.

In this paper we expand this outline to describe key management actions that have been taken since 1999 to increase populations, and we document their outcomes, including changes in abundance and the distribution of kōkako and resultant conservation status changes for the taxon. While kōkako restoration is probably widely regarded as a conservation success story, there are no published accounts of how this was achieved and what could have been done better. We also collate recent new findings about kōkako biology and ecology, describe how the KRG interacts with iwi and community groups, and discuss current and future challenges for kōkako management. We hope the paper establishes an authoritative account of recent kōkako conservation that benefits biodiversity managers and administrators, and project participants.

PEST CONTROL AND ITS OUTCOMES

Intensive control of mammal pests is the primary management action currently undertaken to increase kōkako populations. Brushtail possums, ship rats, and stoats are key predators and disturbers of kōkako eggs, chicks, and adults; possums and ship rats also eat kōkako foods (Innes *et al.* 1999). Harriers are frequent predators at kōkako nests; however, they have only rarely been targeted for control in the past 20 years.

When acute toxins such as aerial 1080 are used, key pest control targets are to have residual (post-control) indices of 1% Residual Trap Catch (RTC; Bionet and National Pest Control Agencies 2020) for possums and 1% Residual Tracking Index (RTI; Gillies 2013) for ship rats at 1 November, which is about when nesting usually begins. When pest

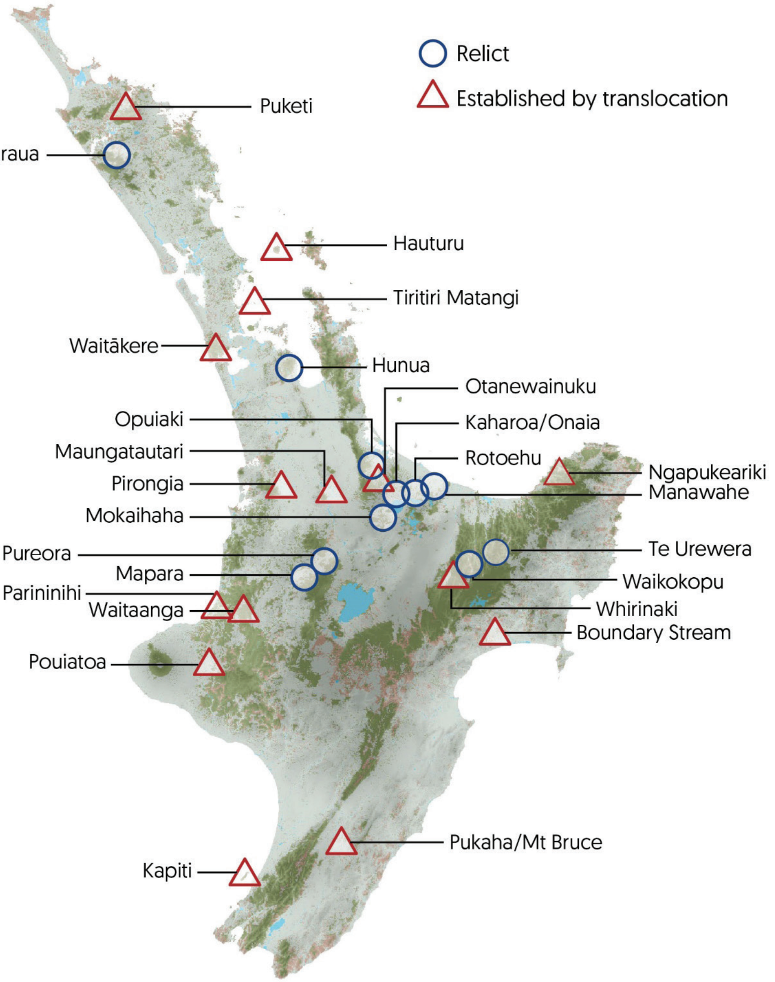

Figure 1. Current (2024) distribution of relict and translocated kōkako populations. The Hunua and Manawahe populations are shown as relict but were also boosted by translocated birds during 2006–2019 and 2019–2021, respectively. Pureora consists of four interbreeding subpopulations at Waipapa North and South, Okahukura, Tunawaea, and Mangatutu. The population at Waitaanga self-established after a translocation to Parininihi 30 km to the west.

control is ongoing, such as with bait stations, targets are to maintain possums below 5% RTC and ship rats below 5% RTI during the November–February breeding season. Other indexing tools such as chew cards or wax tags should not be used because no robust guidelines are available to calibrate their results against RTC and RTI. There are no formal, post-control targets for stoats because suitable methods have not been available.

We collated all available information about methods and outcomes of pest control targeting the key mammal pest species to protect kōkako populations at 25 unfenced mainland sites during the seven kōkako breeding seasons (October to February) of 2015–16 to 2021–22, inclusive. These sites are as shown in Fig. 1 but exclude Waitaanga, and for this analysis we separated the subpopulations (Mangatutu, Okahukura, Tunawaea, Waipapa north, and Waipapa south) of Pureora.

Possums

Across all sites, possum control was undertaken on average in 4.4 of the 7 years (n = 25). The most common method was using toxins in permanent or single-use bait stations attached to trees (45%, 51/112 site-years), followed by aerial 1080 and mixed trapping/ground poisoning (both 19%, 21/112 site-years) and trapping alone (17%, 19/112 site-years). Toxins used (in order of declining frequency) were potassium cyanide, aerial 1080, cholecalciferol, brodifacoum, 1080 in bait stations, and Double-Tap® (a mix of cholecalciferol and diphacinone).

A residual possum abundance of 5% trap-catch using the RTC method was measured and achieved around 1 November on average in 1.5 years of the 7, across all sites; that is, in 34% of years when possum control was attempted. It is likely that this abundance was achieved more often because residual abundance was not always monitored, especially after aerial 1080 operations, when >95% kills are now routine (Morgan *et al.* 2006) and some sites used bite mark indices not analysed here. In kōkako sites during 2015−16 to 2021−22, aerial 1080 achieved lower residual abundance (mean 0.9%, n = 8, *sd* = 1.31) than ground-based toxins (mean 1.9%, n = 31, *sd* = 2.0) or a mix of trapping and poisoning (mean 2.9%, n = 4, *sd* = 3.4), and much lower than trapping alone (mean 23.4%, n = 4, *sd* = 27.9).

Ship rats

Across all sites, ship rat control was undertaken on average in 5.6 of the 7 years (n = 25). This is more frequent than for possum control, because rat populations recover more quickly from low levels, including after aerial 1080 operations (e.g. Sweetapple & Nugent 2007). By far the commonest control method was toxins in permanent or single-use bait stations attached to trees (58%, 81/140 site-years), followed by aerial 1080 and mixed trapping/ground poisoning (each 15%, 21/140 site-years) and trapping alone (12%, 17/140 site-years). Toxins used (in order of declining frequency) were pindone, diphacinone, aerial 1080, brodifacoum, 1080 in bait stations, Double Tap®, and cholecalciferol.

A ship rat abundance of ≤5% RTI (Gillies 2013) was measured and achieved around 1 November on average in 2.7 years of the 7, across all sites; that is, in 48% of years when ship rat control was attempted. In kōkako sites during 2015−16 to 2021−22, aerial 1080 achieved lower residual abundance (mean 3.5% RTI, n = 13, *sd* = 7.5) than ground-based toxins (mean 8.9%, n = 72, *sd* = 15.3) or a mix of trapping and poisoning (mean 8.7%, n = 16, *sd* = 6.9), and much lower than trapping alone (mean 17%, n = 7, *sd* = 19.8).

Stoats

Currently the few available data suggest that stoats are rare predators at kōkako nests; however, they may be significant, albeit perhaps intermittent, predators of subadults and adults (Innes *et al.* 1999; Flux *et al.* 2006). Sign left at nests suggested that stoats caused failures of just 4% of 75 nesting attempts during years with pest control at Mapara (1995−1997); however, 12 of 31 banded females were lost in the 3 years after pest control ceased, and stoats preyed on all three nests at which the cause of female loss was known (Flux *et al.* 2006). They are capable of killing large chicks, subadults, and adults when nesting or roosting, and so are a management target at nearly all sites. Stoats are also targeted at many kōkako sites to protect other taxa, such as brown kiwi (*Apteryx mantelli*). Across all sites, stoat control was undertaken on average in 4.4 years of the 7 (n = 25). Methods included trapping with DOC200, Goodnature A24, DOC250 or (in earlier years) Fenn kill traps, as well as secondary poisoning via aerial 1080 or station-placed toxins. There are currently no robust tools to measure the residual (post-operation) abundance of stoats and so the effectiveness of stoat control for kōkako is difficult to assess; the most promising monitoring technique currently being developed is camera traps (Smith & Weston 2017; Craig Gillies, unpubl. report, 2023).

Nest success outcomes

The success of nesting attempts has been measured with adequate samples for robust analysis at four sites. The mean percentage of monitored nests fledging at least one young in a season was 20% at Manawahe (2018−19 to 2023−24, n = 19), 30% at Parininihi (2017−18 to 2022−23, n = 87), 59% at Pirongia (2017−18 to 2023−24, n = 71), and 67% at Hunua (2013−14 to 2020−21, n = 67; DB, AR, unpubl. data). The low success rate at Manawahe was not primarily due to predation but to unusually high rates of egg unviability (70% of clutches during a 2014−15 to 2016−17 study). Hypotheses to explain this outcome in this small, isolated population include genetic effects (inbreeding depression) and increasing drying of the forest, leading to poor quantity and quality of key native fruits (Gaye Payze & Ian Flux, unpubl. report, 2017; Ian Flux, unpubl. report, 2021). Nest success at Parininihi was lower than at Pirongia and Hunua and is probably due to less successful pest control at this lower-altitude forest, which may have a higher year-round carrying capacity for ship rats. Mean annual ship rat RTIs were 24% at Parininihi during 2017−18 to 2021−22, cf. 5% at Pirongia and 2% at Hunua.

TRANSLOCATIONS AND POPULATION PRIORITISATION

Kōkako translocations are undertaken both to bolster the genetic diversity and demographic potential of existing relict populations or translocated populations that have few founder individuals, and to establish populations at high-quality new sites and thus help restore the species across its original range.

During 1981 to 2011, kōkako populations were reintroduced at seven sites (Boundary

Stream, Pukaha / Mt Bruce, Ngapukeariki, Puketi, Whirinaki, Waitakere, and Otanewainuku), and birds were added to an eighth site (Hunua) to reinforce numbers and genetic diversity of the relict population there. New sites included three offshore islands (Hauturu 1981, Kapiti 1991, and Tiritiri Matangi 1997). There were unsuccessful attempts to reintroduce the species at Trounson Kauri Park and to establish it on Lady Alice Island (north Auckland) and Secretary Island (Fiordland). Males alone were contentiously placed on Mokoia Island (Lake Rotorua) for tourism advocacy reasons in 2006, and three were still alive in July 2022 (Innes *et al.* 2013; Carmel Richardson and Graeme Young, unpubl. data). In total 286 birds were moved and released in 94 translocations to 16 sites during 1981−2011 (Innes *et al.* 2013).

During September 2012 to February 2024 a further 296 kōkako were translocated, reintroducing the species at five sites (Maungatautari, Parininihi, Pirongia, Pouiatoa, and Waitaanga) and reinforcing existing populations at six others (Puketi, Waitākere, Hunua, Otanewainuku, Manawahe, and Kapiti Island; Table 1, Fig. 1). Over the entire time in which there have been translocations (1981−2022), major sources of birds have been populations at Mangatutu and Waipapa (both Pureora, 91 birds each), Mapara (King Country) and Ōtamatuna (Te Urewera, 60 birds each), Tiritiri Matangi Island (Auckland, 56 birds), Kaharoa (Bay of Plenty, 53 birds), Mataraua (Northland, 31 birds), Hauturu (Hauraki Gulf, 27 birds), Rotoehu (Bay of Plenty, 25 birds), and Tunawaea (Pureora, 15 birds).

Kōkako translocation techniques and procedures

Current best practice techniques for kōkako translocation are collated in Collen *et al.* (2016). This document covers source and destination site selection; the number and composition of birds to transfer; techniques for capturing, processing, holding, transporting and releasing birds; plus recommended destination site pest control and post-release kōkako monitoring. *In situ* management

Table 1. Destination and source sites for all kōkako translocations undertaken from September 2012 to February 2024, in chronological order by the date of first translocation to each site. The table format repeats that of Appendix 1 in Innes *et al.* 2013, which shows all translocations undertaken before September 2012. In column three the total number of kōkako translocated and the number of females (determined by DNA or tarsus length) are given, respectively, in brackets. Mauimua is Lady Alice Island. The Waitākere project is Ark in the Park. Asterisks indicate destination sites that received kōkako to renew lost populations; releases at other sites were reinforcing an existing population. Note that at least 5 birds translocated to Parininihi dispersed *c.* 30 km east to settle at Waitaanga; as of 2024, no kōkako have been translocated directly to Waitaanga.

Destination site	Total kōkako translocated Sep. 2012− Feb. 2024	Source populations and dates
Puketi*	23	Mataraua (10,6), Sep−Oct 2012; Mauimua (1,0), Apr 2013; Hamilton Zoo (2,1), May 2013; Mataraua (3,2), Feb 2014; Mataraua (7,4), Aug−Oct 2014.
Waitākere	31	Mapara (3,1), Sep 2015; Mangatutu (8,3), Aug−Sep 2015; Mangatutu (10,4), May 2016; Mapara (10,4), May 2016.
Hunua	30	Mapara (6,3), Sep 2015; Mangatutu (6,3), Sep−Oct 2015; Mangatutu (7,3), Jun−Oct 2016; Waipapa (11,6), May−Jun 2019.
Maungatautari*	40	Mangatutu (18,11), Sep−Oct 2015; Mangatutu (22,8) Apr−Oct 2016;
Otanewainuku	21	Kaharoa (11,3), Aug 2016; Kaharoa (10,4), Aug 2018.
Parininihi*	45	Tiritiri Matangi Island (20,9), May−Jul 2017; Mangatutu (15,7), Apr−Jun 2018; Waipapa (10,4), Aug−Sep 2018.
Pirongia*	54	Waipapa (20,7), Jun−Aug 2017; Waipapa (10,5), Jun 2018; Tiritiri Matangi Island (14,8), Jul 2018; Waipapa (10,6), Jul 2022.
Pouiatoa*	20	Hauturu (20,5+), Jun−Jul 2018.
Manawahe	12	Kaharoa (6,3), Aug 2019; Rotoehu (6,3), Sep 2021.
Kapiti Island	20	Waipapa (9,4), Jul 2021; Tunawaea (Pureora, 4,2), Jul 2021; Mangatutu (7,4), Jul 2021.

Table 2. Priority rankings for all kōkako populations, as determined by the Kōkako Recovery Group, based on Emily Weiser, unpubl. report, 2015. Higher priority is given to populations that (a) are relict cf. translocated, (b) have >40 founders, and (c) have >2,000ha of potential habitat. Sites in column 3 are ordered based on the smallest known population size (number of individuals) or the number of kōkako that were translocated, which appears in parentheses after the site names.

Priority	Explanation	Sites
1	Relict mainland populations with a minimum bottleneck size of 40 kōkako	Pureora (138), Te Urewera (99), Rotoehu (50), Mapara (48), Mokaihaha (43)
2	Secure, pest-free, offshore and pest-fenced mainland populations	Kapiti Island (53 translocated 1991−2021), Maungatautari (40 translocated 2015−16), Hauturu (32 translocated 1981−1994)
3	Relict mainland populations with a minimum bottleneck size of <40 kōkako	Opuiaki (26), Waimā–Mataraua (25), Kaharoa (22), Manawahe (12, but 12 translocated 2019–2021), Hunua (3, but 63 translocated 2006–2019)
4	Sustained small bottleneck (Waikokopu) or translocated populations with >2,000 ha habitat	Waikokopu (16), Waitākere (53 translocated 2009−2019), Otanewainuku (40 translocated 2010−2018), Parininihi (45 translocated 2017/18), Pirongia (54 translocated 2018−2022), Puketi (29 translocated 2007−2014), Whirinaki (20 translocated 2009), Pouiatoa (20 translocated 2018), Ngapukeariki (19 translocated 2005), Waitaanga (self-established ca 2018)
5	Small, translocated populations with < 2,000 ha available habitat	Boundary Stream Mainland Island (20 translocated 2001−2007), Pukaha / Mt Bruce (16 translocated 2003−2010), Tiritiri Matangi Island (advocacy and harvest site)

of relict populations (Fig. 1) and completing genetic or demographic goals of reintroduction projects that are already underway have often been prioritised by the KRG over attempts to establish new populations at new sites. The KRG considers it vital that source populations are large and genetically diverse enough to sustain harvesting of birds, which primarily demands sustained and effective pest control before and after harvesting. There is also a necessary, parallel, human process to be undertaken with all translocations, to ensure that managers and iwi at both ends of the mooted translocation are supportive.

Population genetics and priorities for sustained management

The KRG accepts that maintaining genetic diversity will increase the likelihood of the long-term persistence of kōkako populations, and thus the taxon. However, demographic, financial, logistical, cultural, and other considerations are also important for population management decision-making. Preliminary modelling suggested that isolated kōkako populations of around 50 pairs will lose allelic diversity through genetic drift and require periodic replenishment with immigrants from other populations, and that populations smaller than 25 pairs should be avoided to minimise inbreeding depression (Ian Jamieson & Danilo Hegg, unpubl. report, 2011).

From 2012 the KRG worked with Dr Emily Weiser (then at Otago University) and the model, Allele Retain (Weiser *et al.* 2012, 2013), to estimate the retention of rare alleles in all populations with and without supplementation of new birds at different rates and times. The model estimated the number of kōkako that could be taken from each source population (without compromising its own viability) to supplement sites requiring further translocations, and the number of founder individuals required to establish new populations to ensure the retention of high proportions (80−90%) of rare alleles (Emily Weiser, unpubl. report 2015).

As a result, the KRG ranked all populations to reflect their relative importance for maximising the probability of long-term persistence of the taxon (Table 2). Higher rankings were given to populations that were relict (original), had a larger and short-duration minimum bottleneck population size (cf. small and long-lasting), and had a large available habitat area and thus a potentially large final population size with management. The modelling enabled the KRG to conclude as practicable guidelines that key factors to increase kōkako population growth rates are a minimum of 36 founders (unrelated kōkako that successfully produce progeny that survive to adulthood) and a maximised population growth rate to a large size (requiring few mammalian predators and abundant, high-quality kōkako food). Greater final population size is also assisted by choosing large release areas, increasing the scale of pest control and enhancing the connectivity of populations that are near each other but currently isolated.

A current requirement of the KRG for new sites is a minimum of 2,000 ha of available native forest habitat (assuming a potential final population of 250 pairs with an 8 ha territory per pair), which exceeds the area available at some past release sites (Table 3). Outcomes at sites <2,000 ha have been variable. Populations are struggling at Manawahe and Pukaha; Kaharoa had 57 pairs in 2022 and site managers are attempting to increase its effective habitat area by establishment of a corridor to Otanewainuku, while pest-free Tiritiri Matangi Island (220 ha) demands ongoing addition and removal of birds to avoid inbreeding. Kōkako are currently managed in only *c*. 12% of the area of contiguous forest available at mainland sites, due to the labour and expense of control of pests, especially ship rats (Table 3).

Table 3. Sizes of kōkako populations at October 2023, listed from north to south. Numbers are from standardised surveys of territorial adults described in unpublished reports to the Kōkako Recovery Group and exclude juveniles and subadults. Note that populations are only surveyed episodically. Hauturu was surveyed by subsampling, whereas all other sites were surveyed by counting territorial adults. 'Pureora' includes Waipapa north and south, Mangatutu, Tunawaea, and Okahukura subpopulations. Mataraua and Waimā are two disjunct sites separated by *c*. 5 km of contiguous native forest, and are treated here as one population but under two management regimes. 'Kōkako added / removed' shows numbers translocated in (+) or out (-) during 1981–2024. 'Managed area' is for ground-based ship rat control, and tends to be smaller than for possums and stoats. 'Total habitat area' is our estimate of podocarp-broadleaved forest area contiguous with the pest-managed site.

Site	No. pairs	No. singles	Total kōkako	Survey year	Kōkako added / removed	Managed area (ha)	Total habitat area (ha)
Puketi	2	5	9	2022	+29	650	15,000
Mataraua– Waimā	9	21	41	2022	-36	1,824	30,000
Hauturu	422	18	862	2013	+32, -27	2,930	2,930
Tiritiri Matangi	23	8	54	2023	+19*, -56	220	220
Waitākere	16	10	42	2021	+53	2,400	20,000
Hunua	229	9	467	2022	+63*	2,000	17,000
Opuiaki	23	8	54	2023	0	1,100	6,500
Otanewainuku	31	7	69	2020	+40	1,200	10,000
Pirongia	16	5	37	2022	+54	1,370	13,500
Manawahe	4	4	12	2023	+12	775	844
Maungatautari	47	7	101	2020	+40	3,300	3,300
Kaharoa	57	10	124	2022	-53	953	705
Rotoehu	231	7	469	2023	-25	1,367	2,000
Ngapukeariki	8	2	18	2023	+19	1,300	8,000
Mokaihaha	71	10	152	2022	0	2,136	2,136
Te Urewera	144	16	304	2015	-60	Unk.	50,000
Waikokopu	8	4	20	2015	0	Unk.	50,000
Pureora	672	21	1365	2020–23	-197	8,750	30,000
Mapara	145	11	301	2022	-60	1,400	1,400
Whirinaki	6	2	14	2021	+20	2,000	10,000
Waitaanga	3	0	6	2023	0	220	20,000
Parininihi	11	6	28	2022	+45	3,650	20,000
Boundary Stream	36	6	78	2021	+20	811	3,000
Pouiatoa	6	4	16	2022	+20	1,000	20,000
Pukaha / Mt Bruce)	15	8	38	2023	+16	942	942
Kapiti Island	91	2	184	2021	+53	2,000	2,000
TOTAL	2327	211	4865			44,298	381,477

*One of the kōkako translocated to Tiritiri Matangi Island and two translocated to Hunua arrived as eggs.

Habitat quality

Habitat quality at potential new sites is now assessed before the KRG will support translocation proposals. This is because abundant good-quality food year-round is a key factor determining how many nesting attempts kōkako make (Flux *et al.* 2006; Innes *et al.* 2010). In this assessment process, developed by IF, the abundance of 10 key food plants – pigeonwood (*Hedycarya arborea*), karamū (*Coprosma lucida*), kanono (*Coprosma autumnalis*), rewarewa (*Knightia excelsa*), māpou (*Myrsine australis*), toro (*Myrsine salicina*), bush lawyer (*Rubus cissoides*), wineberry (*Aristotelia serrata*), puka (*Meryta sinclairii*), and fuchsia (*Fuchsia excorticata*) – over 2 m tall is counted by a stationary observer through a 360°degree view at five points, 50 m apart, along 8–10 200 m transects with random start-points (Ian Flux, unpubl. report, 2014). Pigeonwood/porokaiwhiri is a particularly important food of nesting and nestling kōkako and grows throughout their historical range, and so its presence is given extra weighting in scoring and assessing sites.

Potential new kōkako sites are regarded as having acceptable habitat when (with at least eight transects) the mean number of key food plants exceeds five per transect; the mean total food plants per transect less one standard deviation exceeds 50; and pigeonwood is seen in ≥30% of transects and has a mean score of >10 plants per transect. The procedure was first calibrated in the most productive relict kōkako habitats at Mapara, Te Urewera and Rotoehu in 2014. The baseline thus established was subsequently used to assess and compare the relative diversity of key kōkako food-plants within ten proposed kōkako sites. No subsequent site, yet assessed, has shown an equal or higher diversity score; however, several sites assessed as having diversity close to baseline scores now have increasing kōkako populations. Conversely, the two sites ranked lowest for diversity are both struggling to maintain kōkako.

SURVEYS AND POPULATION TOTALS

Kōkako populations are monitored to determine the number of translocated birds that form pairs in breeding seasons after release and so are likely to be genetic founders, and to estimate population growth rates. The KRG assumes that if 40 unrelated kōkako establish territories, then at least 36 of these will survive and may become genetic founders, based on adult annual survival being 90%, from previous studies on banded birds (Basse *et al.* 2003, Sinclair *et al.* 2006). Detailed monitoring to verify that birds breed and that their offspring also contribute genetic material to future generations is very expensive.

Currently the KRG recommends that there be annual kōkako censuses for each population until 25 territorial pairs have established, followed by a survey each 4 years until 50 pairs are confirmed. Survey and monitoring techniques and their possible pitfalls are described in detail by Flux *et al.* 2019. Experienced observers are required. Most censuses are counts of all territorial adults undertaken during April–October (outside the breeding season). Other kinds of surveys focus on juveniles when they are still with their parents after fledging, and include ‘roll calls’ in which a sample of territorial birds is rapidly mapped before and after aerial poisoning operations, to estimate their survival (Veltman & Westbrooke 2011).

A fourth survey type is the subsampling of very large populations. This method is a response to the prohibitive scale and expense of counting all territorial adults in very large (>100 pairs) populations (Ian Flux *et al.*, unpubl. report, 2013). The first trial survey used four observers to count kōkako within five 100 ha circular plots selected inside stratified vegetation maps on Hauturu (2,930 ha). On average, 38 person-hours were required for observers to satisfactorily resolve the number of territorial pairs present in each plot. Mean density was 14.4 (*sd* 3.13, *se* 1.56) pair territories per 100 ha, resulting in a population estimate of 422 +/- 115 pairs. The subsampling method was compared with a standard full census at Mapara. In the North Block the standard method took 10 person-days and yielded 22 pairs; the subsample method took 1.5 person-days and estimated 21 pairs. In the South Block, the standard method took 38 person-days and yielded 52 pairs; the subsample method took 11.5 person-days and estimated 77 pairs.

Most recent tallies of adult kōkako numbers at all current sites are shown in Table 3. The magnitudes of errors associated with the counts are unknown.

National population changes through time

It is difficult to determine annual growth rates accurately at most sites because censuses are undertaken only episodically and there are just three (of 26) sites where birds have not been either added or removed by translocation during 1981–2024 (Table 3). However, the national total of territorial pairs has increased steadily (mean rate of increase 7% p.a.), from 458 in 2000 to 2,316 in 2023 (Fig. 2).

The proportion of the national total number of kōkako that is in populations derived from translocations has increased from 24% (109/458) in 2000 to 33% (798/2384) in 2023. The annual contributions of Hauturu to this calculation are calculated on a single survey there in 2013. The total population in relict sites that have received no translocations has increased from 339 pairs in 2000 to 1,586 pairs in 2023, during which time 385 birds were removed from them for translocation. In this same period, the total number of populations

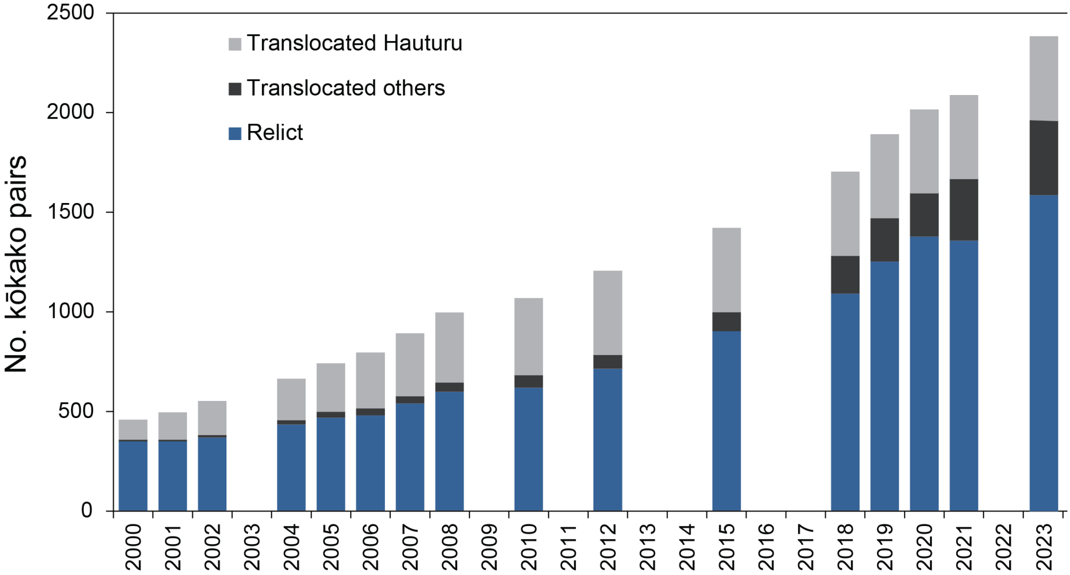

Figure 2. Total numbers of territorial kōkako pairs in translocated (Hauturu and others) and relict populations during 2000–2023. Note that the population on Hauturu has only been surveyed once (in 2013). Numbers at Hauturu are apportioned to previous years assuming a constant growth rate from founder birds and are kept at 422 pairs in years after 2013, on the assumption that the population is at carrying capacity. Populations at all other sites came from repeated field counts. Year gaps reflect episodic censuses of key populations.

increased from 15 to 26 and the number of sites with more than 25 pairs increased from 5 to 16 (regarding the four subpopulations at Pureora as separate, as they were in 2000).

