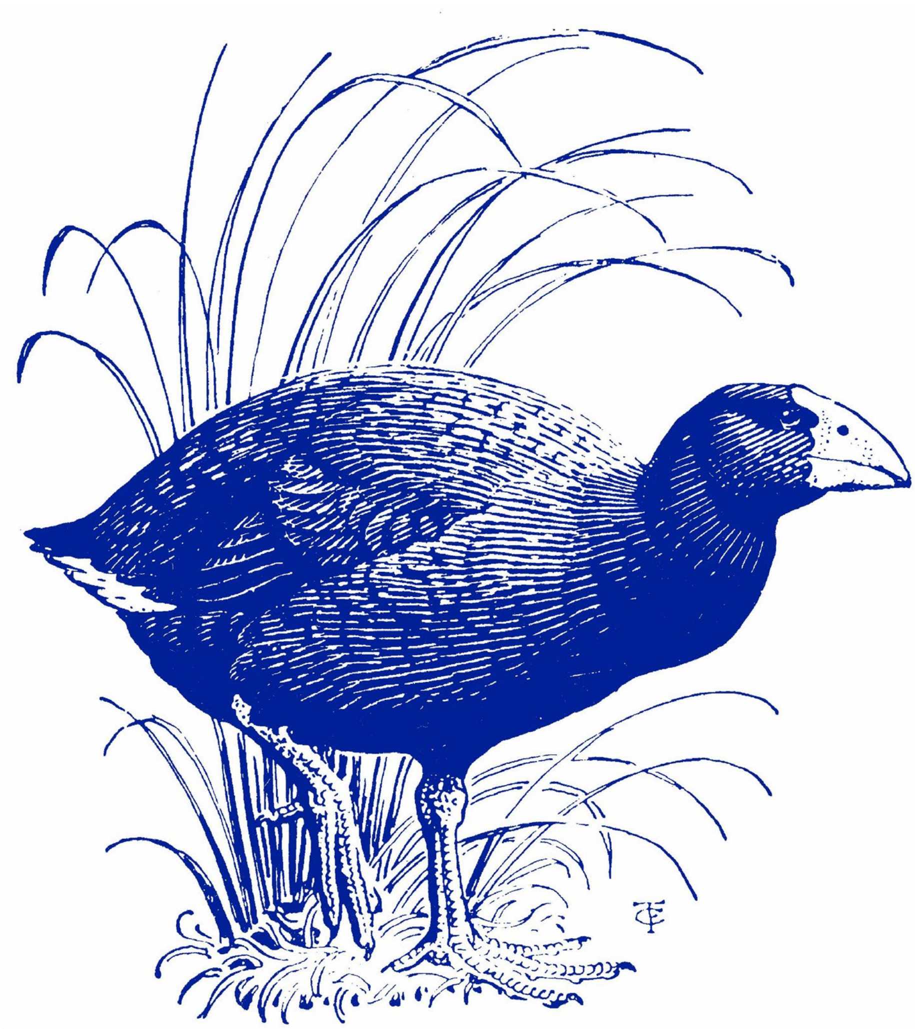
NOTORNIS

Ornithology of the Southern Pacific



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NOTORNIS

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Aspects of the biology and ecology of variable oystercatchers (*Haematopus unicolor*) on the east coast of North Auckland, New Zealand

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Abstract: Many aspects of the ecology of the endemic variable oystercatcher (*Haematopus unicolor*) have not been studied in detail. We colour-banded and monitored a population of the species in a study area between 36°S and 37°S on the east coast of the North Island, New Zealand. Monitoring was intensive during the breeding season from 1994/95 to 1998/99, during which time we gathered information on timing of breeding, chick growth, and productivity. We also recorded measurements of adult birds and eggs. Laying of first clutches was protracted and extended from early September to mid-December. Chicks fledged at lower weights than adults and with shorter total head length and wing, but with tarsus and mid-toe within the adult range. Productivity at four core breeding sites within our study area averaged 0.42