Most sites founded with translocations of 16–54 kōkako each (Otanewainuku, Boundary Stream, Pukaha / Mt Bruce, and Kapiti Island) took 11–17 years to reach 20 territorial pairs, and Pukaha / Mt Bruce at last survey (2023) had declined to 15 pairs. Populations at four early release sites (Ngapukeariki from 2005, Puketi from 2007, and Waitākere and Whirinaki from 2009) and two more recent ones (Parininihi from 2017 and Pouiatoa from 2018) had not yet reached 20 pairs by 2023. The unfenced Pirongia population reached 20+ pairs in 7 years, and the pest-fenced, mammal-free (except for mice, *Mus musculus*) Maungatautari site achieved this milestone (in fact 47 pairs) in just 6 years, and so it has been the fastest growing of all known translocated populations.

Kōkako conservation status

At the beginning of the 1999–2009 Recovery Plan (Innes & Flux 1999) kōkako were classified 'endangered' (20% chance of extinction in 20 years; severe fragmentation; no population >250) on the IUCN Red List (Collar *et al.* 1994). In 2002 DOC classified them as Nationally Endangered, with qualifiers CD (conservation dependant), HI (human-induced loss of range), and RF (recruitment failure; Hitchmough 2002).

In July 2022 the species was reclassified as 'least concern' by the IUCN because, while the national population is small and still heavily dependent on conservation management, the population trend is steadily increasing (BirdLife International 2022). Current classification by DOC is 'Threatened – nationally increasing', the lowest rank of 'Threatened', with qualifiers CD, Inc (increasing) and PF (population fragmentation; Robertson *et al.* 2021).

Several very recent kōkako census results (at Mataraua, Waitākere, Pukaha, Kaharoa, Mangatutu, Tunawaea, and Mapara) have shown population declines, causes of which are not yet clearly understood.

KŌKAKO RESEARCH

Research before 2000

Pioneering research during 1978–1984 that studied kōkako demography, diet, and use of forest habitat at Pureora (central North Island podocarp forest; Rod Hay, unpubl. report, 1981; John Leathwick, unpubl. report, 1981) and Puketi (Northland kauri forest; Powlesland 1987; Best & Bellingham 1991) was prompted by controversy over the logging of indigenous forest (King *et al.* 2015). These studies (from the central North Island, summarised in

Hay *et al.* 1985) revealed poor nesting success and demonstrated diet overlap between kōkako and possums (Leathwick *et al.* 1983; Fitzgerald 1984). These findings significantly shaped subsequent research and remain highly relevant to current kōkako management.

Separate studies during 1986–2006 assessed kōkako survival through aerial 1080 operations aimed at managing bovine tuberculosis at Pureora, using both cereal and carrot baits. Following initial studies with non-toxic baits and surveys to locate suitable birds, the team followed selected territory-mapped kōkako before and after aerial operations to assess their survival. Numerous unpublished reports to the then Forest Research Institute (NZ Forest Service, Rotorua) and to DOC (Te Kuiti) reported that few if any kōkako died of poisoning.

Participants at the June 1988 national kōkako workshop at Rotorua concluded that priority research for kōkako was to "determine whether predator, and browsing mammal competitor, population control will increase kōkako populations" (Innes *et al.* 1988). This was duly explored during 1989–97 by a demonstration of positive kōkako responses to pest control turned on and off at Mapara, Kaharoa, and Rotoehu (Innes *et al.* 1999). The research derived target residual abundances for ship rats and possums that are implemented for kōkako recovery to the present day.

Research 2000–2023

Accounts of previously derived knowledge that were published from 2000 onwards cover population genetics (Double & Murphy 2000; Hudson *et al.* 2000), field sex determination (Flux & Innes 2001), breeding biology (Flux *et al.* 2006), general biology (Higgins *et al.* 2006), translocations (Innes *et al.* 2013), and integration of kōkako data into reviews of forest bird mortality during aerial 1080 operations (Veltman & Westbrooke 2011; Veltman *et al.* 2014). Three papers used data from the 1989–1997 research to make further advances, showing that at least 3 years of effective pest control in each 10 should be enough to maintain kōkako populations (Basse *et al.* 2003) and that simultaneous control of ship rats and possums is required to maximise pest control benefit (Ramsey & Veltman 2005; Sinclair *et al.* 2006).

Four studies of kōkako evolutionary history and phylogeography confirmed and explored the bird's ancient lineage. The ancestors of the Callaeidae probably arrived via transoceanic dispersal after New Zealand had split from Gondwana (Ewen *et al.* 2006; Murphy *et al.* 2006; Shepherd & Lambert 2007; Lubbe *et al.* 2022). A study of historical kōkako distribution showed that they were widespread until 1950, but records suggested "a meaningful gap in its distribution that includes the Ruahine Range" (Salvador *et al.* 2019).

The mixing of kōkako from different source sites to establish genetically diverse founder populations during translocations also mixes birds that have different song dialects. Research at five sites showed that while translocated kōkako initially preferentially selected mates from the same area of origin, both they and the next generation of birds learned new song syllables from neighbours, so that assortative mating based on dialect was not a long-term impediment to population mixing (Rowe 2001; Bradley *et al.* 2013; Valderrama *et al.* 2012, 2013). Trials at the Ngapukeariki and Whirinaki translocation sites to see if 'acoustic anchoring' (broadcasting kōkako song over several weeks at the release site) would stop birds moving away from the release and pest control area showed that released birds were attracted to the playback, but it did not unequivocally demonstrate anchoring (Molles *et al.* 2008; Bradley *et al.* 2012).

KŌKAKO RECOVERY GROUP AND IWI ROLES

The KRG comprises seven people who give expert advice to DOC, but it cannot make decisions for the Department. In practice the two rarely disagree. DOC's terms of reference for the KRG are that it will provide advice, prepare recovery strategies, engage with iwi, inform decision makers and "where necessary undertake technical reviews and quality assurance of population management prescriptions". In reality the KRG has inadequate funding to fulfil all these roles. A new (third) recovery plan was completed and submitted in 2017; however, DOC stopped publication because it was revising iwi consultation processes. Seven years later no new process has emerged, and so the KRG is largely using the submitted plan anyway, retitled 'Priorities for kōkako conservation'.

Under this plan (p. 17), current long-term recovery goals are to:

1. Improve [North Island kokako] status to 'Not threatened' under the New Zealand Threat Classification System by restoring the national population to 20,000 mature individuals by 2035, and

2. Restore the species as a naturally functioning component of forest ecosystems across at least 10% of North Island forest area containing kōkako habitat (cf. <1% in 2004), including at least three populations in each local government region, by 2035.

The KRG has held annual meetings attended by many stakeholders since about 1990 and considers that free and open exchanges between all participants have been key to the programme's success. Since 2016 each site has been asked to supply a standard annual report that describes objectives, kōkako survey and pest control data, and future plans. The KRG spends most time listening to project leaders about outcomes and giving diverse advice, and also advises community groups and DOC about the suitability of potential new sites to receive kōkako. This latter function includes assessing habitat quality and deciding the best source sites for birds to be harvested, should translocations be approved.

The KRG facilitated several key practical documents, especially manuals of 'Kōkako standard management techniques' (Flux *et al.* 2019), translocation techniques (Collen *et al.* 2016), and captive husbandry (Rosemary Vander Lee & Ian Fraser, unpubl. report, 2011), although the species is no longer held for captive breeding. Kay Milton, from Supporters of Tiritiri Matangi Inc., wrote an advocacy guide for the species (Kay Milton, unpubl. report, 2015) because pest-free Tiritiri Matangi Island has many visitors and fulfils an important advocacy role for the national recovery programme. Most of the significant mainland sites for kōkako still have no or very outdated advocacy signage.

Iwi now have active roles in most kōkako conservation sites. Three sites (Ngapukeariki, Te Urewera, and Parininihi) are iwi-led, and iwi consultation and permissions are required at both ends of any planned translocation. Ngāti Rereahu and Tūhoe have been especially generous in allowing many kōkako to leave Pureora and Te Urewera respectively for translocation elsewhere. Management of the Te Urewera population was fully returned to Ngāi Tūhoe post-Treaty settlement entities in 2016; however, the KRG has not been provided with information about pest control methods or kōkako outcomes in this key relict population since. The important field base hut at Ōtamatuna burnt down in 2022, which will make it more difficult to undertake ground-based conservation management. Kōkako abundance has not been surveyed there since 2015 (Table 3).

DISCUSSION

Populations

Research and management arrived just in time to save kōkako as a moderately widespread species in North Island mainland forest ecosystems. These birds were, and remain, not as vulnerable to predators as the smaller, hole-nesting North Island saddleback (*Philesturnus rufusater*) and hihi (*Notiomystis cincta*), which both disappeared from the North Island in the late 1800s.

However, the last surviving individuals of numerous relict kōkako populations (e.g. Coromandel, Great Barrier Island [Aotea Island], Pirongia and vicinity, Maungatautari, Karakariki, Tihoi, and Wanganui) disappeared entirely during 1970–1995 before factors causing their decline were understood. During 2000–2023 further relict populations have been lost at Puketi (Northland), at Otanewainuku (Bay of Plenty), and at Moki, Makino, and probably Waitaanga (Taranaki). All current populations (although unknown for Te Urewera) are now pest-managed, and the long-term survival of the taxon requires effective, ongoing pest management. Since 2000, eleven populations have been re-established by translocation (at, in chronological order, Boundary Stream, Pukaha / Mt Bruce, Ngapukeariki, Puketi, Whirinaki, Waitākere, Otanewainuku, Maungatautari, Parininihi, Pirongia, and Pouiatoa); a twelfth population self-established when birds translocated to Parininihi dispersed 30 km east to Waitaanga. New populations were typically established using founders taken from the relict populations at a select few source sites, principally Mangatutu and Waipapa (Pureora), Mapara (King Country), and Ōtamatuna (Te Urewera).

The national population has grown steadily since 2000; however, at half the rate (7% p.a.) estimated from data collected on the Mapara population during 1992–2000 (14.9%; Basse *et al.* 2003; Sinclair *et al.* 2006). The reason for this slower rate is unknown and requires research. Some populations (e.g. Puketi, Waimā, Mataraua, Manawahe, Kaharoa, and Pukaha / Mt Bruce) have declined in some years, and others (e.g. Waitākere, Ngapukeariki, Whirinaki) have been slow to grow. However, initial slow growth of translocated populations has been typical, except at pest-free Maungatautari. Inadequate pest control and other habitat variation probably explains slow population growth at most sites. The impacts of stoats and harriers as predators are less well understood than the impacts of ship rats and possums.

Kōkako are abundant on both Hauturu (estimated 422 pairs in 2013) and Kapiti (91 pairs) Islands, and so these two sites have now fulfilled the goal of pest-free safe sites for the taxon. Growth rates at pest-fenced Maungatautari are high, and it is unfortunate that no other large (2,000+ ha) mainland sites are currently destined for fence construction, although a possible Wainuiomata site has been proposed (Jim Lynch, unpubl. report, 2021). The population on Hauturu is probably at carrying capacity. During the survey there in 2013 observers noted that the smallest territory size was 5.8 ha (mean 6.6 ha) and that few juveniles or subadults were sighted; perhaps this reflects a demographic response to the high density. Better understanding and recognition of where and when density-dependent negative feedback produces a declining rate of increase in mainland populations is required (Sinclair *et al.* 2006).

Tiritiri Matangi Island is a valuable and productive kōkako site despite its low prioritisation

(Table 2) and limited habitat. It was used during 1997–2017 to accumulate genes of captured Taranaki kōkako until birds with these genes could be returned by translocation to a pest-managed site (Parininihi). The constant risk of inbreeding at such a small (220 ha) site demands steady removal and replacement of birds. Sites receiving birds from Tiritiri Matangi have been Mokoia Island, Hunua, Waitākere, Parininihi, and Pirongia. Tiritiri Matangi receives 20,000 visitors annually; this, and the generally low vegetation and high density of kōkako, means that it is an important advocacy site for the species, including its status at other sites.

Reintroducing populations at new sites by translocation spreads the load of pest management to more people, and in a small way helps restore ecological integrity (Lee *et al.* 2005) and some original ecological processes to the native forests concerned. However, national population persistence, including retention of rare alleles, is best assisted by maintaining rapid growth and attaining large population sizes in a few key relict populations, especially Pureora, Te Urewera, Rotoehu, Mapara, and Mokaihaha (Table 2). For diverse reasons, management at these prioritised populations can always falter; pests were controlled at DOC-managed Mapara in only half of the last 20 years, and kōkako numbers and the animal pest management pest control in Te Urewera have not been reported since 2015. Translocated populations can contain only a part of the genetic diversity of the relict populations that they were harvested from. Population stages after release are establishment, growth, regulation and persistence (Seddon 1999). The single most important management action required to protect kōkako in the future is effective pest control to maximise population growth at all sites until carrying capacity is reached, but especially in key relict populations such as Pureora, Hunua, and Rotoehu, which have already attained high numbers (>200 pairs each).

New surveys of the large Hauturu and Te Urewera populations are also now urgently needed to maintain an accurate assessment of the size and conservation status of the national kōkako population.

Pest control

Mainland kōkako populations at unfenced sites are limited by the area over which there is pest control rather than the area of available forest (Table 3). Sustaining low numbers of ship rats, possums, and stoats for the November-to-February breeding period year after year is technically and physically hard work, especially for community groups and iwi that have to apply for funding for materials for their work, then supply labour unpaid and in their own time. There are diverse and sometimes conflicting sources of advice about the best control methods, and currently there is little accessible, objective evaluation and collation of new control methods by any agency, which is what community groups need. Resources of the National Pest Control Agencies (Bionet.NZ) cover many pests, but not ship rats; some guidelines are available from DOC and the Predator Free NZ Trust; however, pest control is complex and sites vary. The DOC database 'Pestlink', which previously collated results from many DOC operations, is currently not maintained apart from in relation to aerial 1080 operations.

Of the three main target taxa, possums are easiest to control and slowest to reinvade, while both ship rats and stoats are hard to control, for different reasons. Ship rats are very abundant year-round in 'warm' North Island forests in which kōkako prefer to live (Walker *et al.* 2019) and reinvade rapidly during and after control operations, including by aerial 1080 (Griffiths & Barron 2016; Carpenter *et al.* 2023). Their dense populations demand that control devices be placed quite close together, preferably 75x75 m or 50x100 m, which in turn demands large track networks, often in steep terrain, that must be maintained.

The absence of effective tools to monitor stoat populations has meant that the effectiveness of stoat control could not be cost-effectively examined; hopefully camera traps will improve this. Stoats have large home ranges (40–65 ha in North Island podocarp forests; King & Veale 2021), and so traps can be widely spaced; however, many stoats are known to avoid traps when alternative food is abundant, and some are so innately cautious as to be effectively untrappable (Johnstone *et al*. 2024). Stoats may also reinvade from well outside a kōkako management block or spend little time inside the block. Little wonder that aerial 1080 is preferred by many community groups as a 'year off' from intensive ground-based pest control, because it typically controls all three target mammals to near-zero abundance (Byrom *et al.* 2016; Robertson *et al.* 2019). However, all three target species reinvade rapidly and aerial 1080 is too expensive to apply annually everywhere.

Surprisingly, the launch of Predator Free New Zealand as a conservation vision in 2016 and the concomitant establishment of ca 20 landscape-scale projects (mean area *c.* 43,000 ha; Predator Free 2050 2021) has not so far made managing kōkako blocks (with mean area of ship rat control *c.* 1,846 ha) any easier. This is partly because the only large-scale ship rat control tool being trialled is aerial 1080 (O'Malley *et al*. 2022), which is already a known tool for kōkako managers.

Our results suggest that aerial 1080 achieves lower residual abundances of ship rats and possums than bait stations or trapping, and it also kills stoats (Murphy *et al.* 1999), all on large scales and at *c.* 20% of the per-hectare cost of ground operations (Parliamentary Commissioner for the Environment 2011). However, ship rats recover rapidly and frequently become temporarily more abundant 1–3 years after a 1080 operation (Sweetapple & Nugent 2007). Aerial 1080 applications have been implemented in eleven kōkako sites: Mapara, Mokaihaha, Ngapukeariki, Pariniinihi, Pouiatoa, Pukaha / Mt Bruce, Pureora, Rotoehu, Mataraua, Waitaanga and Whirinaki. Ongoing use of aerial 1080 over large areas is required to maximise the cost-effectiveness of kōkako recovery.

Need for research

DOC recovery groups have no ready access to research funding and the KRG has not facilitated any substantial field research for 20 years. Universities and museum staff obtained funds to study song and phylogeny, respectively, but no substantial ecological research about limiting factors (especially predation and food supply) has been undertaken since initial kōkako research ended in 1997. The detailed 1978−1984 studies on habitat use (Leathwick *et al.* 1983; Hay *et al.* 1985; Best & Bellingham 1991) are again relevant to current kōkako management because of the declining control of browsing ungulates in recent years (Leathwick & Byrom 2023). Numbers of ungulates and other browsers such as wallabies are therefore increasing at many kōkako sites, with little-understood repercussions for the diverse leaves and fruits that are probably responsible for the episodic big breeding years that periodically boost kōkako numbers (Flux *et al.* 2006). The impacts of stoats on kōkako populations remain little understood. Finally, further study of Hauturu and some dense mainland populations would be valuable to learn more about kōkako demography at sites at carrying capacity.

The future

Kōkako management is characterised by diverse collaborations between community groups, iwi, and agencies, including regional councils, and Ngā Whenua Rāhui and operations staff of DOC. Relationships between community groups and DOC vary from site to site. Previously available community-allocated funding ceased in 2017, coinciding with new major national programmes such as Jobs for Nature and Predator Free 2050 Ltd which prioritised employment and predator control, respectively, rather than biodiversity improvement. Some community groups complain that DOC has lost many employees with substantial experience, knowledge, and skills relating to pest control. DOC has stopped deriving 'best practice' pest control methods from its Pestlink database. One view given is that 'DOC is reliant on communities to do their work and then make[s] it very hard to do it' (G. Young, Kaharoa Kōkako Trust, pers. comm.).

However, DOC now undertakes much more aerial 1080 pest control via the National Predator Control Programme than 15 years ago, partly because OSPRI (formerly the Animal Health Board) has eradicated bovine tuberculosis from many areas and so does fewer aerial 1080 operations than it used to. Also, the Department has *c.* 4,000 threatened species requiring management and a limited budget, and DOC staff themselves have more paperwork associated with projects than 15 years ago, due, for example, to the Health and Safety at Work Act 2015.

Research into kōkako ecology, pest control methods and outcomes is needed, but funds are inevitably scarce for this when DOC is obliged to manage many species that are more threatened and require more urgent management. Kōkako recovery has not had an updated formal recovery plan for 7 years, and pest management at some key relict sites (e.g. Opuiaki, Mapara, and Waipapa) has been haphazard. The loss of the support hut at the former Ōtamatuna mainland island (Te Urewera) and extensive treefall along pest control lines at Waipapa after Cyclone Gabrielle in 2023 are reminders that in remote areas where ground-based work is required, under-investment in infrastructure (e.g. huts, tracks, bait lines, bait stations, traps) increases the risk that conservation targets won't be achieved.

Increased iwi involvement is a significant and welcome recent trend in kōkako conservation; however, this demands substantial reciprocal learning and exchange between iwi and kōkako managers. With such open collaboration, we believe that further iwi engagement in kōkako restoration offers huge mutual benefit, but it will clearly take time to become effective at all sites.

New, cost-effective, large-scale pest (predator and browser) control tools are needed to take the strain off community groups. Rapid kōkako population growth at Maungatautari has shown what is possible at sites free of all pests, including deer, pigs, and goats. The Predator Free 2050 initiative (Department of Conservation 2021) may yield this in time; however, no significant new tools have been developed so far.

Vegetated corridors that dispersing kōkako will use are being implemented to connect some currently isolated populations (especially Kaharoa−Otanewainuku) and are possible at others (Mapara−Pureora and Rotoehu−Manawahe). This should increase the effective population size at these sites.

The kōkako programme is widely viewed as successful (King 2023); however, we should not be complacent. Climate change may reduce the future availability and quality of forest tree fruit, a key kōkako food (Yukich Clendon *et al.* 2023), increase baseline pest densities, and increase the likelihood of novel pathogens establishing in kōkako habitats.

The Waimā–Mataraua (Northland) kōkako population declined from 68 pairs in 2018 to 10 pairs in 2023, despite ship rat and possum control targets being met, and stoats being trapped; we do not understand why. Declines were also revealed in the latest surveys at Waitākere, Kaharoa, Mapara, and Pukaha / Mt Bruce, and in very recent (2024) surveys at Pureora (DB, AR, unpubl. data), while the nationally significant populations in Te Urewera and on Hauturu have not been surveyed for a decade.

A current short-term recovery goal of 3,000 pairs by 2025 is certainly unachievable, and in fact a national population decline at next collation now seems possible.

The quality and quantity of pest management need to be improved and community groups need more institutional support. Twenty years after timely research that successfully paved this taxon's path towards recovery, more research is now badly needed if long-term recovery goals are to be achieved.

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LITERATURE CITED

Basse, B.; Flux, I.; Innes, J. 2003. Recovery and maintenance of North Island kokako (*Callaeas cinerea wilsoni*) populations through pulsed pest control. *Biological Conservation 109*: 259–270.

Best, H.A.; Bellingham, P.J. 1991. A detailed habitat study of North Island kokako in Puketi Forest, Northland. *Science and Research Internal Report 103*. Department of Conservation, Wellington, New Zealand.

Bionet and National Pest Control Agencies. 2020. A1 possum population monitoring using the trap-catch, waxtag and chewcard methods. Bionet Portal, Ministry of Primary Industries, Wellington, NZ, 42 pp.

BirdLife International. 2022. *Callaeas wilsoni*. The IUCN Red List of Threatened Species 2022: e.T103730482A216851596

Bradley, D.W.; Molles, L.E.; Valderrama, S.V.; King, S.; Waas, J.R. 2012. Factors affecting post-release dispersal, mortality, and territory settlement of endangered kokako translocated from two distinct song neighbourhoods. *Biological Conservation 147*: 79–86.

Bradley, D.W.; Molles, L.E.; Waas, J.R. 2013. Post-translocation assortative pairing and social implications for the conservation of an endangered songbird. *Animal Conservation 17(3)*: 197–203.

Byrom, A.E.; Innes, J.; Binny, R.N. 2016. A review of biodiversity outcomes from possum-focused pest control in New Zealand. *Wildlife Research 43*: 228–253.

Carpenter, J.K.; Monks, A.; Innes, J.; Griffiths, J. 2023. Radio collaring reveals long-distance movements of reinvading ship rats following landscape-scale control. *New Zealand Journal of Ecology 47(1)*: 3522.

Collar, N.J.; Crosby, M.J.; Stattersfield, A.J. 1994. Birds to watch 2. The world list of threatened birds. *Birdlife Conservation Series 4*. Cambridge, UK, 407 pp.

Collen, R.; Flux, I.; Innes, J.; Speed, H.; Thurley, T.; Wills, S. 2016. Best practice techniques for the translocation of North Island kōkako (*Callaeas wilsoni*). Department of Conservation, Wellington, New Zealand, 55pp.

Department of Conservation 2021. Predator Free 2050 5-year progress report. NZ Department of Conservation, Wellington, New Zealand.

Double, M.; Murphy, S. 2000. Genetic variation within and among populations of North Island kokako. *Science and Research Internal Report 176*. Department of Conservation, Wellington, New Zealand.

Ewen, J.G.; Flux, I.; Ericson, P.G.P. 2006. Systematic affinities of two enigmatic New Zealand passerines of high conservation priority, the hihi or stitchbird *Notiomystis cincta* and the kokako *Callaeas cinerea*. *Molecular Phylogenetics and Evolution 40*: 281−284.

Fitzgerald, A.E. 1984. Diet overlap between kokako and the common brushtail possum in central North Island, New Zealand. Pp. 569−573 *In:* Smith, A.P.; Hume, I.D. (eds) *Possums and gliders*. Sydney, Australia, Australian Mammal Society.

Flux, I.; Bradfield, P.; Innes, J. 2006. Breeding biology of North Island kokako (*Callaeas cinerea wilsoni)* at Mapara Wildlife Management Reserve, King Country, New Zealand. *Notornis 53*: 199−207.

Flux, I.; Innes, J. 2001. A field technique for determining the sex of North Island kokako (*Callaeas cinerea wilsoni*). *Notornis 48*: 217−223.

Flux, I.; Innes, J.; Barea, L.; Burns, R.; Corkery, I.; Parker, K.; Speed, H.; Thurley, T.; Wills, S. 2019. Kōkako standard management techniques. doc-5897165. Department of Conservation, Wellington, NZ, 65 pp.

Gillies, C. 2013. Animal pests: tracking tunnel indices of small mammal abundance. Version 1.0. DOCDM-322684. Department of Conservation, Wellington, New Zealand.

Griffiths, J.; Barron, M. 2016. Spatiotemporal changes in relative rat (*Rattus rattus*) abundance following large-scale pest control. *New Zealand Journal of Ecology 40*: 371–380.

Hay, J.R.; Best, H.A.; Powlesland, R.G. 1985. *Kokako*. John McIndoe, Dunedin, New Zealand and New Zealand Wildlife Service, Wellington, New Zealand, 32 pp.

Higgins, P.J.; Peter, J.M.; Cowling, S.J. (eds) 2006. *Handbook of Australian, New Zealand and Antarctic birds*. Volume 7: Boatbill to starlings. Melbourne, Oxford University Press.

Hitchmough, R. (compiler) 2002. New Zealand Threat Classification System Lists. Department of Conservation, Wellington, 194 pp.

Hudson, Q.J.; Wilkins, R.J.; Waas, J.R.; Hogg, I.D. 2000. Low genetic variability in small populations of New Zealand kokako *Callaeas cinerea wilsoni*. *Biological Conservation 96*: 105−112.

Innes, J.; Fitzgerald, N.; Binny, R.; Byrom, A.; Pech, R.; Watts, C.; Gillies, C.; Maitland, M.; Campbell-Hunt, C.; Burns, B. 2019. New Zealand ecosanctuaries: types, attributes and outcomes. *Journal of the Royal Society NZ 49*: 370−393.

Innes, J.; Flux, I. 1999. North Island kokako recovery plan 1999−2009. *Threatened Species Recovery Plan 30*. Department of Conservation, Wellington, New Zealand.

Innes, J.; Hay, R.; Flux, I.; Bradfield, P.; Speed, H.; Jansen, P. 1999. Successful recovery of North Island kokako *Callaeas cinerea wilsoni* populations, by adaptive management. *Biological Conservation 87*: 201−214.

Innes, J.; Kelly, D.; Overton, J.; Gillies, C. 2010. Predation and other factors currently limiting New Zealand forest birds. *New Zealand Journal of Ecology 34(1)*: 86−114.

Innes, J.; Molles, L.E.; Speed, H. 2013. Translocations of North Island kokako, 1981−2011. *Notornis 60*: 107−114.

Innes, J.; Owen, K.; Smale, S. (compilers) 1988. Proceedings of the kokako workshop, FRI, Rotorua, June 7−9, 1988. Forest Research Institute (now SCION) Project Record 1960, 30 pp.

Johnstone, K.C.; Price, C.; Garvey, P.M. 2024. Personality, sex and capture biases: challenges for predator monitoring and management. *Journal of Applied Ecology 61*: 2207−2218.

King, C.M. 2023. Asking the right questions about Predator Free New Zealand. *New Zealand Journal of Ecology 47(1)*: 3558.

King, C.M.; Gaukrodger, D.J.; Ritchie, N.A. (eds) 2015. *The drama of conservation. The history of Pureora Forest, New Zealand*. Springer International Switzerland and Department of Conservation, Wellington, New Zealand. 357 pp.

King, C.M.; Veale, A.J. 2021. *Mustela erminea*. Family Mustelidae. pp. 285−341 *In:* King, C.M.; Forsyth, D.M. (eds) *The handbook of New Zealand mammals*. 3rd edn. CSIRO Publishing, Melbourne, Australia.

Lavers, R.B. 1978. Distribution of the North Island kokako (*Callaeas cinerea wilsoni*). A review. *Notornis 25*: 165−185.

Leathwick, J.R.; Byrom, A.E. 2023. The rise and rise of predator control: a panacea, or a distraction from conservation goals? *New Zealand Journal of Ecology 47(1)*: 3515.

Leathwick, J.R.; Hay, J.R.; Fitzgerald, A.E. 1983. The influence of browsing by introduced mammals on the decline of the North Island kokako. *New Zealand Journal of Ecology 6*: 55–70.

Lee, W.; McGlone, M.; Wright, E. 2005. Biodiversity inventory and monitoring. A review of national and international systems and a proposed framework for future biodiversity monitoring by the Department of Conservation. Landcare Research Contract Report LC0405/122. Lincoln, Landcare Research.

Lubbe, P.; Rawlence, N.J.; Kardailsky, O.; Robertson, B.C.; Day, R.; Knapp, M.; Dussex, N. 2022. Mitogenomes resolve the phylogeography and divergence times within the endemic New Zealand Callaeidae (Aves: Passerida). *Zoological*

Journal of the Linnaean Society 196(4). doi:10.1093/zoolinnean/zlac060.

McDowall, R.M. 1969. Extinction and endemism in New Zealand land birds. *Tuatara 17*: 1–12.

Molles, L.E.; Calcott, A.; Peters, D.; Delamare, G.; Hudson, J.; Innes, J.; Flux, I.; Waas, J. 2008. "Acoustic anchoring" and the successful translocation of North Island kokako (*Callaeas cinerea wilsoni*) to a New Zealand mainland management site within continuous forest. *Notornis 55*: 57–68.

Morgan, D.R.; Nugent, G.; Warburton, B. 2006. Benefits and feasibility of local elimination of possum populations. *Wildlife Research 33*: 605–614.

Murphy, E.C.; Young, J.B.; Robbins, L.; Dowding, J.E. 1999. Secondary poisoning of stoats after an aerial 1080 poison operation in Pureora Forest, New Zealand. New Zealand *Journal of Ecology 23*: 175–182.

Murphy, S.A.; Flux, I.A.; Double, M.C. 2006. Recent evolutionary history of New Zealand's North and South Island kokako (*Callaeas cinerea*) inferred from mitochondrial DNA sequences. *Emu 106*: 41–48.

O'Malley, T.D.R.; Stanley, M.C.; Russell, J.C. 2022. Assessing two different aerial toxin treatments for the management of invasive rats. *Animals 12*: 309. doi.org/10.3390/ani12030309

Parliamentary Commissioner for the Environment. 2011. *Evaluating the use of 1080: predators, poisons and silent forests.* Parliamentary Commissioner for the Environment, Wellington, New Zealand.

Powlesland, R.G. 1987. The foods, foraging behaviours and habitat use of North Island kokako in Puketi State Forest, Northland. *New Zealand Journal of Ecology 10*: 117–128.

Predator Free 2050. 2021. Predator Free 2050 5-year progress report. Department of Conservation, Wellington, New Zealand, 104 pp.

Ramsey, D.; Veltman, C. 2005. Predicting the effects of perturbations on ecological communities: what can qualitative models offer? *Journal of Animal Ecology 74*: 905–916.

Reischek, A. 1886. Ornithological notes. *Transactions of the New Zealand Institute 19*: 190.

Robertson, H.A.; Baird, K.A.; Elliott, G.P.; Hitchmough, R.A.; McArthur, N.J.; Makan, T.D.; Miskelly, C.M.; O'Donnell, C.F.J.; Sagar, P.M.; Scofield, R.P.; Taylor, G.A.; Michel, P. 2021. Conservation status of birds in Aotearoa New Zealand, 2021. *New Zealand Threat Classification Series 36*. Department of Conservation, Wellington, NZ, 43 p.

Robertson, H.A.; Guillotel, J.; Lawson, T.; Sutton, N. 2019. Landscape-scale applications of 1080 pesticide benefit North Island brown kiwi (*Apteryx mantelli*) and New Zealand fantail (*Rhipidura fuliginosa*) in Tongariro Forest, New Zealand. *Notornis 66*: 1–15.

Rowe, S.J. 2001. Song repertoire variation in kokako (*Callaeas cinerea wilsoni*) and saddlebacks (*Philesturnus carunculatus rufusater*) following translocation to Kapiti Island. Unpubl. MSc Thesis, Victoria University of Wellington, New Zealand. 185 pp.

Salvador, R.B.; Tomotani, B.M.; Miskelly, C.M.; Waugh, S.M. 2019. Historical distribution data of New Zealand endemic families Callaeidae and Notiomystidae (Aves, Passeriformes). *Check List 15*: 701–727.

Seddon P.J. 1999. Persistence without intervention: assessing success in wildlife reintroductions. *Trends in Ecology and Evolution 14(12)*: 503.

Shepherd, L.D.; Lambert, D.M. 2007. The relationships and origins of the New Zealand wattlebirds (Passeriformes, Callaeatidae) from DNA sequence analyses. *Molecular Phylogenetics and Evolution 43*: 480–492.

Sinclair, A.R.E.; Innes, J.; Bradfield, P. 2006. Making endangered species safe: the case of the kokako of North Island, New Zealand. *New Zealand Journal of Ecology 30*: 121–130.

Smith, D.H.V.; Weston, K.A. 2017. Capturing the cryptic: a comparison of detection methods for stoats (*Mustela erminea*) in alpine habitats. *Wildlife Research 44(5)*: doi:10.1071/WR16159

Sweetapple, P.J.; Nugent, G. 2007. Ship rat demography and diet following possum control in a mixed podocarp-hardwood forest. *New Zealand Journal of Ecology 31*: 186–201.

Valderrama, S.V.; Molles, L.E.; Waas, J.R. 2012. Effects of population size on singing behavior of a rare duetting songbird. *Conservation Biology 27*: 210–218.

Valderrama, S.V.; Molles, L.E.; Waas, J.R.; Slabbekorn, H. 2013. Conservation implications of song divergence between source and translocated populations of the North Island kokako. *Journal of Applied Ecology 50*: 950–960.

Veltman, C.J.; Westbrooke, I.M. 2011. Forest bird mortality and baiting practices in New Zealand aerial 1080 operations from 1986 to 2009. *New Zealand Journal of Ecology 35(1)*: 21–29.

Veltman, C.J.; Westbrooke, I.M.; Powlesland, R.G.; Greene, T.C. 2014. A principles-based decision tree for future investigations of native New Zealand birds during aerial 1080 operations. *New Zealand Journal of Ecology 38(1)*: 103–109.

Walker, S.; Kemp, J.R.; Elliott, G.P.; Mosen, C.C.; Innes, J.G. 2019. Spatial patterns and drivers of invasive rodent dynamics in New Zealand forests. *Biological Invasions 21*: 1627–1642.

Weiser, E.L. 2015. Management strategies for establishing and maintaining genetically robust populations of kōkako. Unpubl. report to the Kōkako Specialist Group. Allan Wilson Centre for Molecular Ecology and Evolution; Department of Zoology, University of Otago, Dunedin, New Zealand and Division of Biology, Kansas State University, USA.

Weiser, E.L.; Grueber, C.E.; Jamieson, I.G. 2012: AlleleRetain: a program to assess management options for conserving allelic diversity in small isolated populations. *Molecular Ecology Resources 12*: 1161–1167.

Weiser, E.L.; Grueber, C.E.; Jamieson, I.G. 2013: Simulating retention of rare alleles in small populations: assessing management options for species with different life histories. *Conservation Biology 27*: 335–344

Williams, G.R. 1976. The New Zealand wattlebirds (Callaeatidae). Pp. 161−170 *In:* Frith, H.J.; Calaby, J.H. (eds). *Proceedings of the 16th International Ornithological Congress*. Australian Academy of Science, Canberra, 765 pp.

Yukich Clendon, O.M.M.; Carpenter, J.K.; Kelly, D.; Timoti, P.; Burns, B.R.; Boswijk, G.; Monks, A. 2023. Global change explains reduced seeding in a widespread New Zealand tree: indigenous Tūhoe knowledge informs mechanistic analysis. *Frontiers in Forests and Global Change 6*. doi.org/10.3389/ffgc.2023.1172326

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Aspects of breeding by Hutton's shearwaters (*Puffinus huttoni*) at a recently established colony at Te Rae o Atiu, Kaikōura Peninsula, New Zealand

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Abstract: A colony of the Nationally Vulnerable Hutton's shearwater (*Puffinus huttoni*) was established by translocations to Te Rae o Atiu, Kaikōura Peninsula from 2005. Weekly observer visits to the wooden nestboxes, and records from passive integrated transponder readers, provided detailed records of breeding activity. Birds visited many nestboxes in a season, with up to 29 birds recorded at one nestbox, and one bird recorded at 23 nestboxes. Breeding started at 4 years for males and 5 years for females. The pre-laying exodus by females averaged 11.8 days; however, there were instances of birds making up to three brief visits back to the colony. Egg laying was usually on the night of arrival back from the pre-laying exodus, and was asynchronous — average 6 November, but as late as 25 December. There were seven instances of two eggs being found in a nestbox in one season, with evidence of relaying in at least one case. The average hatching date was 13 December, incubation averaged 52 days, with a mean hatching success of 58%. Fledgling period was 87 days on average, with a mean success of 88%, resulting in mean productivity of 52%. Chicks left nestboxes on average 8 nights before fledging, before their first migration to Australian waters. Adults stopped visiting the nestboxes on average 17 days before their chicks fledged for females and 8 days for males. Fledging mass averaged 415 g, 75% of the mean peak mass of 550 g. Single parents successfully fledged a chick when the mate was lost or ceased visiting for up to 71 days before fledging, and a light mass chick (310 g) returned to Te Rae o Atiu and paired up. Divorce occurred in 36% of pairings that did not end with the loss of a partner; 87% of birds had at least one divorce, and one bird lost one mate and divorced six times in 13 years. Nestbox fidelity showed changes by many pairs, especially if there has been a change of partner.

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Keywords: Hutton's shearwater, *Puffinus huttoni*, Te Rae o Atiu, Kaikōura Peninsula, New Zealand, breeding, Kaikōura tītī.

INTRODUCTION

Hutton's shearwater (*Puffinus huttoni*) is a small black-and-white shearwater (length 36–38 cm; mass 365 g; Marchant & Higgins 1990) that is classified as Endangered (BirdLife International 2021), and Threatened – Nationally Vulnerable under the New Zealand Threat Classification system (Robertson *et al.* 2021). Hutton's shearwater is considered to be one of a group of eight small, closely related shearwaters comprising the Manx shearwater (*P. puffinus*) group; the others being the fluttering shearwater (*P. gavia*) in New Zealand, Newell's shearwater (*P. newelli)* in the Hawaiian Islands, Townsend's shearwater (*P. auricularis*)

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in the Revillagigedo Islands off the west coast of Mexico, Balearic shearwater (*P. mauretanicus*) and Yelkouan shearwater (*P. yelkouan*) in the Mediterranean Sea, and black-vented shearwater (*P. opisthomelas*) off Baja California (Brooke 1990; Warham 1990).

In 1965, following up on anecdotal reports from high-country farmers, hunters and others of "muttonbird" burrows high in the Seaward Kaikōura Range, Hutton's shearwater breeding grounds were found in the headwaters of the Kōwhai River (42.261°S, 173.603°E) at altitudes between 1,200 and 1,800 m a.s.l. by Geoff Harrow (1965). Hutton's shearwaters breed at the highest altitudes of the Manx group of shearwaters, with Newell's shearwater breeding close to 1,200 m (BirdLife International 2021) and Townsend's shearwater above 800 m (Martinez-Gomez & Jacobsen 2004). In autumn, Hutton's shearwaters migrate to Australian waters before returning in spring (Imber & Crockett 1970; Halse 1981; Warham 1981; Rowe & Taylor 2020).

There are only two known natural Hutton's shearwater colonies remaining today – in the Kōwhai River and at Shearwater Stream (42.167°S, 173.727°E) (Marchant & Higgins 1990; Cuthbert 2001; Sommer *et al.* 2009). Major threats to these colonies are pigs (*Sus scrofa*) (Cuthbert 2002) and earthquakes. The 7.8 magnitude Kaikōura earthquake on 14 November 2016 resulted in about 12% of the colony area being lost through landslides and a reduction in burrow density of about 29% in the surviving colonies; a minimum of 40,000 breeding Hutton's shearwaters were lost in landslides and potentially another 80,000 from burrow collapse (Cuthbert 2019; and see Cargill *et al*. 2023).

The Department of Conservation (DOC) identified the Hutton's shearwater as a threatened species requiring medium term action for its recovery (Molloy & Davis 1992). It was recommended that a third, lowland colony be established (Paton & Davis 1997; Cuthbert 2001). An agreement was reached in 2005 between DOC and Whale Watch Kaikōura for a new colony (now called Te Rae o Atiu) to be established on Whale Watch land on the Kaikōura Peninsula (42.429°S, 173.703°E). The first translocation of chicks was in 2005, and a further five translocations were undertaken up to 2013. Rowe & Howard (2023) report on the first 16 years' progress of the new colony and described some of the pitfalls encountered when establishing a new colony without a predator-proof fence in place for the first five years. This paper reports on aspects of the breeding of Hutton's shearwaters at Te Rae o Atiu after birds returned from their migrations to Australian waters.

METHODS

The initial area selected was 0.3 ha of farmland enclosed by a standard farm fence; this was extended to 2 ha in 2010 when the predator-proof fence was erected (Rowe 2014; Rowe & Howard 2023). All observations reported here are of birds breeding in 108 artificial burrows (wooden nestboxes), the details of which and the translocation programme can be found in Rowe & Howard (2023).

In total, 493 chicks translocated from the Kōwhai River colonies to Te Rae o Atiu were banded with unique numbered leg-bands. Monitoring of the new colony was usually carried out during visits in the morning at approximately weekly intervals. In the early years, the Hutton's Shearwater Charitable Trust (HSCT) site protocols restricted night visits as we did not want to disturb any returning birds unduly; it was considered that birds seen and/or handled during the day would have settled by nightfall. Band numbers of birds found in nestboxes were recorded and, up until 2010, white correction fluid (Twink™) was applied to their heads to reduce handling. A line running from above the bill to the back of the head was applied to the first bird found in a nestbox and a line across the head was applied to the second bird assumed to be its mate. However, this simple system proved not to be foolproof as some birds seen together in a nestbox very early in the season and marked were later found to be breeding in other nestboxes with different partners, and sometimes both members of the new pair had the same marking.

Chicks from the 2012 and 2013 cohorts also had passive integrated transponders (PIT-tags) inserted in the back of their necks after translocation to Te Rae o Atiu. PIT-tag reader systems similar to those used by Taylor *et al*. (2012) were placed on frequented nestboxes to log when birds passed through the antennae coils placed around the outlet tunnels, 20 cm up from the entrance (Rowe 2014; Rowe & Howard 2023). From 2012-13, birds from the earlier translocations that returned as adults were PIT-tagged when captured in nestboxes. Some of the earlier birds were not tagged, or not tagged for several seasons, as they were not found in nestboxes during the weekly checks, although they may have been present at night. Movement of a set of three pins at the external entrance to the tunnel indicated which nestboxes may have been used since the last visit and that needed PIT-tag readers installed. Movements of another set of pins at the nest chamber entrance indicated which nestboxes were used since the last monitoring visit. Many PIT-tag readers were not attached to nestboxes until the internal pins had been moved, and so there may be some bias in recording the dates of first returns to a given nestbox. Incomplete records were occasionally caused by operator error, battery failure, and antennae detuning through moisture ingress into the coils (Taylor *et al*. 2012). Because the PIT-tag reader can record several times per second and therefore fill the memory in a short time, the recorder was programmed to record each PIT-tag once per minute.

The pre-laying exodus in petrels is defined as the period which a female was absent from the colony immediately before laying (Warham 1990; Bull 2005). For statistical purposes, the egg laying date was defined as the middle of the date of first sighting of the egg and the previous date that the female was determined to be present, provided the interval was <= 8 days, otherwise it was considered indeterminate; the date was refined by the return date of the female to the nestbox after an exodus. Chick hatching date was determined as the middle of monitoring visits but was refined where there was evidence of egg pipping, wet chicks, and from chick size using growth rates from Cuthbert & Davis (2002). Chick fledging date was determined as the middle of the last date seen and the first date absent, or the last date the chick was present according to PIT-tag records.

Eggs were measured using digital calipers to 0.1 mm. Digital scales were used to obtain egg mass to 0.1 g and chick mass to 1 g. Sexes were determined from feather samples using DNA analysis (Griffiths *et al.* 1998; undertaken by the Equine Parentage and Animal Genetic Service Centre, Massey University or Zoology Department, University of Canterbury). Birds that were not DNA-sexed were inferred to be the opposite sex to their mates. It was not possible to infer sexes in some instances. In most cases, birds sitting on eggs or with chicks are assumed to be the parents of the egg and/or chick; however, there were some instances where the link could not be confirmed.

A bird arriving back in its n^th^ year after hatching is considered to be n-years-old as it will pass its n^th^ birthday in late December/early January (Brooke 1990). With the exception of some late fledging birds, laying through to fledging occurs within New Zealand Daylight Saving Time (NZDST). The PIT-tag readers were programmed in NZDST to reduce the possibility of errors in setup. All times given here are in NZDST.

Data presented are from the 2005-06 translocation up until 2022-23; data from 2021-22 are limited because a case of avian pox was detected and visits to the colony and bird handling were reduced as a precaution against disease spread. Calculated averages are given with 95% confidence intervals. Other statistics and tests performed used routines in Freese (1967) or Sokal & Rolfe (1981). The values of t, r, F and χ^2 are compared to tabulated values at the 95% significance level; calculated test statistics < tabulated values are not significant and *vice versa*.

RESULTS

Annual return from Australia

Hutton's shearwaters undertake an autumn migration to Australian waters and arrive back to the New Zealand breeding grounds from late-August. Very few birds were seen in nestboxes during daytime before egg laying. Therefore, reliable data on the dates of first returns are only available for PIT-tagged birds. These show that on average, the earliest birds were back each year on 30 August (range 22 August to 10 September). Birds aged 2–6 years-old tended to arrive back later in the year than older birds that arrived back from late August (Fig. 1). There was no significant difference between the first recorded dates back each year for each female and each male over the years 2017–2022 (female average 14 September; male average 16 September; unpaired sample t test: $t = 0.17 < t_{P=0.05} = 1.97$, df = 169).

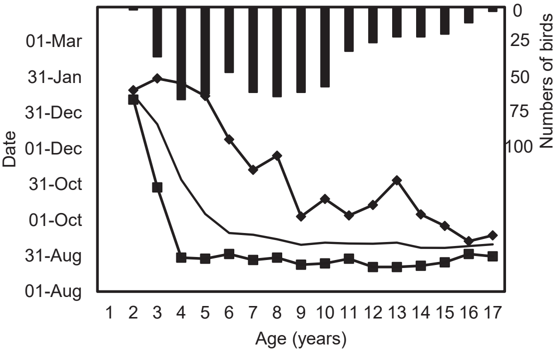

Figure 1. The date PIT-tagged Hutton's shearwaters first returned to Te Rae o Atiu by age. Data are from 2013-14 (when the 2006 translocation chicks were already in their 8^th^ year) through to 2022-23. ■ = earliest date; line only = average date; ♦ = latest date.

Age of first return from Australia

Hutton's shearwaters returning to the colonies for the first time generally make landfall in their 3^rd^ (males) or 4^th^ year (females); however, the difference was not significant ($\chi^2 = 7.56 < \chi^2_{P=0.05} = 7.81$, df = 3; Fig. 2). Three of 139 birds were recorded back first in their 2^nd^ year and others were as late as 11-years-old. It is probable that some birds were back at Te Rae o Atiu earlier than noted, as we know from PIT-tag records that not all recorded birds were seen by human observers. For example, only 35% of 4-year-old birds recorded back at Te Rae o Atiu from PIT-tag records from the 2012 and 2013 transactions and Te Rae o Atiu bred chicks were physically seen, and birds from the 2006 to 2008 translocations were not PIT-tagged until into their 5th year or later.

Nestbox visitations

Over the course of a season, adult Hutton's shearwaters often visited a number of nestboxes apart from that in which they bred. Up to 29 birds visited a given nestbox in one season, e.g., nestbox 58 in 2017-18 (Fig. 3). X20909 was the only male with an extended presence over the season and was the probable male incumbent. These records do not show an obvious female presence; however, an egg was laid between 18 and 28 November.

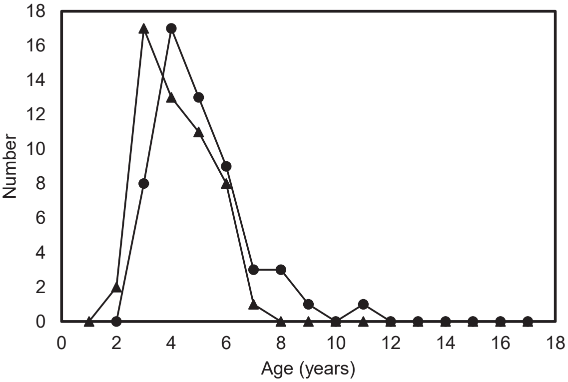

Figure 2. Age at which Hutton's shearwaters were known to return to Te Rae o Atiu for the first time. Key: ▲ males; ● females.

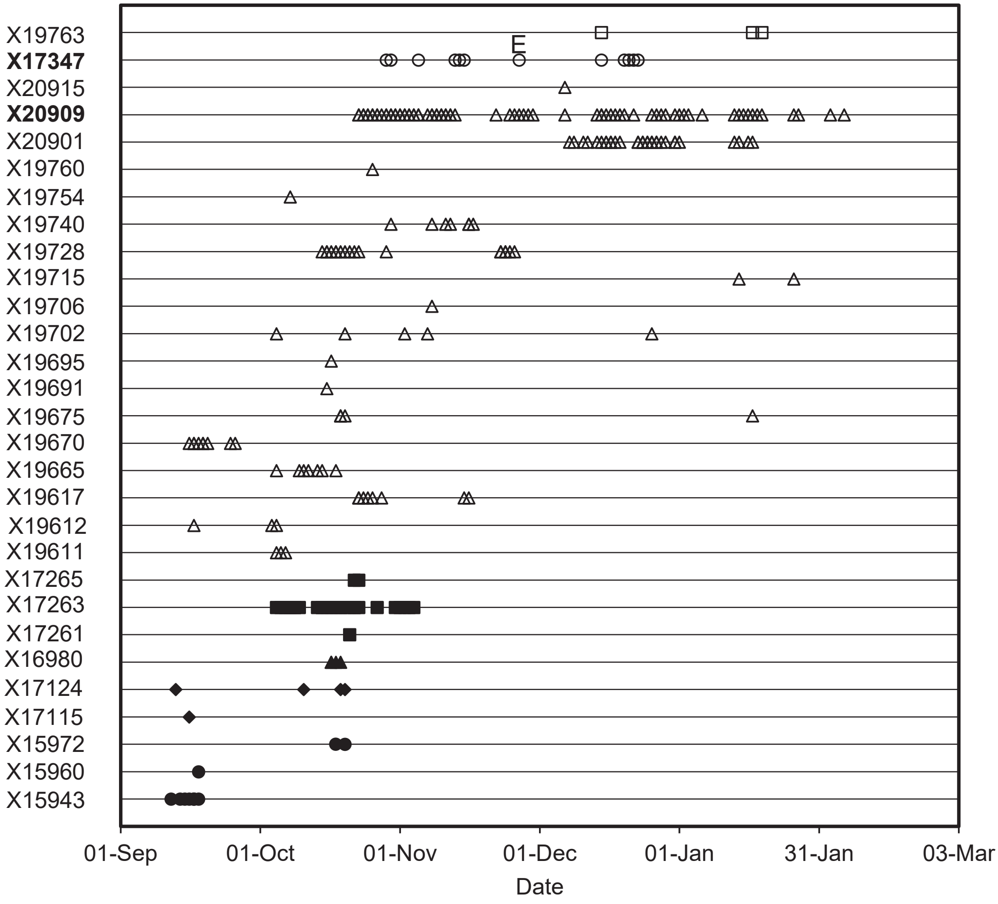

Figure 3. Timelines when 29 Hutton's shearwaters triggered the PIT-tag reader at Te Rae o Atiu nestbox 58, 2017–18. X20909 (bold) is the probable male incumbent at this nestbox and X17347 (bold) was likely to have laid an egg on 27 November (point E). Each marker type represents birds from one cohort, the oldest being at the bottom: ● = 2006; ♦ = 2007; ▲ = 2008; ■ = 2012; Δ = 2013; ○ = bird first banded as adult; □ = 2014-15 Te Rae o Atiu bred chick.

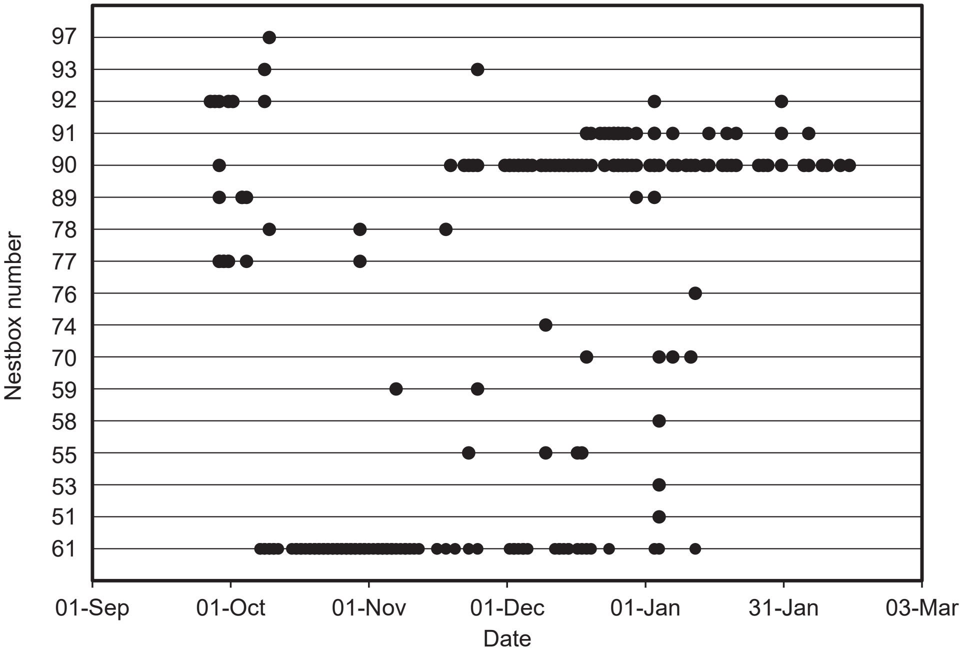

Figure 4. Timelines for Hutton's shearwater X19728 triggering the PIT-tag readers at 17 Te Rae o Atiu nestboxes in 2018-19. Note his home nestbox was #61; however, there were significant concurrent visits to nestbox 90 until mid-December, and then at nestboxes 90 and 91 until February.

The only female seen in nestbox 58 during that interval was X17347 on 27 November, and it is probable that she laid the egg after returning from a 12-day pre-laying exodus beginning 15 November. Some of the visits to nestbox 58 were by younger birds, e.g., 5-year-olds from the 2013 translocation, that visited the colony later in the season.

Individual birds visited up to 23 nestboxes in a season. For example, male X19728 from nestbox 61 in 2018–19 visited 17 nestboxes (Fig. 4). In addition to nestbox 61, this bird was a frequent visitor to nestbox 90 from mid-November then to nestboxes 90 and 91 from mid-December. The number of visits may have been related to age (he visited more nestboxes as a 5- and 6-year-old than when older), or whether or not he was caring for a chick (Table 1).

Pre-laying exodus

Before laying, females were absent from the colony for several days on pre-laying exoduses. The lengths of 203 absences from the colony were determined from PIT-tag records (Fig. 5). These absences averaged 11.8 days (sd = 3.3 days, CI = ± 0.5 days, n = 203), and ranged from 5 to 22 days. Absences for individual birds varied widely (Fig. 6). For example, X15997 was recorded as being away for 6 days in 2014, 20 days in 2018, and averaged 12.1 days (sd = 4.4 days, CI = ± 2.7 days, n = 10).

Table 1. Number of nest boxes visited by a male Hutton's shearwater, other than his home nestbox.

Year	Age (years)	Number of nestboxes	Egg hatched
2017-2018	5	11	No
2018-2019	6	17	No
2019-2020	7	4	Yes
2020-2021	8	3	Yes
2021-2022	9	3	Yes
2022-2023	10	5	No

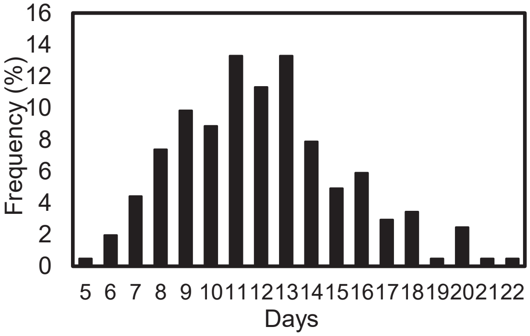

Figure 5. Frequency of the length of pre-laying exoduses of Hutton's shearwaters at Te Rae o Atiu 2012-2022.

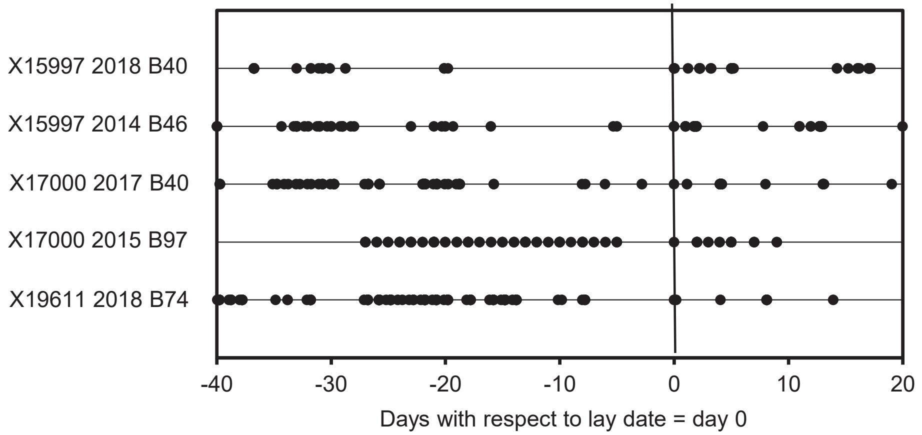

Figure 6. Examples of timelines for breeding female Hutton's shearwaters triggering the PIT-tag readers at Te Rae o Atiu nestboxes before and after egg laying (day 0) showing the variation in absences during pre-laying exoduses.

On the basis that many shearwater species have an exodus of 14 days or more (Warham 1990; Bull 2005), 57 instances of exoduses <10 days were re-examined. Twenty-six of these had another gap >4 days long before a brief visit to the colony. If that visit was ignored, the exoduses of these 26 birds were extended by an average of 8 days; the balance did not show evidence of significant gaps prior to the exodus determined previously. As an example, X15997 in 2014 had an 11-day gap prior to the short visit 6 days before the lay-date which, if ignored, extended the determined exodus to 17 days (Fig. 6). X17000 in 2015 had a 5-day absence with no earlier gaps, whereas during 2017 she was absent for only 43 hours before laying; the exodus could be considered extending to 16 days with three brief visits back to Te Rae o Atiu during that time. The trace for X19611 suggests there were two visits during an exodus of 14 days.

The 2021 PIT records were examined for 28 of 36 layings when both parents had records. Of these, 27 showed that the male was present for the majority of the time that the female was away as, e.g., in Fig. 7. In only one instance was the male away for a significant amount of the time the female was absent – an 8-day break by X17265 at the end of the 16-day exodus for X17000.

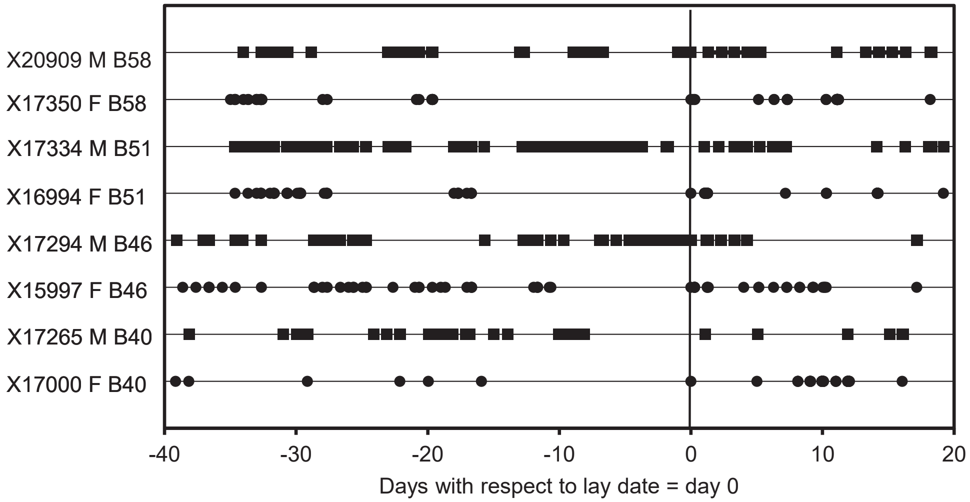

Figure 7. Timelines for selected breeding pairs of Hutton's shearwaters triggering PIT-tag readers at Te Rae o Atiu during 2021 before and after egg laying (day 0) showing the variation in male attendance during the female pre-laying exodus. ■ males, ● females.

Egg-laying and eggs

By the end of 2022-23 season, 279 eggs had been laid at Te Rae o Atiu. Two eggs were laid in one nestbox in one season seven times.

The age at which Hutton's shearwaters at Te Rae o Atiu were first recorded with eggs was significantly different between the sexes ($\chi^2 = 21.87 > \chi^2_{tab,P = 0.05} = 9.49$, df = 4, Table 2). Two females are known to have successfully laid eggs at 4 years old, while 18 (38%) of 47 individuals laid first at 5 years old. A higher proportion of males started breeding at 4 years old; 14 (29%) of 49 males that age were in pairs that produced eggs.

Table 2. Ages at which Hutton's shearwaters were first observed with an egg at Te Rae o Atiu.

Age (years)	4	5	6	7	>7	Total
Male	14	22	11	2	0	49
Female	2	18	10	9	8	47
Total	16	40	21	11	8	96

Laying was asynchronous, occurring between 20 October and 25 December (a spread of 66 days), with an average lay date of 6 November (Table 3); 90% of eggs were laid within a 4-week period (Fig. 8). On an annual basis for 2012 to 2022, the average laying date varied from 2 to 12 November (SD = 2 days, CL = ±1 day, n = 11). Apart from 2010 (the two eggs that year were laid on 20 & 23 November), the first eggs in any year were laid from 20 October to 2 November, average 27 October. There were seven eggs (2.7%) laid as late as December: second eggs that were laid in nestboxes on 3 Dec 2017, 3 Dec 2021, 7 Dec 2012, 11 Dec 2015, and single eggs that were laid on 2 Dec 2021, 6 Dec 2021, and 25 Dec 2012.

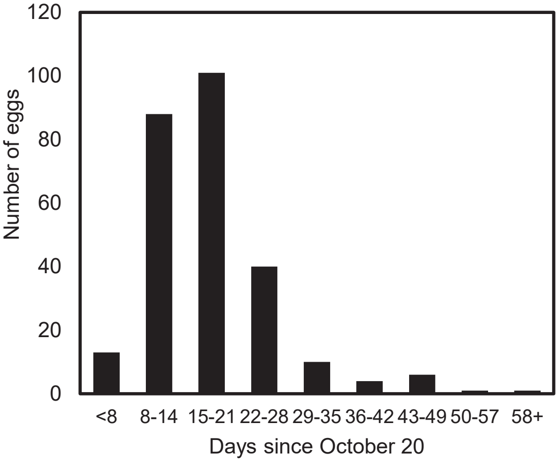

Figure 8. Numbers of Hutton's shearwater eggs laid at Te Rae o Atiu, 2010–2022 in seven–day intervals from the earliest recorded date, 20 October.

Observers visiting Te Rae o Atiu noted the period when an egg was laid in a nestbox, and PIT-tag readers have the time when the female arrived back from the pre-laying exodus, hence, allowing laying dates to be refined. Records show females arrived at nestboxes from their exoduses shortly after sunset (about 2015 h) through to 0200 h, with 89% arriving between 2000 h and 2300 h. Most females (73%) left nestboxes 2–8 hours after arrival and after laying their egg; 85% departed between 0200 h and 0500 h. The rest left after one or more days, having begun to incubate the egg. Males were present at least 66% of nights that eggs were laid. Where clear records were available, on the first day of incubation, 36% of nestboxes were occupied by males, 22% by females, and 42% of eggs were unattended.

Table 3. Breeding data for Hutton's shearwaters at Te Rae o Atiu, Kaikōura, 2010–2022.

	Laying date	Hatching date	Incubation duration (days)	Fledgling date	Fledging duration (days)
Number	279	163	163	145	145
Earliest	20 Oct	13 Dec	45	13 Mar	78
Average	6 Nov	27 Dec	52	23 Mar	87
Latest	25 Dec	25 Jan	63	19 Apr	97
sd (days)	8.6	7.6	3.2	7.1	3.8
95% CI (days)	± 1.0	± 1.3	± 0.6	± 1.2	± 0.8
Hatching success (%)		58.4			
Fledging success (%)				89.0	
Productivity (%)				52.0	

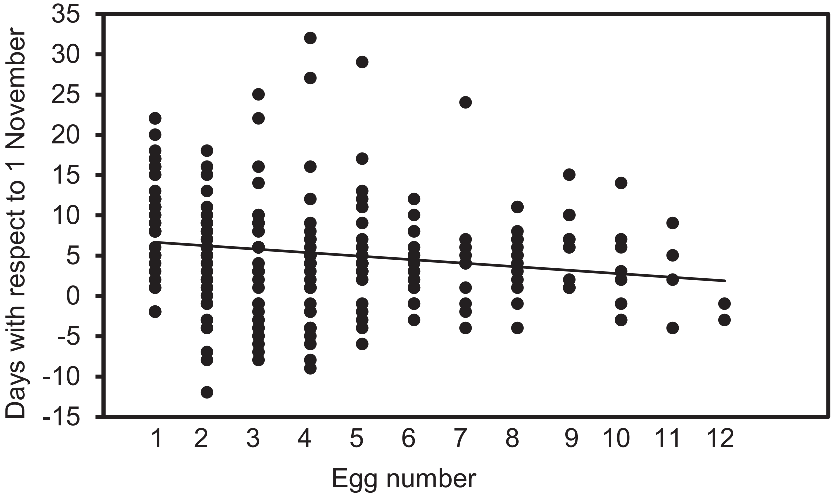

Figure 9. Relationship between the date of laying with respect to 1 November and the number of the egg known to have been laid by an individual female (one egg per annum).

Females tended to lay earlier as they become more experienced (Fig. 9). The relationship 'lay date = 7 November – 0.43 x egg number' is significant ($F = 6.93 > F_{0.95} = 3.89$, $r^2 = 0.029$, $n = 235$); however, this only explains 2.9% of the variation in the data. A similar relationship with female age, 'lay date = 9 November – 0.41 x age years' was also significant ($F = 6.97 > F_{0.95} = 3.89$, $r^2 = 0.029$, $n = 233$).

Measurements of 90 eggs laid from 2010 to 2016 are summarised in Table 4. There was no significant relationship between the length and breadth of these eggs, breadth mm = 41.2 - 0.023 x length mm ($r = 0.048 < r_{P=0.05} = 0.207$, $r^2 = 0.0023$, $df = 88$) with only 0.2% of the variance in the data being explained. However, there was a significant relationship showing an increase in egg mass with the age of the female parent: mass = 45.7 + 0.72 x years ($r = 0.330 > r_{P=0.05} = 0.210$, $r^2 = 0.109$, $df = 86$) (Fig. 10); however, the relationship explained only 11% of the variance in the data.

Table 4. Measurements of Hutton's shearwater eggs laid at Te Rae o Atiu, Kaikōura, from 2010 to 2016.

	Length (mm)	Breadth (mm)	Mass (g)
Number	90	90	88
Average	59.9	39.9	51.2
Maximum	66.0	42.6	60.9
Minimum	51.7	35.8	41.2
SD	2.6	1.3	3.8
95% CL	± 0.5	± 0.3	± 0.8

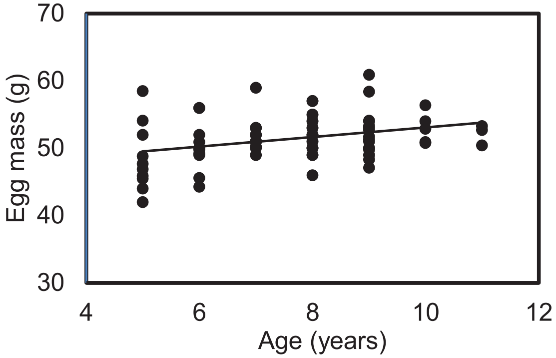

Figure 10. The relationship between the mass of Hutton's shearwater eggs and the age of the female parent.

Incubation and hatching

Of the 279 eggs laid at Te Rae o Atiu between 2010 and 2022, 163 (58%) hatched (Table 3). Hatching was spread over a period of 43 days (13 December to 25 January); none of the eggs laid after 6 December hatched. The egg laying period to 6 December spanned 47 days, similar to the hatching period. Seventy-five % of eggs hatched within ±8 days of the average date, 27 December. The incubation period averaged 52 days (Table 3) and 88% hatched within ±4 days of that. There was a tendency for eggs laid later in the season to have lower hatching rates (Table 5).

As birds have become older and more experienced at breeding, their hatching success improved (Fig. 11). From 257 layings grouped into female age-classes, there was a significant

Table 5. Hatching percentages of Hutton's shearwater eggs laid with respect to 1 November (Day 1)

Date range	Number of eggs laid	Number of eggs hatched	% of eggs hatched
< 1	55	40	72.7
1 – 7	109	74	67.9
8 – 14	61	31	50.8
15 – 22	20	6	30.0
23 – 28	8	4	50.0
> 29	9	2	22.2
Total	262	157	59.9

relationship that explained 61% of the variance in the data: hatching success (%) = 23.9 + 4.1 x age class (years) ($r = 0.78 > r_{P=0.05} = 0.553$, $r^2 = 0.61$, df = 12).

PIT-tag records indicated that there were instances when no birds were on eggs the day following laying. Visits to nestboxes from 2011 to 2022 also found eggs not being incubated and that subsequently hatched. Discounting the immediate days after laying, for eggs that hatched, there were 36 (2.5% of 1448) unattended eggs <21 days after laying, and 13 (0.9%) unattended eggs >=21 days after laying, including three in the last 10 days before hatching. Nine eggs were unattended twice, and one egg three times. There was an average of 9.3 observations/nestbox/season which equates to each nest being checked every 5.6 days, suggesting that the number of occurrences of eggs being left unattended may have been 5-6 times higher than observed.

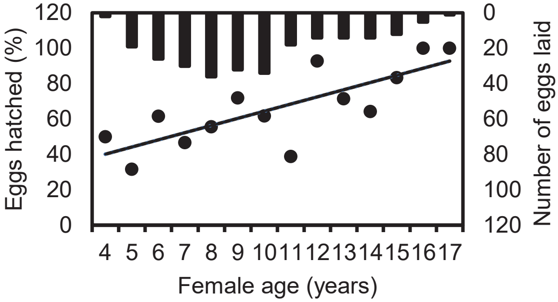

Figure 11. The relationship between the age-class of female Hutton's shearwaters at Te Rae o Atiu and hatching success over the period 2010-2022: ● = eggs hatched/egg laid (%); solid bars = number of eggs laid in that age class.

Chick growth and fledging

Of the 163 eggs that hatched, 145 chicks fledged (89%), resulting in a breeding success (= productivity = fledglings/egg laid) over the study of 52% (Table 3). Most of the 18 chicks that died did so in the first ten days after hatching. However, three chicks died in the last week before fledging: two of unknown natural causes; the third chick became caught in the exit tunnel, was extracted, but subsequently died. From available records, all chicks that died over 20 days old had weights that were comparable to the Kowhai River average (Cuthbert & Davis 2002) and were being visited by both parents through to the time they died, i.e. none appeared to have been abandoned.

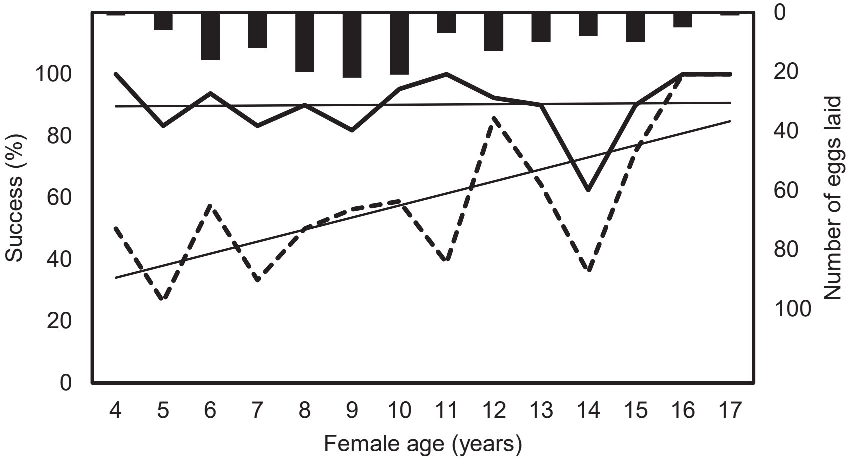

Figure 12. Relationships between fledging success (solid line = fledglings/egg hatched) and productivity (dashed line = fledglings/egg laid) with the age of the female parent. Bars are the number of eggs laid by parents in that age group.

The time from hatching to fledging averaged 87 days (range 78–97) and 85% of chicks fledged within 6 days of that time. Where fledging dates could be estimated, the average date was 23 March (range 13 March to 19 April; Table 3); 80% of chicks fledged within 7 days of 23 March.

With the exception of the 14 year-old age class, the fledging success (fledglings/egg hatched %) was 82% or better for all female age groups (Fig. 12). However, the relationship between fledging success and female parent age was not significant, success (%) = 89.2 + 0.088 x age (years), and explained only 0.1% of the variance in the data ($r = 0.04 < r_{P=0.05} = 0.53$, $r^2 = 0.001$, df = 12). Productivity averaged 52.0% and the relationship with female age (Fig. 12) was significant, explaining 48% of the variance in the data: success (%) = 19.3 + 3.8 x age ($r = 0.69 > r_{P=0.05} = 0.53$, $r^2 = 0.48$, df = 12).

Chick growth was highly variable. Fledgling mass averaged 415 g (range 267–565 g, sd = 47 g, CI = 9 g, n = 112 birds), 75% of the average peak mass of 550 g (range 377–693 g, sd = 70 g, CI = 12 g, n = 111). Fig. 13 shows variation in growth curves for 12 chicks that fledged in 2017. In addition to the differences in peak mass and fledging mass, the variability between measurements also reflected the frequency of feeds, and the length of time since the last feed before the measurements. At fledging, the average wing length was 226 mm (range 208–237 mm, sd = 7 mm, CI = 2 mm, n = 81); the degree of variability is demonstrated in Fig. 14 for 12 2016-17 fledglings.

Adults generally ceased returning to the colony to feed chicks several days before their chicks fledged. Considering only birds that returned the following season, i.e. confirmed to be alive when their chicks fledged, females stopped visiting nests an average of 17 days before fledging (range = –54–0 days, SD = 11 days, CI = 2 days, n = 92) whereas male parents were last recorded at nests on average 8 days before the chick departed (range = -44–7 days, SD = 8 days, CI = 2 days, n = 96). The difference between departure dates of the sexes (unpaired sample t-test: $t = 7.08 > t_{P=0.05} = 1.97$, df = 186) was revealed as significantly different frequency distributions ($\chi^2 = 50.4 > \chi^2_{P=0.05} = 11.1$, df = 5, Fig. 15). The last time either parent visited the nest averaged 6 days before the chick fledged (range -24–7 days, SD = 6 days, CI = 1 day, n = 103). Fifteen % of males and no females were recorded at nests up to 7 days after chicks had departed.

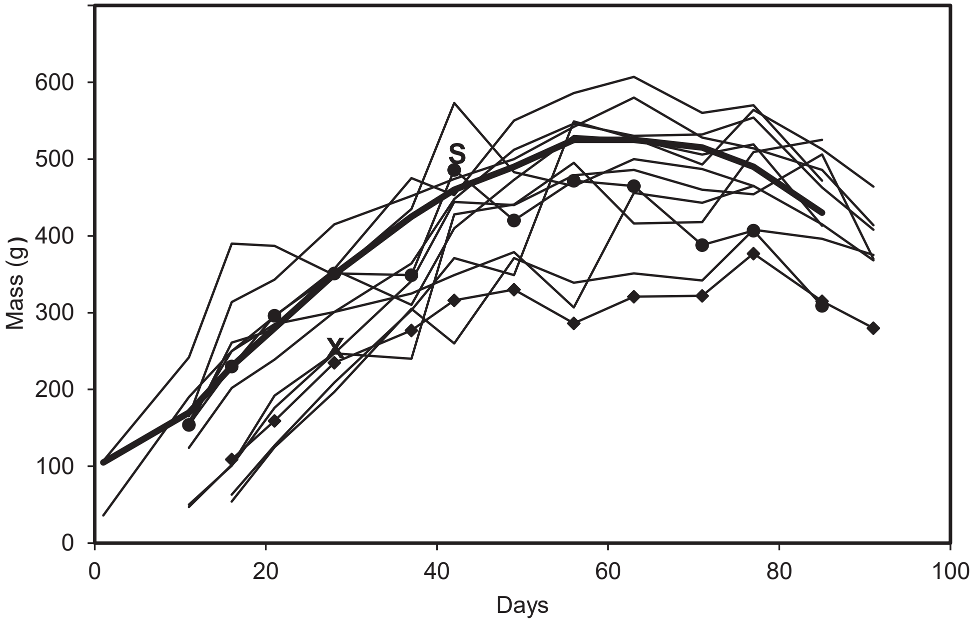

Figure 13. The variability of growth curves for 12 Hutton's shearwater chicks at Te Rae o Atiu in 2016–17. The first chick measurements were made on 19 December 2016 (day 1) and the final measurements were made on 20 March 2017 (day 91) just prior to the last chicks fledging. The heavy line is the average growth curve for chicks at the Kōwhai River colonies (extracted from Fig. 1d in Cuthbert & Davis 2002). ♦ = X21226 growth pattern after the loss of male X19745 at point X; ● = X21233 growth pattern after male X17294 stopped provisioning at point S.

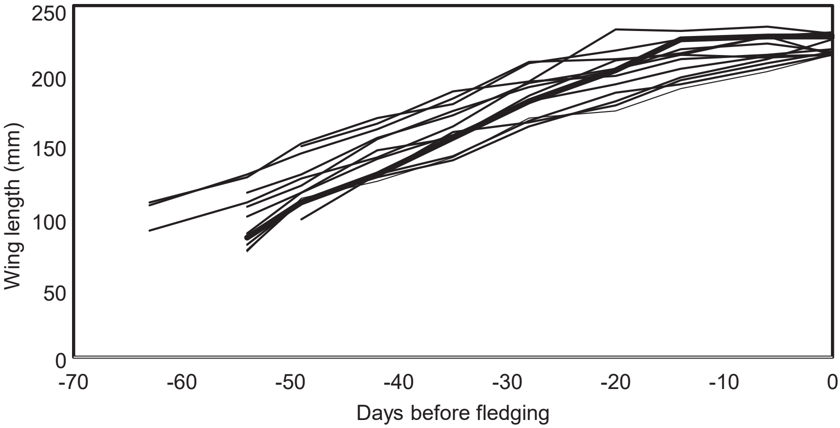

Figure 14. The variability of wing growth curves for 12 Hutton's shearwater chicks at Te Rae o Atiu in 2016-17. The heavy line is the average curve for chicks at the Kōwhai River colonies extracted from Cuthbert & Davis (2002).

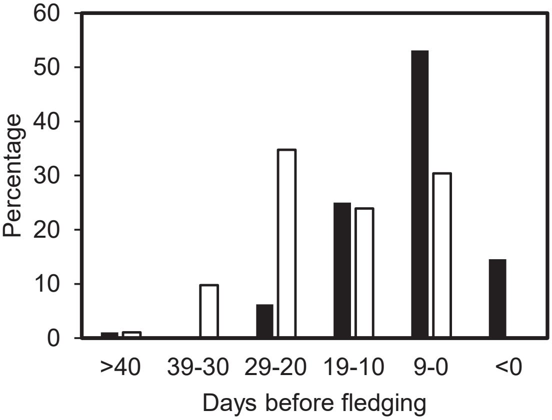

Figure 15. The frequency distribution of the number of days that the adults stopped feeding chicks before they fledged. Open bars = females; solid bars = males.

In 6% of cases, a parent ceased to feed its chick over 30 days before fledging, for reasons unknown (not death, as they were back the next season having left their partner to continue feeding the chick until fledging). One example was a chick whose 5-year-old male parent ceased feeding it 44 days before fledging. The female (also 5-years-old) continued to feed it until it fledged at 310 g (this was 77% of Kowhai River average fledging mass of 404 g; Cuthbert & Davis 2002; Fig. 13). This pair divorced prior to the next season. Although the chick departed at a very light mass, it returned as a 3-year-old and bred. Another (10 yo) female ceased provisioning her chick 54 days before fledging, and a further nine females ceased visiting their nests 30–38 days before their chicks fledged (all did so). All these females returned and bred the following season, with two of the 11 pairs having undergone divorces.

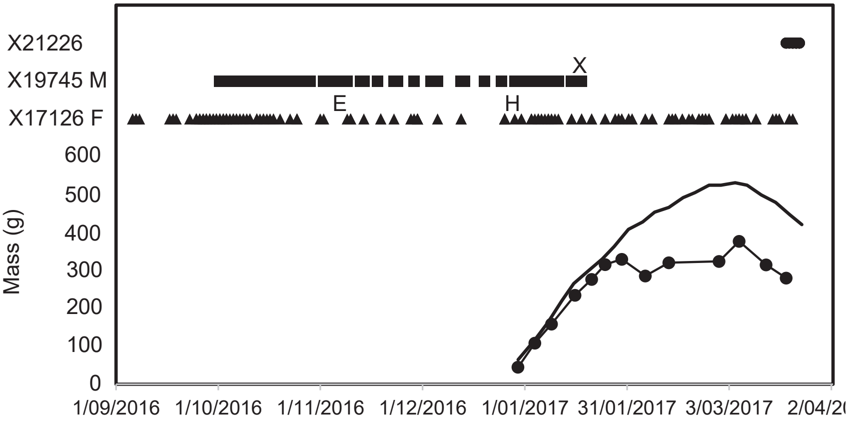

Figure 16. Timeline of Hutton's shearwaters entering and leaving nestbox 12, 2016-2017, showing the success of female X17126 provisioning chick X21226 alone for 64 days until fledging on 26 March. ▲Female X17126; ■ male X19745; ● chick X21226; E = egg laid; H = hatched; X = date X19745 was last recorded; solid line = Kōwhai River chick growth (extracted from Fig. 1a in Cuthbert & Davis 2002); line with dots = X21226 growth.

Two males (4 yo and 5 yo) were lost, presumed dead, as they were not recorded again, 64 and 71 days before their chicks fledged; their 10 yo mates continued to feed the chicks until they fledged. One female fed chick X21226 for 64 days (Figs 13 & 16) until it fledged with a mass of 280 g, (*c*. 69% of the average fledging mass of Kōwhai River chicks). The chick was not seen again after fledging. Another female fed her chick for 71 days until it fledged, and a 10 yo male fed his chick for 54 days after his mate failed to return.

PIT-tag records showed chicks first left nestboxes on average 8 nights (sd = 3.6 nights, CI = 0.7 nights, n = 115) before fledging. A few birds left on their first night out of the nest, and at least one emerged for 20 nights before fledging (Fig. 17). At least 18 chicks were recorded at nestboxes other than their own; two were recorded at two other nestboxes and one at three others. Chicks were last recorded at their nestboxes on the day of leaving between 19:37 h and 05:55 h; 54% were last recorded between 20:00 h and 21:00 h and another 23% between 00:00 h and dawn (Fig.18); sunset is about 19:30 h NZDST at this time of year.

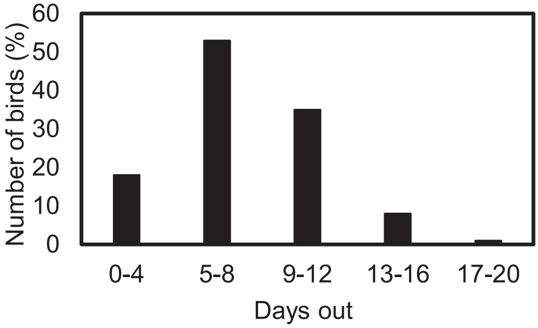

Figure 17. Frequency of days that Hutton's shearwaters at Te Rae o Atiu emerged before fledging.

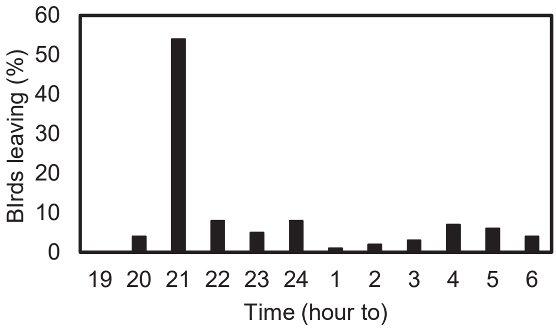

Figure 18. Frequency of the time that Hutton's shearwaters fledglings at Te Rae o Atiu last exited the nestboxes. Sunset is about 19:30 h NZDST at 23 March, the average fledging date.

Fidelity of pairings and nestboxes

In 12 years of breeding activity from 2010-11 to 2021-22, 219 pairings of 46 females and 52 males that produced eggs were identified. Seventeen partnerships (7.8%) ended when one or both partners were lost between seasons. The other 202 pairings showed a high degree of variability with respect to fidelity to partners, with 73 (36.3%) ending in divorce (i.e. both parents known to be present in a later year). In their final year together, 40% of pairings that divorced successfully fledged a chick whereas the other 60% did not; the difference was not significant ($\chi^2 = 3.08 < \chi^2_{P = 0.05} = 3.84$, df = 1).

Regression analyses of the proportion of each age group that divorced significantly decreased with age: males (%) = 55.4 – 3.0 x age (years) ($r = 0.739 > r_{P=0.95} = 0.532$, $r^2 = 0.546$ df = 12); females (%) = 60.4 – 3.3 x age (years) ($r = 0.851 > r_{P=0.95} = 0.553$, $r^2 = 0.266$, df = 11).

Thirty-five females (85%) and 35 males (88%) had at least one divorce, four females and four males had >3 divorces. The longest partnership persisted for 9 years in the same nestbox from 2013 to 2021, and a second 9-year partnership moved between three nestboxes, staying for four consecutive years in each of the first two. At the other extreme, one male had six divorces and lost one mate in 13 years, another male had seven divorces in a row before staying with the same mate for 4 years, and a female had four divorces and one mate loss in 10 years.

Two pairings only showed 'long-term' nestbox fidelity, for 9 and 6 years. Other females stayed in the same nestbox for up to 11 years but with multiple changes of partners. There were only four instances of males staying in a nestbox for more than 4 years, with the longest being for 9 years.

DISCUSSION

This study has provided known-age breeding data for Hutton's shearwaters at a new colony that was established by translocations to Te Rae o Atiu on the Kaikōura Peninsula from 2005 to 2013 (Rowe & Howard 2023) and that has been monitored ever since. The two natural Hutton's shearwaters colonies are in the Seaward Kaikoura mountains between 1200 and 1800 m a.s.l. and 20 km inland, whereas Te Rae o Atiu is adjacent to the sea at 80 m a.s.l.; therefore the logistics required to get to the colonies is vastly different. At Te Rae o Atiu, birds bred in a cluster of 108 wooden nestboxes spaced about 1.5 m apart. Thus, monitoring is easier compared to the long, narrow, stony, winding burrows up to 2 m long at the natural colonies (Cuthbert 1999, 2017). New technology, namely PIT tag recorders attached to the nestbox tunnels, provided bird identity and time of movement data. An additional benefit for the birds was that competition for nesting sites at Te Rae o Atiu was less than at the mountain sites.

As with other shearwaters in the Manx group, we found Hutton's shearwaters little impacted by observer handling (Harris 1966a, b; Warham 1990) with no nest desertion detected in our study.

There are a number of factors that need to be kept in mind when considering comparisons of Te Rae o Atiu birds to those at the natural Kowhai River colonies, and other shearwater species. At 2022-23 the Te Rae o Atiu colony consisted of 86 birds made up of: 19 birds from the 2006 to 2008 translocations and aged 15–17 years; 27 birds from the 2012 and 2013 translocations aged 10 or 11 years; 39 Te Rae o Atiu bred chicks aged 3–10 years; one bird of unknown age that was first caught as an unbanded adult at the colony. The average age of the breeding birds with eggs or chicks in 2022 was 10 years for males and 11 years for females. Thus, the colony is made up of young birds, and lacks the older birds that are expected at a long-established colony. While there are no studies of longevity of Hutton's shearwaters, Kowhai River birds have been captured at 20–23-years-old and one at 32 years (Rowe & Taylor 2020). This suggests that the older birds at Te Rae o Atiu now present may have many more years of breeding to come, and it could be many years before the age distribution at the new colony approaches that of the mountain colonies. Therefore, results with time/age factors will need to be qualified as they could change with more older birds present.

A small number of Hutton's shearwaters return from their first overseas migration to Te Rae o Atiu as 2-year-olds; however, the majority first return as 3- or 4-year-olds, which is slightly older than the 2- to 3-year-olds for Newell's shearwaters (KESRP 2021) and Manx shearwaters (Harris 1996b; Brooke 1990). Most petrel species, including Manx shearwaters, have been found to have breeding males returning to a colony earlier in a season than females (Warham 1990). Our Hutton's shearwater data did not show this trend, with no significant difference between average times for males and females to return in the six years 2017 to 2022. This may be a consequence of the young average age in the colony and the lack of competition for burrows.

One unexpected finding was the extent to which adult Hutton's shearwaters visited other nestboxes during a season – birds visited up to 23 nestboxes, and one nestbox was visited by 29 different birds. Cuthbert (2017) only noted up to five or six birds visiting a Kōwhai River burrow early in the season when they were attempting to acquire a burrow, or they may, as Warham (1990) noted, wander while awaiting the arrival of females. The late season visits to other nestboxes here confirm similar, but smaller scale, observations at Kōwhai River, where 10 of 27 PIT-tagged adults entered some of the other 25 scattered burrows with PIT-tag readers installed (Rowe 2018). We have not found reports of this occurring later in the season by other petrel species, and surmise it could be a normal phenomenon only found as a result of the intensive PIT-tag records obtained at Te Rae o Atiu, or it is an artifact of the translocation and the lack of competition in the newly established population.

Most Hutton's shearwater females went on a pre-laying exodus of about 12 days (range 5–22 days), with males tending to remain about the colony. This is similar to Manx shearwaters (10–14 days; Harris 1966b; Brooke 1990; Warham 1990), Balearic shearwaters (13.5–21 days; ACAP 2021; Guilford *et al.* 2012), Yelkouan shearwaters (13 days; Gatt *et al*. 2019), and Newell's shearwater (14 days; Raine *et al.* 2022). Estimating exoduses can be rather subjective, as some Hutton's shearwater females made up to three overnight visits back to Te Rae o Atiu during the exodus, which is contrary to its strict definition, but is behaviour that Warham (1990) reported for Antarctic prions (*Pachyptila desolata*). Because of the range in length of Hutton's shearwaters exoduses, with some birds making brief visits ashore, it is possible that some birds were feeding closer to the colonies than others, but there is no pre-laying tracking evidence to confirm this. During chick rearing, Hutton's shearwaters mainly foraged south of Banks Peninsula (Bennet *et al.* 2019); other shearwater species are known to visit different sites during the exodus compared to when gathering food for chicks, e.g. Yelkouan shearwater (Gatt *et al.* 2019).

The youngest Hutton's shearwater breeders at Te Rae o Atiu were 4-year-old males and 5-year-old females. These ages for first breeders are similar to those for translocated fluttering shearwaters at Maud Island, Marlborough Sounds (5 years; Bell *et al*. 2005), Manx shearwaters (4–5 years; Harris 1966b, with some breeding as young as 3–4 years; Harris 1966a; Brooke 1990), and Yelkouan shearwaters (3–4 years; Anon 2020).

Shearwaters generally lay one egg without replacements in the event of failures (Marchant & Higgins 1990; Warham 1990) and this is the norm for small shearwaters, e.g. Balearic shearwater (ACAP 2021), Yelkouan shearwater (Anon 2020), black-vented shearwaters (Keitt *et al*. 2000) and Newell's shearwater (FWS 2021; KESRP 2021). This was the case for 265 layings at Te Rae o Atiu; however, in seven instances we found two eggs in the one nestbox in the one season. One of these eggs was considered to be a replacement laying, and was the only one of these 14 eggs to hatch (and the chick subsequently fledged; Rowe *et al.* 2024).

The average laying date of Hutton's shearwaters at Te Rae o Atiu, 6 November (range 2-12 November by year), was similar to 8 and 9 November at the Kōwhai River colonies (Cuthbert & Davis 2002) even though Te Rae o Atiu is 1200 m lower in altitude and not affected by snow cover. Laying at Te Rae o Atiu is asynchronous and spread over 66 days, 20 October to 25 December; the last date was 14 days later than any other laying. At the Kowhai River colony, the spread was over 38 days, 23 October to 1 December (Cuthbert & Davis 2002); 2.7% of Te Rae o Atiu layings were later than these dates. Excluding the single late egg, the laying period of 52 days is closer to, but still 14 days longer than, at the Kōwhai River, where laying can be influenced by snow cover. The spread was also longer than for fluttering shearwaters at 39 days (Berg *et al*. 2018). It is possible that the long tail of the egg laying distribution was due to replacement layings made observable through the use of accessible nestboxes (Rowe *et al*. 2024), although was only confirmed in the one instance.

PIT-tag records showed that 73% of females were at their nestbox for the first night only after their pre-laying exodus to lay the egg. At least 22% of females were known to have stayed two to four nights; they may not have laid on arrival or had laid and were undertaking the first incubation shift. This fits with Warham's (1990) observations that many shearwaters lay the first night back, although some may delay laying for at least 2 days. Warham also suggested that delayed departures of females may be a consequence of the absence of mates that usually undertake the first prolonged incubation shift. Hutton's shearwater males were in attendance on the night of egg-laying in 66% of cases. At least 36% of them took the first incubation shift by staying one or more days; 21% of males left the night of laying and the status of the rest was uncertain. Where we determined who undertook incubation the first day after laying, in 42% of cases no adults were present, and the egg was left unattended. A similar situation seems to occur with the Manx shearwater, where many females leave the night of laying and the average time until a male begins incubating the first shift is a little more than one day (Brooke 1990).

Hutton's shearwater eggs at Te Rae o Atiu were incubated on average for 52 days, only slightly longer than the 50.3 days at Kōwhai River (Cuthbert 2001; Cuthbert & Davis 2002). This was similar to the incubation periods for other small shearwaters; e.g. 50 days for fluttering shearwaters at Burgess Island (Berg *et al*. 2018), and 51 days for Manx shearwaters (Harris 1966b; Brooke 1990; Gillies *et al*. 2022).

During incubation, our weekly observations found instances when no birds were present on eggs; however, this did not appear to impact egg viability. Intermittent incubation, with associated chilling of the egg, occurs in many petrel species when the returning partner is delayed (Warham 1990), including Manx shearwater (Matthews 1954; Brooke 1990) and black-vented shearwaters (Keitt *et al*. 2000). Hatching success of Hutton's shearwater at Te Rae o Atiu was 59%, similar to the Kōwhai River colonies at 57.3% (Cuthbert 2001) but lower than for fluttering shearwaters at Burgess Island, 73.8% (Berg *et al*. 2018). We expected a higher success at Te Rae o Atiu than at Kowhai River, as the Te Rae o Atiu colony is in a protected predator-free site. However, the birds here were young breeders, and hatching success has improved as they aged.

The time from hatching to fledging for the Hutton's shearwater at Te Rae o Atiu, 87 days, was similar to the 84 days for birds at the Kōwhai River colonies despite those birds having to fly 1200 m higher and 20 km further inland (Cuthbert 2001; Cuthbert & Davis 2002). Cuthbert and Davis (2002) suggested that the longer fledging period at Kowhai River compared to, say, the Manx shearwater at 71 days (Brooke 1990) was due to a lower rate of mass gain, but the similar growth regimes at Te Rae o Atiu and Kowhai River infer that there may be an unknown species-specific phenomenon at play.

Fledging success at Te Rae o Atiu (89%) was higher than at Kōwhai River 85.2% (Cuthbert 2001), similar to fluttering shearwaters on Burgess Island (88%; Berg *et al*. 2018), but lower than reported for Manx shearwater (95%; Harris 1966a, b). The fledging success rate suggests that if an egg can be incubated through to hatching, there is a high chance the chick will fledge, a finding reported for other petrels by Warham (1990). Because there was a high fledging success, productivity was controlled by incubation success, which improved with age of the female parent. The productivity for Hutton's shearwater here was 52% compared to 47% at the Kōwhai River colonies (Cuthbert 2001), 36% for black-vented shearwaters (Keitt *et al*. 2003), 67% for Yelkouan shearwaters (Bourgeois & Vidal 2007), 75% for Manx shearwaters (Harris 1966b), and 72% for fluttering shearwaters at Maud Island (Bell *et al*. 2005) and 64% at Burgess Island (Berg *et al*. 2018).

The mass of Te Rae o Atiu fledglings ranged between 267–565 g (average 415 g) and averaged 75% of their peak mass, a loss similar to Kōwhai River birds at 79% (Cuthbert & Davis 2002). Hutton's shearwater chicks appear to lose less mass from their peak until fledging than some small shearwaters including the Manx shearwater 73% (Brooke 1990) but more than fluttering shearwaters at Burgess Island 89% (Berg *et al*. 2018) or black-vented shearwaters 88% (Keitt *et al*. 2003).

Pre-fledging parent-reared shearwaters at Te Rae o Atiu were recorded at the exit to the tunnels, presumably to imprint on the site by roaming about, but also visiting other nestboxes. This averaged eight nights (range 0–20 nights) before the last recording (and assumed fledging) and confirms earlier observations: Te Rae o Atiu translocated chicks averaged 7.7 nights, range 1–17 nights (Rowe

2014); Kōwhai River native chicks range 1–18 nights (Rowe 2018). Pre-fledging Hutton's shearwater chicks have previously been reported to visit other nestboxes in the days up to fledging (Rowe 2014, 2018) as have fluttering shearwater chicks at Mana Island (Gummer & Adams 2010).

Observers of pre-fledging birds at Kōwhai River noted that the birds spent several nights at the mouths of the burrows, rarely came out and were never seen to exercise their wings before leaving (Harrow 1976; Cuthbert 2001; Cuthbert & Davis 2002). This was also observed for fluttering shearwaters at Burgess Island (Berg *et al*. 2018) with all birds seen outside the burrows leaving the colony that night. Exercising wings before fledging is an activity observed in other petrel species (Brooke 1990; Warham 1990) including black-vented shearwaters (Keitt *et al*. 2000) and Manx shearwaters (Harris 1966b). Wing exercising has now been observed for Hutton's shearwaters at Te Rae o Atiu using trail cameras (Rowe *unpubl. data*, HSCT video files March 2017) and at Kōwhai River using thermal imaging (Howard *pers. obs.*, thermal video available).

In common with some other shearwater species (Warham 1990) there is a tendency for Hutton's shearwater adults to cease feeding chicks several days before they depart. Manx shearwaters desert their chicks on average for 8–9 days (range 1–23, n = 204) before they fledge (Harris 1966b; Brooke 1990). The average for Te Rae o Atiu Hutton's shearwater parents was longer for females (17 days) than males (8 days), and chicks fasted on average 6.3 days before leaving. Brooke also noted that the desertion period was longer for chicks that hatched later ($r = 0.249$ >. $r_{P=0.05} = 0.138$, $n = 204$); however, that was not the case at Te Rae o Atiu ($r = 0.130 < r_{P=0.05} = 0.273$, $n = 49$). At Te Rae o Atiu and at Kōwhai River (Rowe 2018) there are records of adult males still in attendance 7 days after their chicks had departed. Warham (1990) also noted cases of petrels in attendance after chicks have departed. Warham (1990) suggested several scenarios that would cover this range, from true desertion (when an adult needs to look after itself and abandons the chick), to a chick refusing food as they have adequate reserves and are ready to leave the colony whether the parents are still coming back or not. The experience with translocated Hutton's shearwaters chicks showed that they fledged when they were ready despite being offered food up until the day they left (e.g. R. Williams, 2012, *Hutton's shearwaters translocation report, March-April 2012*, unpublished report for the Hutton's Shearwater Charitable Trust; Wildlife Management International Ltd., 2013, *Hutton's shearwater: report on the translocation of chicks to Te Rae o Atiu, March 2013*, unpublished report for the Hutton's Shearwater Charitable Trust). Marchant & Higgins (1990) stated that Hutton's shearwater fledglings mostly left their burrows before midnight (0100 h NZDST) on their night of departure. The PIT-tag records here confirm that, with only 19% leaving after midnight.

An unexpected result of PIT-tag monitoring was the number of parents that last visited 71–30 days before their chick fledged, with the remaining parent able to provide enough sustenance for the chick to fledge. Three such cases were due to loss of a parent, while in another three cases the missing parent returned the following breeding season. Rowe (2018) also reported adult males ceasing to feed up to 61 and 73 days before chick fledging at Kōwhai River; however, it was not known whether this was due to death of the parent. We are unaware of other reports of single seabird parents being able to successfully feed a chick over such a long period until it fledged. It is likely that this phenomenon has only been discovered here because of the intensive monitoring in place.

Divorce probably occurs in most petrel species (Warham 1990); however, Manx shearwaters tend to have the same partner and burrow year after year with divorces uncommon (Brooke 1990). The frequency of divorce by Hutton's shearwaters at Te Rae o Atiu is high, with over 85% of birds having had two to seven partners. Unlike Manx shearwaters (Brooke 1990), the frequency of divorces was not significantly different between pairs that failed breeding compared to those that successfully fledged chicks. The high numbers of divorces are likely to be a consequence of the population consisting of mainly young breeders, as the divorce rate decreased with age; in 2022-23, 32% of birds in pairs that laid eggs were under 10 years-old.

In summary, Hutton's shearwaters at Te Rae o Atiu near sea-level had breeding ecology that was similar to birds breeding above 1200 m in the source colony, and that was similar to other small shearwaters of the Manx group. The main difference compared to related species was the longer chick fledging period, which was similar for both Te Rae o Atiu and Kowhai River populations. Other unusual behaviour observed at Te Rae o Atiu, such as birds visiting multiple nestboxes, the variability of pre-laying exoduses, and high divorces rates can probably be attributed to the young age of breeding birds in this new colony.

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LITERATURE CITED

ACAP (Agreement on the Conservation of Albatrosses and Petrels). 2021. Species assessments: Balearic Shearwater *Puffinus mauretanicus*. Downloaded from https://www.acap.aq/resources/acap-species/1456-balearic-shearwater/file on 9 September 2021.

Anon. 2020. One year in life of Yelkouan shearwater. Downloaded from www.lifeartina.eu/en/one-year-in-life-of-yelkouan-shearwater/ on 10 September 2021.

Bell, M.; Bell, B.D.; Bell, E.A. 2005. Translocation of fluttering shearwater (*Puffinus gavia*) chicks to create a new colony. *Notornis 52*: 11–15.

Bennet, D.G.; Horton, T.W.; Goldstein, S.J., Rowe, L.K.; Briskie, J.V. 2019. Flying south: foraging locations of the Hutton's shearwater (*Puffinus huttoni*) revealed by time-depth recorders and GPS tracking. *Ecology and Evolution 9*: 7914–7927.

Berg, M.; Linnebjerg, J.F.; Ismar, S.M.H.; Gaskin, C.P.; Rayner, M.J. 2018. Breeding biology of fluttering shearwaters (*Puffinus gavia*) on Burgess Island in northern New Zealand. *Emu-Austral Ornithology 118*: 173–182.

BirdLife International. 2021. IUCN Red List for birds. Downloaded from http://www.birdlife.org on 7 May 2021.

Bourgeois, K; Vidal, E. 2007. Yelkouan shearwater nest-cavity selection and breeding success. *Comptes Rendus Biologies 330*: 205–214.

Brooke, M. 1990. *The Manx shearwater*. London, T. & A.D. Poyser.

Bull, L.S. 2005. Influence of migratory behaviour on the morphology and breeding biology of *Puffinus* shearwaters. *Marine Ornithology 34*: 25–31.

Cargill, C.P.; Townsend, D.; McArthur, N.R.; Morgenstern, R.; Morrisey, M.; Sherley, G.; Bell, M. 2022. The conservation status of Hutton's shearwater (*Puffinus huttoni*) at Shearwater Stream, Kaikōura, New Zealand: a small population at risk? *Notornis 70*: 1–13.

Cuthbert, R.J. 1999. The breeding ecology and conservation of Hutton's shearwater (*Puffinus huttoni*). PhD thesis. Dunedin, University of Otago.

Cuthbert, R.J. 2001. Conservation and ecology of Hutton's shearwater (*Puffinus huttoni*). *Conservation Advisory Science Notes No. 335.* Wellington, Department of Conservation. 35p.

Cuthbert, R.J. 2002. The role of introduced mammals and inverse density dependent predation in the conservation of Hutton's shearwaters. *Biological Conservation 108:* 67–78.

Cuthbert, R.J. 2017. *Seabirds beyond the mountain crest.* Dunedin, Otago University Press.

Cuthbert, R.J. 2019. A reassessment of population size and trends of Hutton's shearwater following the 2016 Kaikōura earthquake and outlook for species management. *New Zealand Aquatic Environment and Biodiversity report No. 209.* Wellington, Fisheries New Zealand.

Cuthbert, R.J.; Davis L.S. 2002. The breeding biology of Hutton's shearwater. *Emu 102*: 323–329.

Freese, F. 1967. *Elementary statistical methods for foresters*. United States Department of Agriculture, Forest Service, Agricultural Handbook 317.

FWS (United States Fish & Wildlife Service). 2021. Kilauea Point National Wildlife Refuge, Hawaii. Newell's shearwater. Downloaded from https://www.fws.gov/refuge/kilauea_point/wildlife_and_habitat/Newells_shearwater.html on 10 September 2021

Gatt, M.C.; Lago, P.; Austad, M.; Bonnett-Lebrun, A.-S.; Metzger, B.J. 2019. Pre-laying movements of Yelkouan shearwaters (*Puffinus yelkouan*) in the central Mediterranean. *Journal of Ornithology 160*: 625–632.

Gillies, N.; Padget, O.; Syposz, M.; Bond, S.; Guildford, T. 2022. Resource allocation underlies parental decision-making during incubation in the Manx shearwater. *Ornithology 139*: 1–15.

Griffiths, R.; Double, M.C.; Orr, K.; Dawson, R.J.G. 1998. A DNA test to sex most birds. *Molecular Ecology 7*: 1071–1075.

Guilford, T.; Wynn, R.; McMinn, M.; Rodriguez, A.; Fayet, A.; Maurice, L.; Jones, A.; Meier, R. 2012. Geolocators reveal migration and pre-breeding behaviour of the critically endangered Balearic shearwaters *Puffinus mauretanicus. PLoS ONE 7*: e33753.

Gummer, H.; Adams, I. 2010. Translocation techniques for fluttering shearwaters (*Puffinus gavia*): establishing a colony on Mana Island, New Zealand. Wellington, Department of Conservation. 52p.

Halse, S.A. 1981. Migration by Hutton's shearwater. *Emu 81*: 42–44.

Harris, M.P. 1966a. Age of return to the colony, age of breeding and adult survival of Manx shearwaters. *Bird Study 13*: 84–95.

Harris, M.P. 1966b. Breeding biology of the Manx shearwater (*Puffinus puffinus). Ibis 108*: 17–33.

Harrow, G. 1965. Preliminary report on discovery of nesting site of Hutton's shearwater. *Notornis 12:* 59–65.

Harrow, G. 1976. Some observations of Hutton's shearwater. *Notornis 23:* 269–288.

Imber, M.J.; Crockett, D.E. 1970. Sea birds found dead in New Zealand in 1968. *Notornis 17*: 223–230.

Keitt, B.S.; Tershey, B.R.; Croll, D.A. 2000. Black-vented shearwater (*Puffinus opisthomelas*). In: *The birds of North America online*. DOI: 10.2173/bna.521.

Keitt, B.S.; Tershey, B.R.; Croll, D.A. 2003. Breeding biology of the black-vented shearwater *Puffinus opisthomelas. Ibis 145*: 673–680.

KESRP (Kaua'i Endangered Seabird Recovery Project). 2021. Newell's shearwater. Downloaded from https://kauaiseabirdproject.wordpress.com/newells-shearwater on 10 September 2021.

Marchant, S.; Higgins, P.J. (eds). 1990. *Handbook of Australian and New Zealand birds.* Vol. 1. Melbourne, Oxford University Press.

Martinez-Gomez, J.E.; Jacobsen, J.K. 2004. The conservation status of Townsend's shearwater *Puffinus auricularis auricularis. Biological Conservation 116*: 35–47.

Matthews, G.V.T. 1954. Some aspects of incubation in the Manx Shearwater *Procellaria puffinus*, with particular reference to chilling resistance in the embryo. *Ibis 96*: 432–440.

Molloy, J.; Davis, A. 1992. *Setting priorities for the conservation of New Zealand's threatened plants and animals.* Wellington, Department of Conservation. 44 p.

Paton, B.; Davis, A. 1997. Hutton's shearwater recovery plan (*Puffinus huttoni*). *Threatened species recovery plan series.* Wellington, Department of Conservation.

Raine, A.F.; Driskell, S.; Rothe, J.; Travers, M. 2022. Evaluating the breeding phenology of the endangered 'a'o (Newell's shearwater *Puffinus newelli*) on Kaua'i to better focus conservation actions and management decisions. *Bird Conservation International 33*: 1–11.

Robertson, H.A.; Baird, K.A.; Elliott, G.P.; Hitchmough, R.A.; McArthur, N.J.; Makan, T.D.; Miskelly, C.M.; O'Donnell, C.F.J.; Sagar, P.M.; Scofield, R.P.; Taylor, G.A.; Michel, P. 2021. Conservation status of birds in Aotearoa New Zealand, 2021. *New Zealand threat classification series No. 36*. Wellington, Department of Conservation. 43pp.

Rowe, L.K. 2014. Post-translocation movements of pre-fledging Hutton's shearwaters (*Puffinus huttoni*) within a newly established colony (Te Rae o Atiu) on the Kaikōura Peninsula. *Notornis 61:* 84–90.

Rowe, L.K. 2018. Observations of Hutton's shearwaters (*Puffinus huttoni*) at a natural colony in the Kōwhai River and a newly established by translocation colony at Te Rae o Atiu, Kaikōura Peninsula. *Notornis 65:* 42–50.

Rowe, L.K.; Howard, T. 2023. Hutton's shearwater (*Puffinus huttoni*) at Te Rae o Atiu, Kaikōura Peninsula South Island east coast, New Zealand: a colony established by translocations – 16 years progress. *Notornis 70:* 14–30.

Rowe, L.K.; Taylor, G.A. 2020. Recoveries of Hutton's shearwaters (*Puffinus huttoni*) from Kaikōura, New Zealand. *Notornis 67*: 469–474.

Rowe, L.K.; Taylor, G.A.; Howard, T. 2024. Re-laying by Hutton's shearwaters (*Puffinus huttoni*) at Te Rae o Atiu, Kaikōura Peninsula, New Zealand. *Notornis 71*: 12–22.

Sokal, R.R.; Rolfe, F. J. 1981. *Biometry*. 2nd edn. New York, W.H. Freeman & Co.

Sommer, E.; Bell, M.; Bradfield, P.; Dunlop, K.; Gaze, P.; Harrow, G.; McGahan, P.; Morrissey, M.; Walford, D.; Cuthbert, R. 2009. Population trends, breeding success and predation rates of Hutton's shearwater (*Puffinus huttoni*): a 20 year assessment. *Notornis 56:* 144–153.

Taylor, G.A.; Cockburn, S.; Palmer, D.; Liddy, P. 2012. Breeding activity of Chatham Island taiko (*Pterodroma magentae*) monitored using PIT-tag recorders. *New Zealand Journal of Ecology 36*: 425–432.

Warham, J. 1981. Does Hutton's shearwater circumnavigate Australia? *Emu 81*: 44.

Warham, J. 1990. *The petrels: their ecology and breeding systems*. London, Academic Press.

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Genetic data confirm that *Diomedea platei* Reichenow, 1898, is the correct name for the population of Buller's albatross *Thalassarche bulleri* breeding at the Chatham Islands, New Zealand

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Abstract: Buller's albatross *Thalassarche bulleri* is generally considered to comprise two subspecies: *T. b. bulleri*, which breeds on islands south of the South Island, New Zealand; and *T. b. platei*, which nests on the Three Kings Islands, off the northern tip of of the North Island, and on outlying islets of the Chatham Islands east of New Zealand. Although the name *platei* has been widely applied to the latter population, some authors have suggested that its type specimen is in fact a juvenile *T. b. bulleri*. As a result, those birds breeding in the Chatham and Three Kings groups have sometimes been considered to represent an unnamed subspecies, or even species, given recent evidence of their genetic differentiation. Because our own morphological examination of the specimen was inconclusive as to which population the type of *platei* belongs, we subjected the individual to molecular testing. From this, we can confirm that the name *platei* has been correctly applied to the northern population of Buller's albatross.

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INTRODUCTION

Buller's albatross *Thalassarche bulleri* has traditionally been considered to comprise two subspecies, both confined as breeding birds to the New Zealand region (Jouanin & Mougin 1979), albeit with quite different phenologies (Sagar & Warham 1998), which led to the suggestion that they might be better treated as two species (Robertson & Nunn 1998). *Thalassarche b. bulleri* (Rothschild, 1893) (southern Buller's albatross) nests on the Solander Islands and the Snares Islands, whilst *T. b. platei* (Reichenow, 1898) (northern Buller's albatross) breeds on the Chatham Islands (on the Sisters/ Rangitatahi and Forty-Fours/Motuhara), with a very small colony on Rosemary Rock, in the Three Kings Islands, northwest of New Zealand's North Island (Wright 1984; Taylor 2000). Both subspecies are apparently much more widely distributed at sea, especially during the off-season and as pre-breeders, regularly reaching the Humboldt Current off Chile and southern Peru, especially between 30 and 40°S (Spear *et al*. 2003; Brooke 2004; Shirihai 2007). However, *T. b. bulleri* can occur as far north as 12°25'S, 105°06'W based on data from an individual banded as a chick on the Snares Islands (Warham 1982). Wold *et al*. (2021) cautioned that, especially during the off-season, the at-sea range of northern Buller's albatrosses is 'unknown'. Nevertheless, in offshore waters of southern Peru, among 41 Buller´s albatrosses, Quiñones *et al*. (2023) identified 40 as the 'northern taxon' and one as the 'southern taxon'. Data from tracked birds confirms that both taxa reach the Humboldt Current (Fischer *et al*. 2023) at different times reflecting their asynchronous breeding periods

Differentiating the taxa away from their colonies is especially difficult because adults overlap in some features, and younger individuals even more so. A comprehensive and critical assessment of characters to permit identification is yet to be published (see McCallum *et al*. 1985; Marchant & Higgins 1990; Shirihai 2007; del Hoyo & Collar 2014; Wold *et al*. 2021).

The names attributed to these taxa have attracted a degree of controversy, ever since Murphy (1930, 1936: 524) stated that *Diomedea platei* Reichenow, 1898 is a synonym of *Diomedea bulleri* Rothschild, 1893, going on to mention that the type of the former

ZMB 47/77
Thalassarche bulleri platei
Diomedeidae age: juvenil sex: ?
loc.: Cavancha, Región de Tarapacá, Chile, South America
leg.: Plate, Ludwig Hermann, 07.1893
det.:
Museum für Naturkunde Berlin

Typical young of
bulleri
R C Murphy
47.77

Figure 1. Labels attached to the holotype of *Diomedea platei* (= *Thalassarche bulleri platei*) at the Museum für Naturkunde, Berlin (ZMB 47.77); the lower one is annotated "Typical young of bulleri R C Murphy", see main text (Carola Radke, © Museum für Naturkunde, Leibniz Institute for Evolution and Biodiversity Science, Berlin)

Figure 2. The holotype of *Thalassarche bulleri platei* at the Museum für Naturkunde, Berlin (ZMB 47.77) (Carola Radke, © Museum für Naturkunde, Leibniz Institute for Evolution and Biodiversity Science, Berlin)

name "proves to be a young specimen of *bulleri*, entirely comparable with others of like age in our American Museum Collection" (Murphy 1930: 6; Murphy 1936: 526). The reverse side of one of the labels attached to the holotype is annotated in Murphy's hand "Typical young of bulleri", presumably written in 1926 when he is known to have visited the Berlin Museum (https://digitallibrary.amnh.org/handle/2246/6241). Mathews (1927: 907) had already suggested that *platei* is a junior name for *bulleri*, albeit without explanation. Peters (1931), Mathews (1934), and Hellmayr & Conover (1948) implicitly followed Murphy (1930) in not recognising any subspecies. The realisation that two taxa (perhaps even species) were involved was accepted only in the late 1970s and 1980s (Jouanin & Mougin 1979; C.J.R. Robertson *in* Reader's Digest 1985; Turbott 1990; Marchant & Higgins 1990). During a surge of interest in the systematics of the albatrosses in the 1990s, Robertson & Nunn (1998) postulated that "the Chatham population is actually an undescribed taxon and *T. platei* should be reduced to a synonym, being just a juvenile plumage phase of *T. bulleri* (Murphy 1936; C. Robertson pers. obs.)". It bears mention, however, that Murphy (1930: 6; Murphy 1936: 525) was evidently choosing not to recognise subspecific recognition within *bulleri*, despite by then having to hand ample material from the Chatham Island group (around the Forty-Fours Islets and Round Rock = Rangituka, southwest of Pitt Island) collected in March 1926 during the Whitney South Sea Expedition (1920–41). He was not necessarily implying that the holotype of *platei* was not from the Chatham population. As noted by Gill *et al*. (2010), who continued to use the name *platei* in reference to the latter subspecies, Robertson & Nunn's claim lacked evidence for their assertion. Nevertheless, authors such as Shirihai (2007) and Onley & Scofield (2007) referred to the possibility of the Chatham birds representing an undescribed taxon, and Dickinson & Remsen (2013: 173, footnote 9) considered the issue to be unresolved.

The holotype of *platei* is held at the Museum für Naturkunde Berlin (ZMB 47.77) and is an immature (unsexed) individual collected at Cavancha, just south of Iquique (20°14'S, 70°10'W), Tarapacá Region, in northern Chile, on 18 July 1893 (Figs. 1–3). Because of the extreme difficulty of

Figure 3. Detail of the right side of the bill of the holotype of *Thalassarche bulleri platei* at the Museum für Naturkunde, Berlin (ZMB 47.77) (Guy M. Kirwan)

identifying the holotype to taxon/population using either plumage or biometrics (see Results, notwithstanding the assertion of Robertson & Nunn 1998 to the contrary), and because both taxa could occur at the collection locality, we elected to subject the holotype of *platei* to genetic screening, and thereby hopefully resolve the issue of its identity.

MATERIAL & METHODS

Molecular analysis

A partial fragment of the mitochondrial control region of the holotype of Diomedea platei ZMB 47.77 was sequenced for comparison with sequences published in Wold *et al.* (2018). DNA from a piece of skin from the belly fissure was extracted using the QIAamp DNA Micro Kit (Qiagan) with an adapted digestion protocol that ensures high quantities of DNA (Lutgen & Burri 2020). A digestion time of 40 hours was applied and additional 20 μl of Proteinase and 180 μl buffer ATL were added after the first six hours of digestion. The primers SPECF1 and GLUR7 from Wold et al. (2018) were used and PCR reaction volumes were 25 μl containing 12.5 μl GoTaq Hot Start Green Master Mix (Promega), 2 μl genomic DNA, 2 μl of each primer with a concentration of 10 μM and 6.5 μl ddH2O using a standard reaction protocol (Schweizer & Shirihai 2013) with annealing temperature of 55°C. PCR was performed on a SensoQuest thermal cycler and sequencing was performed in both directions with the primers used for PCR with LGC Genomics (Berlin).

All sequences of *T. bulleri* from Wold *et al*. (2018), which were obtained on the breeding grounds (26 of *T. b. platei* from the Forty-Fours/Motuhara and the Sisters/Rangitatahi, and 47 of *T. b. bulleri* from North East Island, in the Snares group, and Solander Island), were downloaded from GenBank.

As an independent check, a further five *Thalassarche bulleri* study skins of known provenance at the Museum of New Zealand Te Papa Tongarewa (NMNZ), Wellington, NZ, were sequenced: *T. b. platei*: NMNZ OR.18634; NMNZ OR.18635; NMNZ OR.18107 and *T. b. bulleri*: NMNZ OR.030176; NMNZ OR.18633. A sliver of footpad was removed from each specimen with a sterile scalpel blade. DNA extraction of the footpad tissue, PCR amplification, purification and sequencing followed Shepherd *et al*. (2022), except that the primers used were SPECF1 and GLUR7 (Wold *et al*. 2018) and the PCR annealing temperature was 60°C. Bidirectional sequencing with the same primers was performed by Macrogen (Seoul, South Korea). Sequence alignment was performed using the MAFFT algorithm *7.450* (Katoh *et al*. 2002; Katoh & Standley 2013) implemented as a plug-in in Geneious 2022.0.2 (https://www.geneious.com) with default settings. To visualise genetic variation, a median-joining haplotype network (Bandelt *et al*. 1999) was constructed using PopART 1.7 (Leigh & Bryant 2015) with default settings (epsilon = 0).

Morphology

We examined the holotype of *Diomedea platei* at the Museum für Naturkunde Berlin (ZMB 47.77) on a total of three different occasions (GMK and HS, separately and together). We assessed the following characters: biometrics, bill colour, and plumage colouration.

Measurements were collected by a single person (HS), including of the *platei* holotype, and otherwise restricted to sexed specimens collected on, or near, breeding islands and thus of known population. All available specimens held at the Museum of New Zealand Te Papa Tongarewa (NMNZ), Wellington, NZ, and at the American Museum of Natural History (AMNH), New York, USA, were measured. In total 34 adult and full-grown juveniles of the two populations were available (Table 1, Appendix 1).

Parameters measured included wing length (flattened), tail, tarsus, culmen to feathers, bill width (at the junction of the latericorn and ramicorn), bill depth (at the feathers), bill depth at unguis (maximum height/apex), mandibular unguis length (measured along the base), height of the orange line along the mandibular ramicorn at its mid/highest point, and the height of the uncoloured area at its mid/highest point. Additionally, HS scored the grey of the head (1: pale, 2: medium, 3: dark); how well delineated the paler cap is at its rear (1: diffuse, 2: medium, 3: sharp), and the extent of the pale cap (1: to just behind the eye, 2: to rear crown, 3: to nape), as well as the shape of the upper end of the culminicorn (1: round; 2: intermediate; 3: flat). HS also attempted to assess the size of the dark loral patch measured from the front of the eye to the distal end of the patch. Univariate and multivariate statistics (Principal Component Analysis, PCA, correlation matrix on scaled variables) were then performed on the biometric data from all birds using package Factormine on R (colouration variables were not included in the PCA since they were not continuous).

RESULTS

Molecular analyses

The final control region sequence alignment was 221 base pairs in length. The resulting median-joining haplotype network was consistent with the results presented in Wold *et al*. (2018) and clearly separated the populations of *T. b. bulleri (*including the two newly sequenced samples from the Snares Islands) from those of *T. b. platei* (including two of the three newly sequenced samples from Rangitatahi). However, three samples of *T. b. platei* were located between the two clusters (one of the three newly

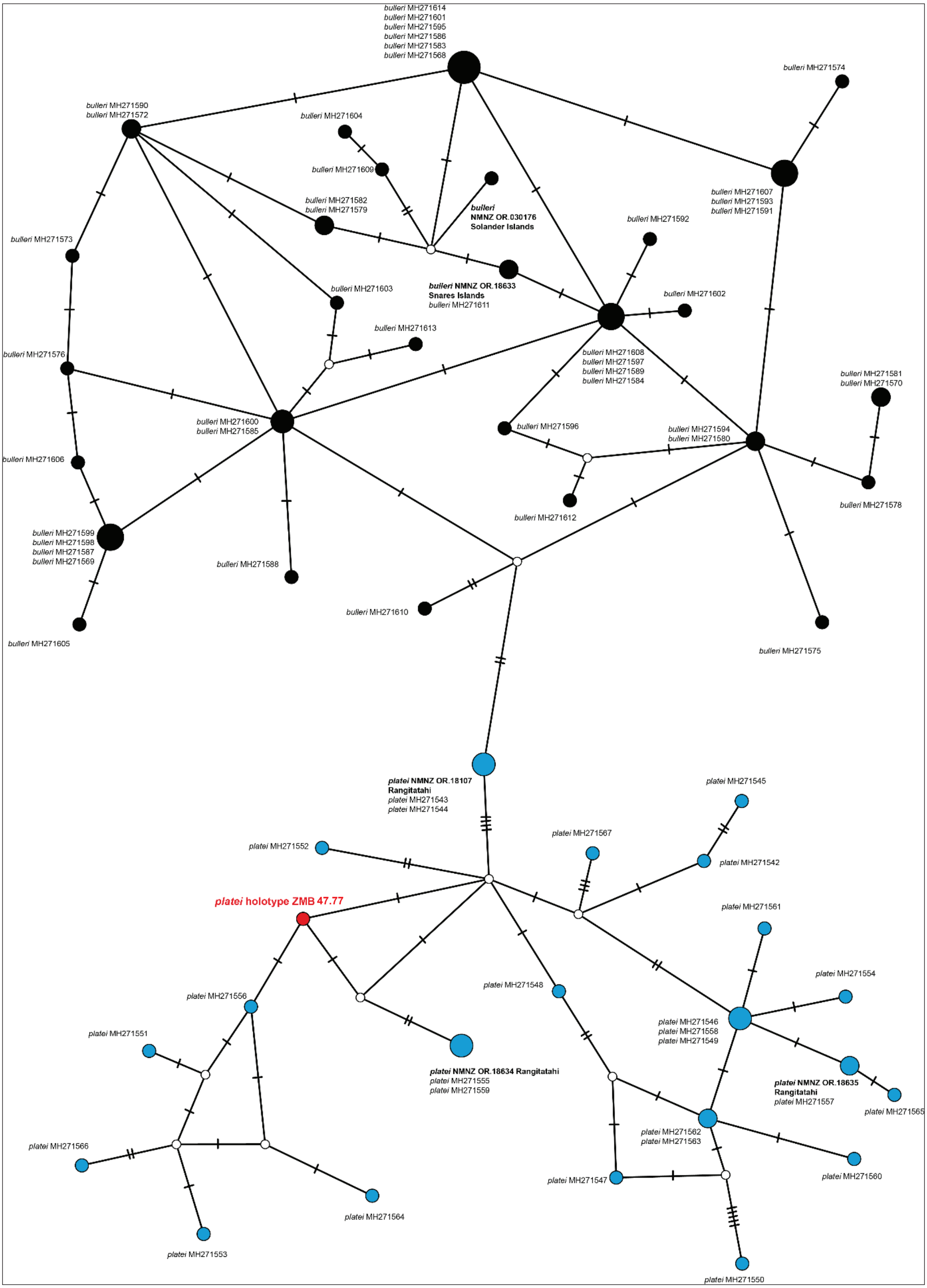

Figure 4. Haplotype network based on 221 base pairs of the mitochondrial control region of 26 individuals of *Thalassarche bulleri platei* and 47 of *Thalassarche b. bulleri* from Wold *et al*. (2018), two *T. b. bulleri* and three *T. b. platei* of known provenance from NMNZ, Wellington, NZ (highlighted in bold), and the holotype of *T. b. platei* ZMB 47.77, (highlighted in red). The latter clusters with samples of *T. b. platei*.

sequenced samples from Rangitatahi and two from Motuhara derived from Wold *et al*. 2018) (Fig. 4). The holotype of *Diomedea platei* ZMB 47.77 clearly clustered with all other samples of *T. b. platei* in Fig. 4.

Morphology

Table 1 summarises biometrics of the analysed specimens of *T. b. bulleri* and *T. b. platei* for juveniles and adult males and females separately, as well as for the type of *T. b. platei*. The holotype of *platei* shows comparatively extreme measurements in bill depth and bill width. In general, its bill is rather narrow, elongated, not so broad and consequently more closely matches the overall shape of *T. b. bulleri* than *T. b. platei*. The height of the orange line along the mandibular ramicorn measured 4.5 mm in the *platei* holotype and is thus close only to female *T. b. platei*. In contrast, the height of the uncoloured area in the *platei* holotype was much closer to *T. b. bulleri*. The scored character states of the *platei* holotype overlapped with both *T. b. bulleri* and *T. b. platei*.

In general, *T. b. platei* differs from *T. b. bulleri* by its darker grey head and neck, more restricted and better delimited white cap, and it has a broader bill profile but with a rounder upper end to the culminicorn, as well as a narrower orange line along the mandibular ramicorn.

The first two axes of the PCA of all biometric measurements explained 44.23% and 18.76% of the total variance (Fig. 5). There was a tendency for a separation between taxa in both adults and juveniles, but even more pronounced between adults and juveniles within both taxa. The *platei* holotype clustered more closely with *T. b. bulleri* juveniles rather than with *T. b. platei* but sample sizes for juveniles were very low. In addition, it has to be taken into account that three of the measured juveniles of *T. b. platei* were taken from the nest and were probably not yet fully grown.

In plumage colouration, the scores of the *platei* holotype were within the range of all other taxa and age classes except in the darkness of the head compared to adult *T. b. bulleri* (Table 1).

DISCUSSION

Our results based on a single mitochondrial genetic marker indicate that at least the mother of ZMB 47.77, the holotype of *Diomedea platei*, belonged to the northern population of Buller's albatross, based on the comparative data available in Wold *et al*. (2018), as well as our independent check of specimens from known populations at NMNZ. Given that there is a lack of inferred gene flow based on genome-wide data between northern and southern populations of Buller's albatross (Wold *et al*. 2021), we consider it highly unlikely that the holotype of *platei* is

Table 1. Mean measurements, by subspecies and age, for all the museum skins included in this study. The measurements of the *platei* holotype specimen are presented in the 'Type' column. Ad = Adult, Juv = Juvenile, F = Female, M = Male. The first 11 parameters were measured in millimetres, and the colour of the last three were scored between 1 and 3 (see Methods). Mean values and standard deviations are given.

	T. b. bulleri			*T. b. platei*			Type
	Ad		Juv	Ad		Juv	
	F (n=6)	M (n=5)	(n=4)	F (n=8)	M (n=7)	(n=4)	
Wing	501.3±9.3	507.2±4.7	498.3±8.7	492.8±10.5	502.1±12.0	497.3±8.1	499
Tail	189.5±4.7	191.0±7.6	177.3±7.5	188.4±1.6	189.5±5.9	173.5±4.5	175
Culmen	116.8±2.3	122.2±4.5	111.7±4.8	118.0±4.2	122.6±1.5	116.2±2.6	115.6
Bill depth (base)	42.3±1.6	45.5±0.8	41.2±1.5	45.9±3.0	47.6±1.4	41.2±1.5	38
Bill depth (unguis)	24.8±1.0	25.4±1.1	22.3±0.5	25.8±0.7	27.2±0.5	23.9±0.9	23
Bill width	26.9±1.0	27.3±0.7	26.6±1.8	29.5±1.8	29.2±1.2	27.3±1.1	23.4
Tarsus	79.3±3.5	82.5±2.6	78.7±2.9	79.5±2.4	82.5±1.9	78.3±1.2	81.5
Mandible	16.7±0.8	17.5±1.3	15.5±1.2	17.8±1.3	18.0±1.1	17.5±0.7	17.9
Height orange line	5.82±0.8	6.7±0.7	6.9±0.8	5.06±0.6	5.76±0.6	5.8±0.2	4.5
Height remaining	3.7±0.6	3.6±1.0	3.5±1.0	5.14±0.7	4.8±0.7	5.1±0.7	4
Loral patch length	18.1±2.7	18.1±2.7	15.4±3.1	15.4±3.4	17.0±3.9	16.8±2.7	17.9
Head colour	1.8±0.4	1.6±0.6	2.0±0.8	2.5±0.5	2.43±0.5	1.75±0.5	1
Rear cap colour	1.0±0.0	1.4±0.6	1.8±0.5	2.3±0.7	2.3±0.5	2.0±0.8	1
Cap colour	2.5±0.6	2.4±0.9	2.5±0.6	1.9±0.3	1.9±0.4	1.0±0.0	1

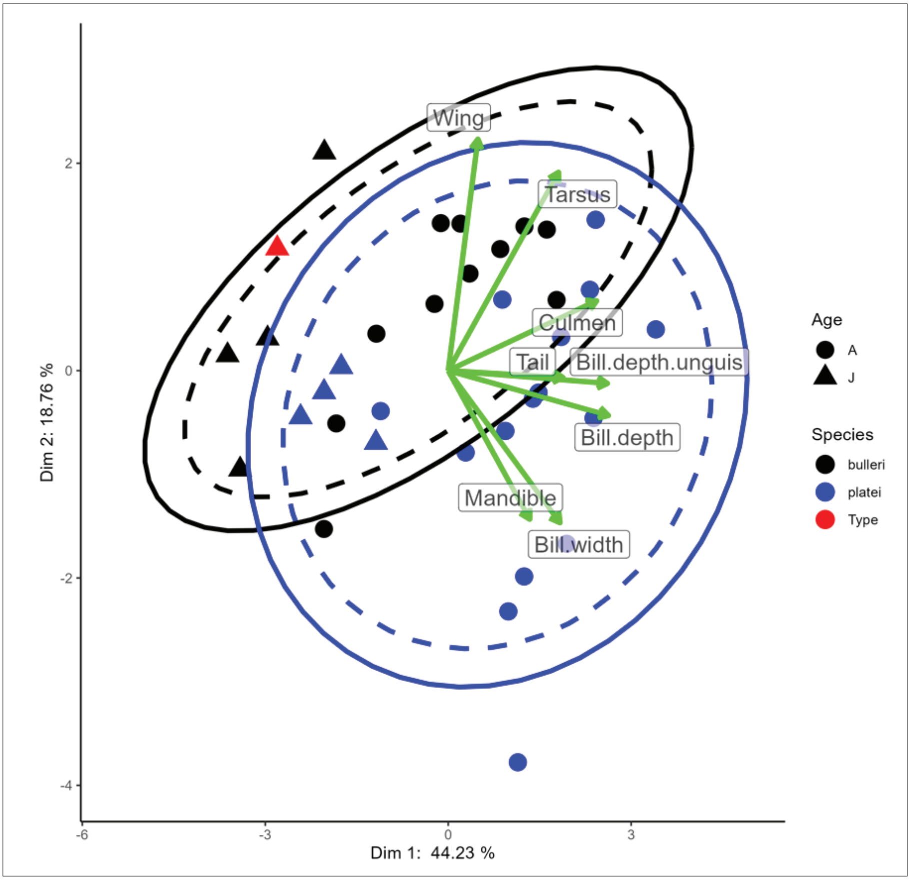

Figure 5. Results of Principal Component Analysis (PCA) on the 35 measured specimens. Symbols represent individuals in multivariate space (here, the first plan with PC axes 1 and 2), according to subspecies (colour) and age (symbol). The holotype of *Thalassarche bulleri platei* is denoted by the red triangle. Biometric variable components are overlaid on the same graph (in green).

of hybrid origin. We can thus be confident that the name *platei* has been correctly applied to the northern population of Buller's albatross.

Morphometric analyses tended to suggest that the *platei* holotype may be slightly morphologically closer to *T. b. bulleri* rather than to *T. b. platei*, in contrast to the genetic results. However, the *platei* type is an unsexed young immature bird and its morphometrics, bill colour and plumage characteristics could be compared only with adults and fully grown juveniles of *T. b. bulleri*. The data provided in Table 1 suggest that the *platei* holotype apparently has atypical measurements for bill depth and width.

In general, phenotypic differences between the two subspecies must be considered as minor; the lack of characters to separate non-adult *T. b. platei* and *T. b. bulleri* was outlined by Shirihai (2007).

The identity of ZMB 47.77 has been the subject of much debate over the years, especially in the first three decades after Reichenow's description. Murphy (1930: 6) noted that *Diomedea platei* had been synonymised with shy albatross *Thalassarche cauta* by several authors, e.g. Ogilvie-Grant (1905: 559), although Godman (1908: 346) refuted this hypothesis and upheld Reichenow's (1898, 1899) original diagnosis. Some authors even regarded *platei* as a subspecies of *T. cauta* (Mathews & Iredale 1921: 54; Dabbene 1926: 324); however, Mathews (1927: 907) subsequently treated the specimen as a synonym of *bulleri*, as did Murphy (1930, 1936). Loomis (1918) considered *platei* to be a young specimen of black-browed albatross *T. melanophris*. Our results confirm that the application of the name *platei* to the northern population of Buller's albatross is correct.

There is growing interest in the taxonomy of *T. bulleri*, especially following the discovery of strong mtDNA genetic differentiation and lack of inferred gene flow between its northern and southern populations, possibly because of their asynchronous breeding seasons (Wold *et al*. 2018, 2021). Speciation through allochrony, i.e. prezygotic isolation via temporal segregation of breeding populations, has been documented on several occasions in Procellariiformes (Friesen *et al*. 2017; Taylor *et al*. 2018, 2019) and other bird groups (e.g. Gómez-Bahamón *et al*. 2020; Tang *et al*. 2022), and may also be occurring in Buller's albatross. As already proposed by Wold *et al*. (2021), this, in combination with minor morphological differences described above for adults (see also Shirihai 2007), might justify the treatment of *bulleri* and *platei* as species level taxa applying an integrative approach towards species delimitation (e.g. Schweizer *et al.* 2023). However, as explained here, identification of the two taxa at sea is not straightforward and is probably impossible for many immatures.

The estimated annual breeding population of both subspecies combined is 32,134 pairs, with 8,704 pairs on the Snares Islands (*bulleri*), 5,280 pairs on the Solander Islands (*bulleri*), 16,000 pairs on the Forty-Fours (*platei*), 2,130 pairs on the Sisters (*platei*) and 20 pairs on Rosemary Rock (*platei*) (BirdLife International 2024), and the species is assessed as Near Threatened (BirdLife International 2024). Clearly, the conservation status of both taxa, especially nominate *bulleri* with its overall smaller population, would require careful reassessment against IUCN Red List criteria should they be treated as separate species, as well as perhaps enhanced measures to protect their relatively small populations.

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LITERATURE CITED

Bandelt, H.; Forster, P.; Röhl, A. 1999. Median-joining networks for inferring intraspecific phylogenies. *Molecular Biology and Evolution 16*: 37–48.

BirdLife International. 2024. Species factsheet: *Thalassarche bulleri*. http://www.birdlife.org (accessed 22 December 2024).

Brooke, M. 2004. *Albatrosses and petrels across the world*. Oxford, Oxford University Press.

Dabbene, R. 1926. Los petreles y los albatros del Atlántico austral. *Hornero 3*: 311–348.

Del Hoyo, J.; Collar, N.J. 2014. *HBW and BirdLife International illustrated checklist of the birds of the world*, vol. 1. Barcelona, Lynx Edicions.

Dickinson, E.C.; Remsen, J.V. (eds) 2013. *The Howard and Moore complete checklist of the birds of the world*, vol. 1. Fourth edn. Eastbourne, Aves Press.

Fischer, J.H.; Bell, M.; Frost, P.; Sagar, P.M.; Thompson, D.R.; Middlemiss, K.L.; Debski, I.; Taylor, G.A. 2023. Year-round GLS tracking of northern Buller's albatross and comparison with southern Buller's albatross. Department of Conservation, Conservation Services Programme POP2022-05: northern Buller's albatross population monitoring. 16 pp.

Friesen, V.L.; Smith, A.L.; Gomez-Diaz, E.; Bolton, M.; Furness, R.W.; González-Solís, J.; Monteiro, L.R. 2007. Sympatric speciation by allochrony in a seabird. *Proceedings of the National Academy of Sciences USA 104*: 18589–18594.

Gill, B.J.; Bell, B.D.; Chambers, G.K.; Medway, D.G.; Palma, R.L.; Scofield, R.P.; Tennyson, A.J.D.; Worthy, T.H. 2010. *Checklist of the birds of New Zealand, Norfolk and Macquarie Islands, and the Ross Dependency, Antarctica*. Wellington, Te Papa Press & Ornithological Society of New Zealand.

Godman, F.C. 1908. *A monograph of the petrels (order Tubinares)*. Volume 2. London, Witherby & Co.

Gómez-Bahamón, V.; Márquez, R.; Jahn, A.E.; Miyaki, C.Y.; Tuero, D.T.; Laverde-R., O.; Restrepo, S.; Cadena, C.D. 2020. Speciation associated with shifts in migratory behavior in an avian radiation. *Current Biology 30*: 1312–1321.

Hellmayr, C.E.; Conover, B. 1948. Catalogue of birds of the Americas and the adjacent islands, pt. 1(2). *Publications of the Field Museum of Natural History* (*Zoological Series*) 13 pt. 1(2).

Jouanin, C.; Mougin, J.-L. 1979. Order Procellariiformes. Pp. 48–121 *In*: Mayr, E.; Cottrell, E.W. (eds) *Check-list of birds of the world*. Volume 1. Revised edn. Cambridge, MA, Museum of Comparative Zoology.

Katoh, K.; Misawa, K.; Kuma, K.; Miyata, T. 2002. MAFFT: a novel method for rapid multiple sequence alignment based on fast Fourier transform. *Nucleic Acids Research 30*: 3059–3066.

Katoh, K.; Standley, D.M. 2013. MAFFT Multiple Sequence Alignment Software Version 7: improvements in performance and usability. *Molecular Biology and Evolution 30*: 772–780.

Leigh, J.W.; Bryant, D. 2015. PopART: Full-feature software for haplotype network construction. *Methods in Ecology and Evolution 6*: 1110–1116.

Loomis, L.M. 1918. A review of the albatrosses, petrels, and diving petrels. *Proceedings of the California Academy of Sciences (4)2*: 1–187.

Lutgen, D.; Burri, R. 2020. DNA extraction protocol for historical toe pad samples from birds v1 (preprint). https://doi.org/10.17504/protocols.io.dm6gpwrdplzp/v1 (accessed 21 June 2022).

Marchant, S.; Higgins, P.J. (eds) 1990. *Handbook of Australian, New Zealand & Antarctic birds*. Volume 1A. Melbourne, Oxford University Press.

Mathews, G.M. 1927. *Systema avium Australasianarum. A systematic list of the birds of the Australasian region*. London, British Ornithologists' Union.

Mathews, G.M. 1934. A check-list of the order Procellariiformes. *Novitates Zoologicae 39*: 151–206.

Mathews, G.M.; Iredale, T. 1921. *A manual of the birds of Australia*. Volume 1. London, H. F. & G. Witherby.

McCallum, J.; Brook, F.; Francis, M. 1985. Buller's mollymawks on Rosemary Rock, Three Kings Islands, in 1985. *Notornis 32*: 257–259.

Murphy, R.C. 1930. Birds collected during the Whitney South Sea Expedition. XI. *American Museum Novitates 419*: 1–15.

Murphy, R.C. 1936. *Oceanic birds of South America*. Volume 1. New York, Macmillan Co. & American Museum of Natural History.

Ogilvie-Grant, W.R. 1905. On the birds procured by the Earl of Ranfurly in New Zealand and the adjacent islands. *Ibis (8)5*: 543–602.

Onley, D.; Scofield, R.P. 2007. *Albatrosses, petrels and shearwaters of the world*. Princeton, NJ, Princeton University Press.

Peters, J.L. 1931. *Check-list of birds of the world*. Volume 1. Cambridge, MA, Museum of Comparative Zoology.

Quiñones, J.; Zavalaga, C.; Robertson, C.J.R. 2023. Identifying northern Buller's albatross (*Thalassarche bulleri* subsp.) in offshore waters of southern Perú. *Notornis 70*: 49–59.

Reader's Digest. 1985. *Complete book of New Zealand birds*. Sydney, Reader's Digest.

Reichenow, A. 1898. Nachrichten. Jahresversammlung der Deutschen Ornithologischen Gesellschaft [*Diomedea platei* n. sp.]. *Ornithologische Monatsberichte 6*: 190.

Reichenow, A. 1899. [Über *Diomedea platei* n. sp.]. *Journal für Ornithologie 47*: 118–119.

Robertson, C.J.R.; Nunn, G.B. 1998. Towards a new taxonomy for albatrosses. Pp. 13–19 *In*: Robertson, G.; Gales, R. (eds) *Albatross biology and conservation*. Chipping Norton, Victoria, Surrey Beatty & Sons.

Sagar, P.M.; Warham, J. 1998. Breeding biology of southern Buller's albatross *Diomedea bulleri bulleri* at the Snares. Pp. 92–98 *In*: Robertson, G.; Gales, R. (eds) *Albatross biology and conservation*. Chipping Norton, Victoria, Surrey Beatty & Sons.

Schweizer, M.; Marques, D.A.; Olsson, U.; Crochet P.-A. 2023. The Howard & Moore Complete Checklist of Birds of the World: framework for species delimitation. *Avian Systematics 1*: N35–N41.

Schweizer, M.; Shirihai, H. 2013. Phylogeny of the *Oenanthe lugens* complex (Aves, Muscicapidae: Saxicolinae): paraphyly of a morphologically cohesive group within a recent radiation of open-habitat chats. *Molecular Phylogenetics & Evolution 69*: 450–461.

Shepherd, L.D.; Miskelly, C.M.; Bulgarella, M.; Tennyson, A.J.D. 2022. Genomic analyses of fairy and fulmar prions (Procellariidae: *Pachyptila* spp.) reveals parallel evolution of bill morphology, and multiple species. *PloS ONE 17(9)*: e0275102. https://doi.org/10.1371/journal.pone.0275102

Shirihai, H. 2007. *A complete guide to Antarctic wildlife*. Second edn. London, A. & C. Black.

Spear, L.B.; Ainley, D.G.; Webb, S.W. 2003. Distribution, abundance, and behaviour of Buller's, Chatham Island and Salvin's albatrosses off Chile and Peru. *Ibis 145*: 253–269.

Tang, Q.; Burri, R.; Liu, Y.; Suh, A.; Sundev, G.; Heckel, G.; Schweizer, M. 2022. Seasonal migration patterns and the maintenance of evolutionary diversity in a cryptic bird radiation. *Molecular Ecology 31*: 632–645.

Taylor, G.A. 2000. *Action plan for seabird conservation in New Zealand*. Part A: Threatened seabirds. Wellington, Dept. of Conservation. Threatened Species Occasional Publication No.16.

Taylor, R.S.; Bailie, A.; Gulavita, P.; Birt, T.; Aarvak, T.; Anker-Nilssen, T.; Barton, D.C.; Lindquist, K.; Bedolla-Guzmán, Y.; Quillfeldt, P.; Friesen, V.L. 2018. Sympatric population divergence within a highly pelagic seabird species complex (*Hydrobates* spp.). *Journal of Avian Biology 49(1)*: e01515.

Taylor, R.S.; Bolton, M.; Beard, A.; Birt, T.; Deane-Coe, P.; Raine, A.F.; González-Solís, J.; Lougheed, S.C.; Friesen, V.L. 2019. Cryptic species and independent origins of allochronic populations within a seabird species complex (*Hydrobates* spp.). *Molecular Phylogenetics & Evolution 139*: 106552.

Turbott, E.G. (convener) 1990. *Checklist of the birds of New Zealand and the Ross Dependency, Antarctica*. Third edn. Auckland, Ornithological Society of New Zealand & Random Century New Zealand.

Warham, J. 1982. Distant recovery of a Buller's mollymawk. *Notornis 29*: 213–214.

Wold, J.R.; Robertson, C.J.R.; Chambers, G.K.; Ritchie, P.A. 2018. Phylogeographic structure and a genetic assignment method for Buller's albatross ssp. (*Thalassarche bulleri* ssp.). *Notornis 65*: 152–163.

Wold, J.R.; Robertson, C.J.R.; Chambers, G.K.; Van Stijn, T.; Ritchie, P.A. 2021. Genetic connectivity in allopatric seabirds: lack of inferred gene flow between northern and southern Buller's albatross populations (*Thalassarche bulleri* ssp.). *Emu – Austral Ornithology 121*: 113–123.

Wright, A.E. 1984. Buller's mollymawks breeding at the Three Kings Islands. *Notornis 31*: 203–207.

Appendix 1. Measurements and morphology scores of museum specimens included in analyses. AMNH = American Museum of Natural History, NMNZ = Museum of New Zealand Te Papa Tongarewa, ZMB = Museum für Naturkunde Berlin. All measurements in millimetres apart from the final four columns, which were scored on a scale of 1 to 3 as explained in footnotes.

Taxon	Museum number	Age and sex	Wing	Tail	Tarsus	Culmen	Bill width	Bill depth	Bill depth at unguis
T. b. bulleri	NMNZ OR.018631	Ad. male	501	193	83.6	124.3	26.4	46.5	23.5
T. b. bulleri	NMNZ OR.016630	Ad. male	504	189	84.4	123.5	28.3	46.0	25.5
T. b. bulleri	NMNZ OR.005579	Ad. male	508	201	78.0	114.4	27.2	44.6	25.6
T. b. bulleri	AMNH 27374	Ad. male	511	180	83.2	126.1	27.6	44.9	25.8
T. b. bulleri	AMNH 526942	Male	512	192	83.4	122.5	27.0	45.3	26.4
T. b. bulleri	NMNZ OR.016631	Ad. female	505	198	81.0	119.6	27.7	44.0	24.8
T. b. bulleri	NMNZ OR.005582	Ad. female	506	186	83.2	117.8	26.8	43.5	26.3
T. b. bulleri	NMNZ OR.018632	Ad. female	507	187	83.0	117.6	28.5	43.0	25.0
T. b. bulleri	NMNZ OR.018633	Ad. female	494	188	77.1	113.8	26.1	39.7	24.9
T. b. bulleri	NMNZ OR.030176	Ad. female	486	186	75.6	114.0	26.2	42.7	23.3
T. b. bulleri	NMNZ 526943	Female	510	192	76.0	117.8	26.4	41.1	24.4
T. b. bulleri	AMNH 8771	Juv. male	496	186	78.3	110.2	25.5	40.3	22.9
T. b. bulleri	AMNH 18195	Juv. male	506	168	77.5	109.6	28.7	40.1	21.6
T. b. bulleri	AMNH 18194	Juv. male	504	176	82.8	118.8	27.5	41.2	22.3
T. b. bulleri	NMNZ OR012303	Juv. female	487	179	76.1	108.3	24.7	43.3	22.4
T. b. platei holotype	ZMB 47/77	Immature	499	175	81.5	115.6	23.4	38.0	23.0
T. b. platei	NMNZ OR.018107	Ad. male	507	188	85.3	124.1	29.4	45.9	28.1
T. b. platei	NMNZ OR.018634	Ad. male	504.5	188.5	83.8	122.6	27.8	48.8	27.4
T. b. platei	NMNZ OR.018479	Ad. male	498	180	83.6	125.1	27.8	46.7	27.1
T. b. platei	AMNH 211396	Male	480	188	82.1	121.0	29.5	48.2	26.9
T. b. platei	AMNH 211395	Male	520	200	82.3	121.9	29.5	48.8	27.4
T. b. platei	AMNH 211394	Male	505	191	81.0	121.1	31.2	48.8	26.8
T. b. platei	AMNH 211397	Male	500	191	79.7	122.6	29.3	45.9	26.5
T. b. platei	NMNZ OR.018635	Ad. female	508	186	79.7	120.3	29.8	49.9	25.4
T. b. platei	NMNZ OR.018106	Ad. female	508	186	78.1	109.6	28.4	39.8	26.3
T. b. platei	NMNZ OR.018478	Ad. female	495	188	84.0	122.6	27.2	45.4	25.1
T. b. platei	AMNH 211401	Female	480	189	75.6	121.5	33.0	44.7	25.3
T. b. platei	AMNH 211403	Female	486	189	79.8	115.9	30.6	47.9	26.5
T. b. platei	AMNH 211405	Female	493	190	79.4	115.2	28.0	46.7	25.9
T. b. platei	AMNH 211400	Female	485	190	81.0	118.6	28.8	47.4	26.9
T. b. platei	AMNH 211404	Female	487	189	78.1	120.3	30.3	45.7	25.2
T. b. platei	NMNZ OR.019251	Juv. male	487	176	79.4	116.4	27.8	42.9	25.1
T. b. platei	NMNZ OR.019252	Juv. female	498	177	78.2	116.9	25.6	41.9	24.2
T. b. platei	NMNZ OR.019253	Juv. female	507	167	76.6	118.8	27.7	40.7	23.3
T. b. platei	AMNH 18699	Juv. female	497	174	79.0	112.7	27.9	39.4	23.2

Details of measurements and scoring systems: Culmen = bill length to base of feathers; Bill width = width at the junction of the latericorn and ramicorn; Bill depth where culmen meets feather bases; Bill depth at unguis measured at maximum height/apex; Unguis length = mandibular unguis length (measured along the base); Orange line height = Height of the orange line along the mandibular ramicorn at its mid/highest point; Uncoloured line height = height of the uncoloured area of the mandibular ramicorn at its mid/highest point; Loral patch length = front of eye to front edge of dark loral patch; Grey of head scored as 1: pale, 2: medium, 3: dark; Cap delineation = how well delineated the pale cap is at its rear (1: diffuse, 2: medium, 3: sharp); Cap extent = extent of pale cap, scored as 1: to just behind the eye, 2: to rear crown, 3: to nape; Culminicorn base shape, scored as 1: round; 2: intermediate; 3: flat.

Museum number	Unguis length	Orange line height	Uncoloured line height	Loral patch length	Grey of head	Cap delineation	Cap extent	Culminicorn base shape
NMNZ OR.018631	17.4	6.4	3.4	17.1	2	2	2	3
NMNZ OR.016630	18.6	6.6	3.6	21.8	2	1	3	1
NMNZ OR.005579	15.4	7.5	2.7	17.7	1	1	3	1
AMNH 27374	18.0	5.8	3.0	14.5	2	2	1	1
AMNH 526942	18.2	7.2	5.2	19.5	1	1	3	1
NMNZ OR.016631	16.1	5.5	3.9	19.0	2	1	2	3
NMNZ OR.005582	16.5	6.8	2.8	18.5	2	1	3	2
NMNZ OR.018632	15.5	5.3	4.4	20.8	2	1	3	3
NMNZ OR.018633	17.2	5.8	3.4	18.2	2	1	2	2
NMNZ OR.030176	17.7	6.7	3.7	12.9	2	1	2	2
NMNZ 526943	17.1	4.8	4.0	18.9	1	1	3	3
AMNH 8771	15.7	5.9	2.9	12.1	2	2	3	3
AMNH 18195	15.7	7.8	2.7	16.2	2	2	2	3
AMNH 18194	13.9	6.9	4.9	14.0	3	2	2	1
NMNZ OR012303	16.7	7.3	3.3	19.1	1	1	3	1
ZMB 47/77	17.9	4.5	4.0	17.9	1	1	1	2
NMNZ OR.018107	16.4	6.5	4.9	24.0	3	2	1	3
NMNZ OR.018634	17.8	6.1	4.2	18.0	3	2	2	3
NMNZ OR.018479	18.5	4.7	4.5	17.5	2	2	2	2
AMNH 211396	18.5	5.5	3.7	18.0	2	3	2	3
AMNH 211395	19.9	5.7	5.7	13.2	2	2	2	1
AMNH 211394	17.7	6.3	5.4	16.8	3	3	2	2
AMNH 211397	17.2	5.5	5.2	11.8	2	2	2	1
NMNZ OR.018635	17.6	4.8	5.1	19.5	3	3	2	2
NMNZ OR.018106	18.0	4.3	4.2	16.9	3	2	2	3
NMNZ OR.018478	17.3	4.9	4.9	16.1	2	2	2	2
AMNH 211401	19.6	5.1	4.4	17.2	3	3	1	3
AMNH 211403	18.0	4.8	5.1	16.6	2	1	2	2
AMNH 211405	17.2	5.3	5.5	10.5	2	3	2	3
AMNH 211400	15.6	4.9	6.0	16.2	2	2	2	2
AMNH 211404	19.4	6.4	5.9	9.9	3	2	2	2
NMNZ OR.019251	16.6	6.1	5.0	18.8	2	2	1	1
NMNZ OR.019252	17.5	5.6	5.6	18.4	2	2	1	3
NMNZ OR.019253	18.2	5.8	4.1	17.2	2	3	1	2
AMNH 18699	17.6	5.8	5.6	13.0	1	1	1	2

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SHORT NOTE

Sightings and dispersal of red-billed gulls (*Chroicocephalus novaehollandiae scopulinus*) banded at Kaikōura, New Zealand, 1959–1970

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Red-billed gulls (tarāpunga, *Chroicocephalus novaehollandiae scopulinus*) occur around the coasts of New Zealand. They are described as "Least concern" by BirdLife International (2022), who merge them with the Australian silver gull (*C. n. novaehollandiae*). However, the New Zealand subspecies was listed as "At risk: Declining" under the New Zealand Threat Classification (Robertson *et al.* 2021). Frost & Taylor (2018) reported a national survey undertaken in 2014–16 which indicated that the population had declined by 33% since 1965. The Kaikōura Peninsula colony, the subject of this note, declined by 51% between 1993 and 2003 (Mills *et al.* 2008) and more through to 2014 (Mills *et al.* 2018). In contrast, numbers in Otago increased since the early 1990s (Lalas *et al.* 2022).

Summaries of banding activities in New Zealand from 1951 show that Brian Bell probably banded the first red-billed gulls at Kaikōura Peninsula, 889 in 1958-59 (Kinsky 1959). In 1959-60 birds were banded at Kaikōura Peninsula by Brian Bell (809 birds), L.K. Clark (700 birds) and Ken Rowe (711 birds) (Kinsky 1960). This early banding at Kaikōura progressed into a study by Jim Mills that is continuing through to the present day (Mills 1970; Mills *et al*. 2018).

From 1959 to 1970, 11,797 birds (11,563 chicks and 234 adults) were banded at Kaikōura under the permits of Ken Rowe. Aluminium size E bands were used until 1967, monel bands in 1968 and stainless steel in 1970. Butt closure was the main band style used except for 2,500 size H lock bands used in 1959 to 1961. The aluminium bands were susceptible to wear by movement against legs, abrasion by particles, and corrosion in salt water (Mills 1972). Band loss occurred after 4 years for butt-to-butt bands and after 6 years for lock bands (Mills 1972) which limits reliable re-sighting duration estimates unless birds were re-banded with stainless steel bands.

Higgins & Davies (1996) reported that most birds dispersed from their colonies in the non-breeding season, although some were sedentary. This note reports sightings, including those found dead, of Kaikōura chicks banded by Ken Rowe. Data used are from paper recovery slips sent to Ken Rowe by the precursors to, and from, the Department of Conservation (DOC) Banding Office that have not been lost through many household shifts, or from files sent to the author from DOC.

In the DOC database, location coordinates were rounded down to 10′, i.e. 42°25'S, 173°42'E was coded as 422S 1734E, which leads to an inherent error in distance up to ± 23 km. Directions in the database are recorded to ±11.25°, e.g. as NNE etc., which equates to an arc of about ±20 km at 100 km distance from Kaikōura Peninsula. Therefore, defining the exact location of sightings from the database

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also has this potential inaccuracy to consider. There were 4,060 sightings of birds recorded 0 km to 19 km from the banding site (Table 1). The great majority of these would have been at the colony and included many dead chicks; there would have been some a short distance off the colony; however, the records that I have cannot distinguish them.

Of the 4,060 sightings of Kaikōura red-billed gulls, 994 were of dead birds. Most were listed as "dead" but included many chicks that died of unknown causes before fledging, and birds that were depredated or died of unknown causes. Sight readings of bands, 3,116, would have included birds with worn aluminium bands that were re-banded with stainless steel bands, including the addition of unique colour combinations from 1968-69 (Mills 1970, 1972; author *unpubl. data*) and observations of breeding birds by Jim Mills and a few experienced ornithologists.

There were 2,969 sightings of birds at distances given as >19 km from Kaikōura (Table 1). A sample of 199 recovery slips from DOC still held by the author showed the types of sightings away from Kaikōura were: sight including of breeding birds at colonies away from Kaikōura (95); unspecified "found dead" (72); there were 32 only with known causes of death as shown in Table 2. Very few recovery slips listed colour combinations, suggesting sight recoveries were of birds caught and released with the band number recorded, or unspecified sight recoveries.

Two observations were "at sea", one being 80 km east of Kaikōura and the other 90 km out in the Tasman Sea off Greymouth. The longest distance recovery was aluminium band E33985 found in 1995 at the Chatham Islands (795 km ESE). This was reported as "band only", and so the time between banding, 23 Nov 1963, and the bird's demise cannot be determined. However, there is no reason to doubt the location as red-billed gulls can travel large distances, having been reported as stragglers to the Kermadec and Lord Howe Islands (Checklist Committee 2022), a Kaikōura bird was found in Australia in 2017 (Mills *et al*. 2020), and there are breeding colonies at the Chatham Islands (Mills 2013).

Dispersal from Kaikōura Peninsula within New Zealand ranged from E19245 at Kaipara Harbour, 644 km N, to H12082 at Stewart Island, 667 km SW. These are at the top end of recoveries reported in New Zealand, Kaikōura to Point Chevalier, Auckland by H6612 at 625 km (Kinsky 1962) and Lake Grassmere to Mullet Bay near Bluff by E6254 at 715 km (Kinsky 1963); Mills (2013) generalised maximum dispersal at 650 km. The northernmost sighting, Kaipara Harbour, was one of six Kaikōura Peninsula birds sighted in Auckland Province (Table 1). Sparse sightings in Hawke's Bay (six), in Taranaki (seven), and those outside of a 30 km radius of Wellington City (35) make a total of 64 in the provincial North Island, 1.8% of all sightings outside of Kaikōura.

Table 1. Localities where red-billed gull chicks banded at Kaikōura Peninsula from 1959 to 1970 were sighted. Wellington City and Christchurch are birds found within 30 km of the city centres.

Area	Total	Live	Dead
At sea	2	1	1
Chatham Islands	1	0	1
Auckland	6	3	3
Hawke's Bay	6	5	1
Taranaki	7	4	3
Wellington	35	27	8
Wellington City	439	380	59
South Island West Coast	6	6	0
Nelson	69	60	9
Marlborough	91	56	35
Inland from Kaikōura	29	27	2
Kaikōura + 19 km	4060	3116	944
North Canterbury	7	3	4
Christchurch	2024	1933	91
South Canterbury	131	109	22
Otago	108	87	21
Southland	7	2	5
Stewart Island	1	1	0
Total	7029	4730	1209

Table 2. A sample of the types of sightings (and cause of death) of red-billed gulls away from Kaikōura.

Sighting	Number
Sight	80
Sighting breeding birds	15
Unspecified "found dead"	72
Vehicle	18
Powerline	1
Plough	2
Shot	3
Aircraft	1
Fishing line/net	7
Total	199

Only eight of these sightings were on the east coast, none was reported inland, and the rest were on the west coast. Within a 30 km radius of Wellington City centre, 439 more sightings were reported. Those in the outskirts of the Wellington City grouping were generally on the west coast north to Porirua (about 20 birds); however, as the majority were reported as "Wellington", it is not possible to define the individual localities given the distance and direction constraints.

In the South Island, few birds were found on the West Coast (6), although a bird banded at Kaikōura Peninsula was reported at Charleston (Kinsky 1962), and 29 were reported about 90 km west from Kaikōura centred on Hanmer, the only area in New Zealand where significant numbers of Kaikōura birds were reported inland. Coastal Nelson (69) and Marlborough (91) were regions north of Kaikōura with multiple sightings. There were seven sightings from north Canterbury and 2,024 within 30 km of Christchurch City centre. South of Christchurch, there were 131 sightings in South Canterbury, 108 in Otago, seven in Southland, and one at Stewart Island. Sightings were predominantly in, or at coastal sites, near the main cities, with those from Nelson, Blenheim, Christchurch, Timaru, Oamaru and Dunedin making up 88.8% of sightings outside Kaikōura. Sightings at Christchurch were particularly high, mainly because R.J. (Dick) Jackson made extensive sightings throughout the area over a number of years, including 1971–74.

There were 3.5 times as many sightings of birds to the south of Kaikōura compared to the north. Repeat sightings showed that birds that headed north or south tended to always do that. However, there were about 50 instances where a bird was seen both to the south and to the north, e.g. in Christchurch and Wellington in different years. Birds were sighted as soon as 67 days after banding in Wellington, and at 74 days in Christchurch; one bird was sighted in Dunedin at 62 days.

There were 15 instances of Kaikōura birds seen by Dick Jackson breeding in the Christchurch area (Table 3). While changing colonies is not the norm (Higgins & Davies 1996; Mills 2013), one reported instance of a red-billed gull nesting at a colony other than where it was bred was a Kaikōura bird at Taiaroa Head Otago Peninsula, (442 km SW of Kaikōura), from 2004–07 (Perriman & Lalas 2012). Mills (1970) reported birds banded as nestlings at Kaikōura have been seen breeding at Lake Grassmere (85 km N of Kaikōura), Nelson (130 km NNW), Kapiti Island (300 km NNE) and the Waitaki River mouth (350 km SW). The furthest sighting of a bird from Kaikōura breeding away from its natal colony was E102951 at Lake Rotorua in 1982 and 1983 (G. Taylor *pers. comm.*; DOC FALCON database*)*.

Table 4 lists recoveries of red-billed gulls banded as chicks and recovered more than 15 years later. Many of these were of uncertain age as they were

Table 3. Observations of Kaikōura banded red-billed gulls breeding in the Christchurch area made by R.J. Jackson in 1971–74; each number is a given nest. * signifies the same bird in consecutive years.

Site	Number of eggs in nests	Number of chicks in nests	Age of known adult (years)
Little Port Cooper	1,2		11,9
Whitewash Head	2,2,1		7*,8*,3
Whitewash Head		1,1,2,2,2	10,9,10,9,9
Sumner Head	1,2,2		11,6,6
Sumner Head		3,2	12,9
Total nests	8	7	15

Table 4. Ages of oldest sightings of red-billed gulls banded at Kaikōura 1959–1970.

Band Number	Band Material	Age (years)	Comments
E43328	Aluminium	46.2	Band only - date of death uncertain
E33985	Aluminium	38.0	Band only - date of death uncertain
E41137	Aluminium	35.5	Band only - date of death uncertain
E95481	Stainless steel	~28.8	Dead – day & month uncertain – year known
E95194	Stainless steel	28.2	Dead
H11144	Aluminium	24.2	Skeleton under house – date of death uncertain
E75452	Monel	17.9	Alive
H11838	Aluminium	17.9	Leg only - date of death uncertain
E43599	Aluminium	17.3	Dead
E38000	Aluminium	15.9	Alive
E75791	Monel	15.6	Dead
E47088	Aluminium	15.1	Band only - date of death uncertain

reported as a band only, leg only, and a skeleton of unknown age. The most reliable age was 28.2 years from a bird found dead at Kaikoura, E95194 with a stainless-steel band. This recovery is older than other specific individual ages that I found in the literature and provides context for the order of generalised longevity of 30 years in Mills (2013) and 28 years in Heather & Robertson (2005). The oldest sighting of a bird with a monel band was E75452 alive at 17.9 years, and for a bird with an aluminium band (and that had not been re-banded) the oldest recovery was E38000 seen alive at 15.9 years; this is very high as Mills (1972) reported loss of aluminium bands through abrasion after about 4 years. The oldest recovery of a bird with an aluminium lock band and that was not re-banded was H7943 seen at Little Port Cooper on a nest with one egg 10.9 years after banding; Mills (1972) reported band loss of aluminium H-bands from about age 7 years. Thus, unless re-banded, it is likely that many birds lost their bands while still alive.

In summary, this note has shown red-billed gulls from Kaikōura dispersed widely, up to 667 km, both north and south, and lived up to 28 years-old.

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LITERATURE CITED

BirdLife International. 2022. Species factsheet: *Larus novaehollandiae*. Downloaded from http://www.birdlife.org on 29/08/2022.

Checklist Committee (OSNZ). 2022. *Checklist of the birds of New Zealand.* 5th edn. Ornithological Society of New Zealand Occasional Publication No. 1. Wellington, Ornithological Society of New Zealand.

Frost, P.G.H.; Taylor, G.A. 2018. The status of the red-billed gull (*Larus novaehollandiae scopulinus*) in New Zealand, 2014–2016. *Notornis 65*: 1–13.

Heather, B.D.; Robertson, H.A. 2005. *The field guide to the birds of New Zealand.* Auckland, Penguin Books.

Higgins, P.J.; Davies, S.J.J.F. (eds). 1996. *Handbook of Australian, New Zealand & Antarctic birds.* Volume 3, Snipe to pigeons. Melbourne, Oxford University Press.

Kinsky, F.C. 1959. *9th Annual report of the Banding Committee Ornithological Society of New Zealand, Inc. for the year ending 31st March 1959*. Wellington, Dominion Museum. 38 pp.

Kinsky, F.C. 1960. *10th Annual report of the Banding Committee Ornithological Society of New Zealand, Inc. for the year ending 31st March 1960*. Wellington, Dominion Museum. 42 pp.

Kinsky, F.C. 1962. *12th Annual report of the Banding Committee Ornithological Society of New Zealand, Inc. for the year ending 31st March 1962*. Wellington, Dominion Museum. 36 pp.

Kinsky, F.C. 1963. *13th Annual report of the New Zealand Bird Banding Scheme for the year ending 31st March 1963*. Wellington, Dominion Museum. 32 pp.

Lalas, C.; Carson, S.; Perriman, L. 2022. Continued increase in red-billed gulls (*Larus novaehollandiae scopulinus*) at Otago, southern New Zealand: implications for their conservation status and the importance of citizen science. *Notornis 69*: 81–88.

Mills, J.A. 1970. The population ecology of red-billed gulls (*Larus novaehollandiae scopulinus*) of known age. Unpubl. PhD Thesis. University of Canterbury. Christchurch.

Mills, J.A. 1972. A difference in band loss from male and female red-billed gulls *Larus novaehollandiae scopulinus. Ibis 114*: 252–255.

Mills J.A. 2013 (updated 2022). Red-billed gull | tarāpunga. In: Miskelly, C.M. (ed.) *New Zealand Birds online.* www.nzbirdsonline.org.nz.

Mills, J.A.; Yarrall, J.W.; Bradford-Grieve, J.M.; Morrissey, M.; Mills, D.A. 2018. Major changes in the red-billed gull (*Larus novaehollandiae scopulinus*) population at Kaikoura Peninsula, New Zealand; causes and consequences: a review. *Notornis 65*: 14–26.

Mills, J.A.; Yarrall, J.W.; Bradford-Grieve, J.M.; Uddstrom, M.J.; Renwick, J.A.; Merila, J. 2008. The impact of climate fluctuation on food availability and reproductive performance of the planktivorous red-billed gull *Larus novaehollandiae scopulinus*. *Journal of Animal Ecology 77*: 1129–1142.

Mills, J.A.; Yarrall, J.W.; Mills, D.A. 2020. First record of a New Zealand banded red-billed gull (*Larus novaehollandiae scopulinus*) recovered from mainland Australia. *Notornis 67*: 479–480.

Perriman, L.; Lalas, C. 2012. Recent increases in population size of red-billed gulls (*Larus novaehollandiae scopulinus*) at Otago, southern New Zealand. *Notornis 59*: 138–147.

Robertson, H.A.; Baird, K.A.; Elliott, G.P.; Hitchmough, R.A.; McArthur, N.J.; Makan, T.D.; Miskelly, C.M.; O'Donnell, C.F.J.; Sagar, P.M.; Scofield, R.P.; Taylor, G.A.; Michel, P. 2021. *Conservation status of birds in Aotearoa New Zealand, 2021.* New Zealand Threat Classification Series 36. Wellington. Department of Conservation. 43p.

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SHORT NOTE

The birds of Ducie Atoll, Pitcairn Islands, in February 2024

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In February 2024, as part of "Operation Putuputu" to support research and management in the Pitcairn Islands Marine Protected Area, we visited Ducie Atoll (for 36 hours) and Henderson Island (2 days) in the Pitcairn Islands during 13–16 February 2024. Ducie is *c*. 470 km east of Pitcairn, and is one of the most remote islands in the world; it has had only a small number of research visits (Rehder & Randall 1975). Henderson is 360 km away, and has had considerable scientific study, particularly of its birds (Fosberg *et al*. 1983; Brooke 1995a, b; Brooke & Hartley 1995; Brooke & Jones 1995; Lavers *et al*. 2016; Bond *et al*. 2019). Although scientific visits to Ducie are few, occasional visits to support the Pitcairn Islands' Marine Protected Area have occurred in recent years (Nikitine *et al*. 2018; Irving *et al*. 2019; Lincoln *et al*. 2022).

As a result, knowledge of Ducie's avifauna is sparse and mostly limited to three short visits during the 1991/92 Sir Peter Scott Commemorative Expedition to nearby Henderson Island (March 1991, June 1991, October 1991), each lasting only a few days (Brooke 1995b), a survey of Ducie itself in early 1971 (Rehder & Randall 1975), the 1935 Templeton Crocker Expedition (Chapin 1936), and the Whitney South Seas Expedition in 1922 (Murphy 1922). Only the 1971 survey was in the austral summer (January) and notes on birdlife were limited to a list of species including those recorded by previous expeditions at

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Table 1. Morphometrics of selected seabirds on Ducie Atoll in February 2024. Values are means ± SD.

Species	Age	n	Mass (g)	Wing length (mm)	Head + bill length (mm)	Culmen length (mm)
Christmas shearwater	Adult	10	315 ± 22	253 ± 5	73.7 ± 3.2	29.9 ± 1.3
Christmas shearwater	Downy chick	8	319 ± 40	181 ± 20	71.0 ± 2.5	28.5 ± 1.4
Christmas shearwater	Fledgling	15	346 ± 36	208 ± 25	71.7 ± 1.8	29.0 ± 1.9
Kermadec petrel	Adult	12	340 ± 74	272 ± 26	72.3 ± 4.6	27.7 ± 2.5
White tern	Adult	1	75	240	71.7	30.4
White tern	Fledgling	2	95.0 ± 0	227 ± 17	70.2 ± 3.9	26.8 ± 0.2

other times of the year. Observations of birds during the austral summer are therefore notably lacking, and knowledge about the general phenology and movement of the seabird species found on the Pitcairn Islands is poor. Importantly, previous research trips to Ducie (Williams 1960; Rehder & Randall 1975; Brooke 1995b) all occurred before Polynesian rats (*Rattus exulans*) were successfully eradicated in 1997 (Howald *et al*. 2007; Brooke 2019).

There are 21 bird species known from Ducie Atoll (Rehder & Randall 1975; Brooke 1995b), comprising 13 breeding species, one non-breeding visitor, two migrants, and five vagrants. We provide observations and measurements (where possible) for the non-vagrant species below, with noteworthy observations from Henderson Island and Pitcairn Island for completeness. Measurements follow Baldwin *et al*. (1931).

Kermadec petrel (*Pterodroma neglecta*) – adults were present in reasonable numbers, with aerial courtship activity peaking in the two hours before dusk. All birds were the intermediate morph (Brooke 2004). One bird was found incubating an egg, which measured 58.3 × 41.8 mm which is notably smaller than those measured in 1991, which had mean dimensions of 64.9 x 46.4 mm (Brooke 1995a). The mean measurements of 12 adults are provided in Table 1. Adult birds were also observed flying overhead on Henderson Island; however, no search for nests was undertaken, and nesting is largely restricted to the plateau. Brooke (1995a) found birds on Ducie had just begun laying in March 1991, and estimated *c*. 30,000 pairs.

Murphy's petrel (*Pterodroma ultima*) – despite Ducie being their largest breeding site with an estimated 250,000 pairs (Brooke 1995a, b), they had not yet returned from migration and were entirely absent from Ducie and Henderson Islands. They normally return to breeding sites in late March to mid-April (Brooke 1995a; Clay *et al*. 2017).

Herald petrel (*Pterodroma heraldica*) – none was seen on Ducie or Henderson or flying overhead. This includes Henderson petrel (*Pterodroma atrata*) on Henderson Island. None was noted in 1971 (Rehder & Randall 1975). They are present nearly throughout the year on Henderson Island (Brooke 1995a), though care must be taken in separating them from the very similar Henderson petrel, which we also failed to see. The Herald petrel population on Ducie was estimated to be in the tens of thousands of pairs (Brooke 1995a).

Phoenix petrel (*Pterodroma alba*) – none was seen on Ducie or flying overhead. Brooke (1995a) did not record any on Ducie in March, June, or October 1991, in contrast to the 1922 Whitney South Seas Expedition which found them in abundance in March (Murphy 1922). Brooke hypothesised that hybridisation with Herald petrels, with which they share a common cytochrome b haplotype, had resulted in their disappearance (Brooke & Rowe 1996).

Christmas shearwater (*Puffinus nativitatus*) – birds were actively breeding, largely on the seaward side of Acadia Island, one of the islands that comprises the atoll. On Ducie, they apparently have an asynchronous and subannual breeding cycle (Brooke 1995b). Adults were most active in the hour before and after sunrise (0500-0700 PST; sunrise at 06:04 PST), undertaking extensive aerial courtship flights and vocalising in singles and pairs on the colony surface. Chicks spanned a range of developmental stages from completely down-covered to nearly fledged. One breeding pair was found together at a nest site with one bird incubating an egg. The mean measurements for 33 shearwaters are provided in Table 1, grouped by age class including adults, birds that were completely down-covered, and those that had obtained most of their adult plumage (i.e., fledglings). Brooke (1995b) conservatively estimated the breeding population to be 3,000 pairs.

Red-tailed tropicbird (*Phaethon rubricauda*) – five were seen soaring above Henderson on 13 & 16 Feb 2024, and only a single bird was observed flying overhead on Ducie. Brooke (1995b) suggested that they bred throughout the year, and that there were 500–1,000 pairs on Ducie in 1991.

Masked booby (*Sula dactylatra*) – On Ducie, birds were breeding asynchronously, with breeding stages ranging from two eggs (perhaps younger birds, as they were not on an identifiable nest) to full-grown chicks. On Henderson Island, no eggs or young chicks were observed; however, a large, down-covered chick and two mature juveniles (not quite at fledging stage) were captured. There are somewhere around 80–100 pairs breeding on Ducie (Brooke 1995b).

Red-footed booby (*Sula sula*) – several birds were roosting on the island in cabbage-trees (*Heliotropum arboreum*) at night. No nests were seen, though they may have been further inland and not visible from the coast. Breeding on Ducie is quite asynchronous (Brooke 1995b).

Brown booby (*Sula leucogaster*) – a scarce visitor to the Pitcairn Islands (Bond & Lavers 2020), one juvenile was seen flying off St Paul's Rocks, Pitcairn, on the evening of 12 Feb 2024. None was seen at Henderson or Ducie.

Great frigatebird (*Fregata minor*) – as with the red-footed boobies, several juveniles and adults were seen soaring over the island and roosting overnight on Ducie. No nests were seen on Ducie; a search was not attempted on Henderson due to the inaccessibility of the colony. Brooke (1995b) estimated only 10-20 breeding pairs, but up to 80 birds present on Ducie in 1991, where they are thought to start breeding in May.

Brown noddy (*Anous stolidus*) – breeding appeared slightly more advanced than for white terns (see below), as nearly fledged and recently fledged young were seen, but no smaller chicks or eggs. Brooke (1995b) estimated 200 pairs breeding on Ducie in 1991. Some individuals were found stricken on the beach and unable to fly, with their feathers covered in a sticky substance (discussed below).

Black noddy (*Anous tenuirostris*) – none was seen on Henderson or Ducie Atoll. Brooke (1995b) observed 10 in March 1991.

Grey noddy (*Anous albivittus*) – none was seen on Henderson or Ducie Atoll. Brooke (1995b) found 15 nests on the lagoon side of Acadia Island, with highly asynchronous breeding.

White tern (*Gygis alba*) – Birds were breeding highly asynchronously, mirroring previous observations (Brooke 1995b). We located an egg, recently fledged young still being provisioned by parents, and all intermediate developmental stages. The total population was estimated to be 5,000 pairs in 1991 (Brooke 1995b).

Sooty tern (*Onychoprion fuscatus*) – none was seen on Henderson or Ducie Atoll. Brooke (1995b) located five nests on the west end of Acadia Island in late July 1991, which was the start of the breeding season as chicks were present in October 1991.

Wandering tattler (*Tringa incana*) – none was seen on Henderson or Ducie Atoll, though it is a regular migrant through the Pitcairn Islands (Williams 1960; Brooke 1995b).

Bristle-thighed curlew (*Numenius tahitiensis*) – Five individuals were seen on East Beach, Henderson Island on 13 Feb 2024, and three at North Beach, Henderson Island on 16 February. None was seen on Ducie Atoll. (Brooke 1995b) saw one bird on Ducie in March 1991.

Evidence of *Boerhavia tetranda*

Anecdotal reports from the last 15 years had suggested many seabirds, primarily Murphy's petrels, may be rendered flightless and perish because of sticky seeds of *Boerhavia tetranda* (a creeping prostrate herb in the family Nyctaginaceae) becoming adhered to their feathers. *Boerhavia* causes avian mortality elsewhere (Wilder 2019), and on Tromelin Island in the Indian Ocean, its distribution on the island increased markedly following the eradication of introduced rats (Le Corre *et al*. 2015), which were also removed from Ducie in 1997 (Howald *et al*. 2007).

While we observed many dead seabirds on the beaches of Acadia Island in February 2024 (Fig. 1), no *Boerhavia* plants or seeds were seen anywhere on the island; the cause of death appeared to be related to an unknown sticky substance which coated the feathers of some birds (Fig. 1). Large numbers of dead birds had been remarked on previously in 1971 (Rehder & Randall 1975), but it was not noted during the Whitney South Seas Expedition in 1922 (Murphy & Pennoyer 1952). No examples of

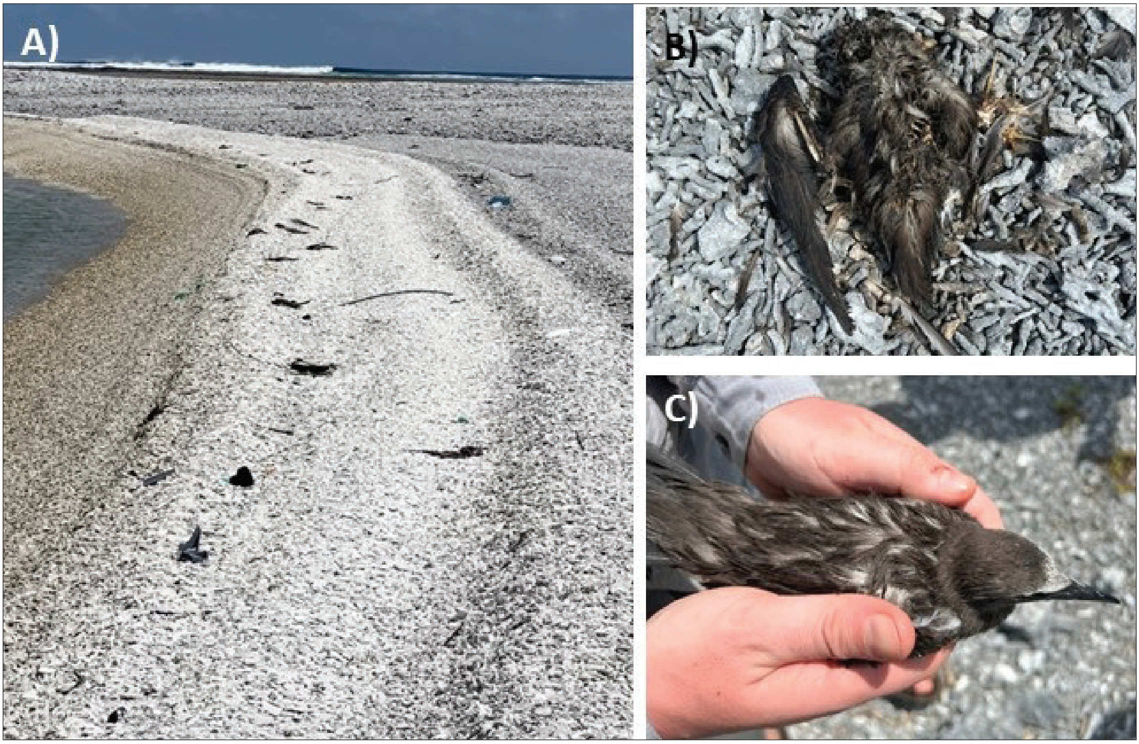

Figure 1. Seabirds (primarily petrels and noddies) along the southern, lagoon-facing beach of Acadia Island, Ducie Atoll in February 2024. Some birds were observed still alive but weak and unable to fly (panel C), their back feathers appeared to be covered in an unknown oily substance. Contrary to earlier reports, there was no evidence of *Boerhavia tetranda* growing on the island, and no sticky seeds were observed on any of the birds or on the island.

Boerhavia have been recorded on botanical surveys of Ducie up to and including 1991/92 (Fosberg *et al*. 1989; Florence *et al*. 1995), though it is present on Henderson Island (Paulay & Spencer 1989). Fosberg *et al*. (1989) listed only one plant species from Ducie, (*Heliotropum arboreum*) and suggested that storms had removed two previously recorded herbaceous species at some point in the 20th century. The cause of mortality observed in 1971 and 2024 is unknown and should be investigated on future visits.

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LITERATURE CITED

Baldwin, S.P.; Oberholder, H.C.; Worley, L.G. 1931. Measurements of birds. *Scientific Publications of the Cleveland Museum of Natural History 2*: 1–165.

Bond, A.L.; Brooke, M. de L.; Cuthbert, R.J.; Lavers, J.L.; McClelland, G.T.W.; Churchyard, T.; Donaldson, A.H.; Duffield, N.D.; Forrest, A.K.; Harrison, G.; MacKinnon, L.; Proud, T.; Skinner, A.; Torr, N.; Vickery, J.A.; Oppel, S. 2019. Population status of four endemic landbird species after an unsuccessful rodent eradication on Henderson Island. *Bird Conservation International 29*: 124–135.

Bond, A.L.; Lavers, J.L. 2020. Records of brown booby *Sula leucogaster* in the Pitcairn Islands with additional observations during 2015–19. *Bulletin of the British Ornithologists' Club 140*: 99–102.

Brooke, M. 2004. *Albatrosses and petrels across the world*. New York, Oxford University Press.

Brooke, M. de L. 1995a. The breeding biology of the gadfly petrels *Pterodroma* spp. of the Pitcairn Islands: characteristics, population sizes and controls. *Biological Journal of the Linnean Society 56*: 213–231.

Brooke, M. de L. 1995b. The modern avifauna of the Pitcairn Islands. *Biological Journal of the Linnean Society 56*: 199–212.

Brooke, M. de L. 2019. Rat eradication in the Pitcairn Islands, South Pacific: a 25-year perspective. Pp 95–99 *In:* Veitch, C.R.; Clout, M.N.; Martin, A.R.; Russell, J.C.; West, C.J. (eds) *Island invasives: scaling up to meet the challenge*. Gland, Switzerland, IUCN.

Brooke, M. de L.; Hartley, I.R. 1995. Nesting Henderson reed-warblers (*Acrocephalus vaughani taiti*) studied by DNA fingerprinting: unrelated coalitions in a stable habitat? *Auk 112*: 77–86.

Brooke, M. de L.; Jones, P.J. 1995. The diet of the Henderson fruit-dove *Ptilinopus insularis*. I. Field observations of fruit choice. *Biological Journal of the Linnean Society 56*: 149–165.

Brooke, M. de L.; Rowe, G. 1996. Behavioural and molecular evidence for specific status of light and dark morphs of the Herald petrel *Pterodroma heraldica*. *Ibis 138*: 420–432.

Chapin, J.P. 1936. Through southern Polynesia. *Natural History 37*: 287–308.

Clay, T.A.; Phillips, R.A.; Manica, A.; Jackson, H.A.; Brooke, M de L. 2017. Escaping the oligotrophic gyre? The year-round movements, foraging behaviour and habitat preferences of Murphy's petrels. *Marine Ecology Progress Series 579*: 139–155.

Florence, J.; Waldren, S.; Chepstow-Lusty, A.J. 1995. The flora of the Pitcairn Islands: a review. *Biological Journal of the Linnean Society 56*: 79–119.

Fosberg, F.R.; Paulay, G.; Spencer, T.; Oliver, R. 1989. New collections and notes on the plants of Henderson, Pitcairn, Oeno, and Ducie Islands. *Atoll Research Bulletin 329*: 1–18.

Fosberg, F.R.; Sachet, M.-H.; Stoddart, D.R. 1983. Henderson Island (southeastern Polynesia): summary of current knowledge. *Atoll Research Bulletin 272*: 1–47.

Howald, G.R.; Donlan, C.J.; Galván, J.P.; Russell, J.C.; Parkes, J.; Samaniego, A.; Wang, Y.; Veitch, D.; Genovesi, P.; Pascal, M.; Saunders, A.; Tershy, B. 2007. Invasive rodent eradication on islands. *Conservation Biology 21*: 1258–1268.

Irving, R.A.; Dawson, T.P.; Christian, M. 2019. Chapter 34 - The Pitcairn Islands. Pp 743–764 *In:* Sheppard, C. (ed.) *World seas: an environmental evaluation*. 2nd edn. Academic Press.

Lavers, J.L.; McClelland, G.T.W.; MacKinnon, L.; Bond, A.L.; Oppel, S.; Donaldson, A.H.; Duffield, N.D.; Forrest, A.K.; Havery, S.J.; O'Keefe, S.; Skinner, A.; Torr, N.; Warren, P. 2016. Henderson Island expedition report: May–November 2015. *RSPB Research Report 57*. Sandy, UK, RSPB Centre for Conservation Science.

Le Corre, M.; Danckwerts, D.K.; Ringler, D.; Bastien, M.; Orlowski, S.; Morey Rubio, C.; Pinaud, D.; Micol, T. 2015. Seabird recovery and vegetation dynamics after Norway rat eradication at Tromelin Island, western Indian Ocean. *Biological Conservation 185*: 85–94.

Lincoln, S.; Cowburn, B.; Howes, E.L.; Birchenough, S.; Pinnegar, J.K.; Dye, S.; Buckley, P.; Sheppard, C.; Wabnitz, C.C.C.; Dutra, L.X.C.; Graham, J.; Archer-Rand, S.; Hardman, E.; Engelhard, G.H.; Townhill, B.L. 2022. Climate change impacts on the coral reefs of the UK Overseas Territory of the Pitcairn Islands: resilience and adaptation considerations. *Journal of the Marine Biological Association of the United Kingdom 102*: 535–549.

Murphy, R.C. 1922. The Whitney South Sea Expedition of the American Museum of Natural History. *Science 56*: 701–704.

Murphy, R. C.; Pennoyer, J.M. 1952. Larger petrels of the genus *Pterodroma*. *American Museum Novitates 1580*: 1–43.

Nikitine, J.; Wilson, A.M.W.; Dawson, T.P. 2018. Developing a framework for the efficient design and management of large scale marine protected areas. *Marine Policy 94:* 196–203.

Paulay, G.; Spencer, T. 1989. Vegetation of Henderson Island. *Atoll Research Bulletin 328*: 1–20.

Rehder, H.A.; Randall, J.E. 1975. Ducie Atoll: its history, physiography, and biota. *Atoll Research Bulletin 183*: 1–40.

Wilder, J.A. 2019. A true "migrant trap": *Boerhavia* (Nyctaginaceae) entanglement as a recurring cause of avian entrapment and mortality. *Wilson Journal of Ornithology 131*: 658–663.

Williams, G.R. 1960. The birds of the Pitcairn Islands, central South Pacific Ocean. *Ibis 102*: 58–70.

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BOOK REVIEW

Ahuahu: A Conservation Journey in Aotearoa New Zealand

David Towns

Canterbury University Press, 2023, 384 pp, softback 280 x 210 mm. ISBN: 978-1-98-850326-4

Those lucky enough to have set foot on a remote, predator-free island have experienced the indigenous wildlife of Aotearoa New Zealand in a state close to how it was meant to be. Those living in Aotearoa today have only experienced a diminished, depauperate version of the landscape, which has been irreversibly modified by humans and the non-native species they brought to this land. David Town's *Ahuahu: a conservation journey in Aotearoa New Zealand* provides a vivid and informative window into the field of island restoration, as a means of repairing and recreating, in as far as possible, the unique ecosystems that once thrived across Aotearoa New Zealand.

David Towns is a conservationist and educator who has been at the forefront of the island restoration movement in Aotearoa New Zealand for the past 40 years. This book is a personal memoir detailing the triumphs, challenges, and lessons learned throughout his career. The narrative centres on the Mercury Islands archipelago, located 8 km off the northeastern coast of the Coromandel Peninsula of Te Ika-a-Māui (the North Island). The story of Ahuahu, or Great Mercury Island, serves as an insightful case study of island restoration projects in Aotearoa New Zealand, particularly regarding the battle against invasive mammalian pests. However, the book's scope is broader than the title suggests. While Ahuahu and the other Mercury Islands provide a narrative focal point, they serve to introduce the wider role of offshore islands in the story of species conservation in Aotearoa. The breadth of material covered includes topics one might encounter at a university-level introduction to conservation biology – island ecology and biogeography, invasion biology, restoration ecology, conservation genetics, and the wide-ranging impacts of human presence in island ecosystems. Beyond the expected ecological themes, the latter chapters explore themes of conservation ethics and sociocultural approaches to environmental management.

The early chapters set the scene by providing a broad historical account of key events in Aotearoa's geological, evolutionary, and ecological history – leading up to the catastrophic human-led introductions of non-native species with the arrival of the first Polynesian peoples. While establishing the rationale for conservation efforts, these chapters provide fascinating insight into the island biodiversity of Aotearoa – including the ecological role of seabirds, reptiles and large invertebrates in island ecosystems. While these topics have been discussed elsewhere (e.g. Markwell 1999; Bellingham *et al*. 2010), the interwoven narrative of firsthand involvement gives a unique and personal perspective on the subject matter.

The book goes on to recount the technological and logistical challenges over the 25 years leading up to Ahuahu being declared pest-free in 2016. The developments in techniques and technologies for ground and aerial methods to control invasive mammals exemplify what established Aotearoa New Zealand as a world leader in pest eradication on islands. Towns discusses the methods and tools for monitoring the effectiveness of such efforts, and the governance and organisational processes required for success. This provides an inspiring example of scientific problem solving – adapting to the various challenges of pest control operations on islands of different sizes and landscapes, pest profiles and stages of ecological degradation. Comparing Ahuahu with other case studies, such as Raoul Island in the Kermadec archipelago and Korapuki, one of the smaller islands in the Mercury archipelago, sheds light on some key factors that influence the fate of island restoration projects – oceanic versus continental islands, complexity of biological communities, stage of recolonisation, and legacy effects of previous management. Also discussed are the technological advancements in the field of conservation genetics, which have aided our understanding of managing small populations, improving systematics, species identification and the ability to apply a forensic lens to invasion biology. The implications for a few key species, including kākāpō (*Strigops habroptilus)*, kakaruia or Chatham Islands black robin (*Petroica traversi*) and tuatara (*Sphenodon punctatus*), are outlined.

The final third of the book switches focus from the scientific aspects of conservation to the sociocultural aspects. It also tackles the cultural and ethical issues – including the controversy surrounding the kiore or Polynesian rat (*Rattus exulans*) being considered sacred to some iwi (indigenous tribes). The complexities of involving communities in decision-making and understanding their motives and values to remove impediments to conservation action are key themes. All this is framed within the context of Te Tiriti o Waitangi – The Treaty of Waitangi, and its relevance to the use and protection of natural resources in Aotearoa, and our evolving understanding of how it should be interpreted and applied.

As a former senior scientist for the Department of Conservation and a key figure in pest eradication projects, Towns' scientific background brings a wealth of knowledge to the subject matter. Much has changed over the 40 years covered by the author's experience. As such, the timeline provides a fascinating historical account of the development of ideas in conservation biology, which was but a fledgling discipline when the author took his first steps on Ahuahu.

The book is distinctly Aotearoa-focussed, allowing the author to explore the intricacies and nuance of sociocultural issues in this country. While some connections with international examples are provided, placing island restoration in Aotearoa within the broader academic discourse, as in Craig *et al*. (2000) or Towns *et al*. (2019), is not the key intention of the book. In my opinion, a key triumph of this book is how the author has integrated and acknowledged the importance of indigenous knowledge and values. The contribution of Māori to conservation in Aotearoa is emphasised throughout, and values such as kaitiakitanga (guardianship) and rangatiratanga (Māori self-determination, autonomy over culture, community and resources; also see Palmer *et al*. 2020) are woven throughout the narrative. This important sociocultural aspect of island conservation has not always been properly acknowledged in the academic literature or has failed to empower or embody indigenous aspirations fully (Roberts *et al*. 1995). The tone of *Ahuahu* aligns with the growing emphasis on biculturalism and more holistic approaches to environmental management in New Zealand – integrating Mātauranga Māori (Māori knowledge) and tikanga (customs) to ensure cultural values align with ecological priorities.

Some readers might find the element of personal reflection detracts from the scientific focus, but I considered this a highlight of the book. Well-informed and well-referenced assertions, supported by data and fieldwork throughout, provide scholarly rigour, blended with historical interest and cultural context. And a dose of whimsy is thrown in for good measure, in the form of quaint historical excerpts and poetic quotes. The first-hand narrative style provides a storytelling quality and exudes a sense of deep personal connection to the Mercury Islands, making this a more engaging read than an impersonal, purely academic text.

The structure and layout of the book, and the clear and evocative way that information is presented, shows that a skilled and passionate educator has written this book. Visually, the book is excellent, with high-quality images and figures throughout that complement the text and further engage the reader with the subject matter. These include stunning photographs of native wildlife, annotated maps showing the locations of islands and ecosanctuaries throughout Aotearoa, graphs or tables summarising scientific content, charming historical artworks, and models or diagrams explaining concepts. Furthermore, using callout boxes to clarify concepts ensures the text can go into biological and scientific depth, yet it remains accessible to readers who are unfamiliar with the technical concepts (e.g. stable isotope analysis, social network analysis, etc.) Given the usefulness of these callout boxes and the various tables and figures, a table of contents listing these would have aided the utility as a reference text, as I found myself searching for bits of information that I had previously read and wanted to revisit.

Minor editorial quibbles aside, this book is written in a style that will delight a wide-ranging audience, from impassioned amateur naturalists to seasoned professionals seeking a general overview or fresh perspective on island restoration. For students or newcomers to the field of ecology, conservation and related disciplines, this book provides a treasure trove of concepts, tools, and references, without being impenetrably jargony or technical. It will connect you with the subject much more intimately than a more academic text would, providing a more holistic overview of island restoration in Aotearoa. The *conservation journey* alluded to in the title, is a fitting description – I appreciated that it was not simply a reporting of the findings, but the description of the fieldwork and the author's personal involvement in it, with all pitfalls encountered along the way. Despite the grim realities of past ecological devastation, the book's tone remains optimistic. This optimism extends to the immense task of reversing ecological ills but also in the convergence of Māori and Western views to chart the course of conservation action going forward.

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LITERATURE CITED

Bellingham, P.J.; Towns, D.R.; Cameron, E.K.; Davis, J.J.; Wardle, D.A.; Wilmshurst, J.M.; Mulder, C.P. 2010. New Zealand island restoration: seabirds, predators, and the importance of history. *New Zealand Journal of Ecology 34*: 115–136.

Craig, J.; Anderson, S.; Clout, M.; Creese, B.; Mitchell, N.; Ogden, J.; Roberts, M.; Ussher, G. 2000. Conservation issues in New Zealand. *Annual Review of Ecology and Systematics 31*: 61–78.

Markwell, T.J. 1999. Keystone species on New Zealand offshore islands: ecological relationships of seabirds, rats, reptiles and invertebrates on Cook Strait islands. PhD thesis. Victoria University of Wellington.

Palmer, S.; Mercier, O.R.; King-Hunt, A. 2020. Towards rangatiratanga in pest management? Māori perspectives and frameworks on novel biotechnologies in conservation. *Pacific Conservation Biology 27*: 391–401.

Roberts, M.; Norman, W.; Minhinnick, N.; Wihongi, D.; Kirkwood, C. 1995. Kaitiakitanga: Māori perspectives on conservation. *Pacific Conservation Biology 2*: 7–20.

Towns, D.R.; Daugherty, C.H.; Broome, K.; Timmins, S.; Clout, M. 2019. The thirty-year conservation revolution in New Zealand: an introduction. *Journal of the Royal Society of New Zealand 49*: 243–258.

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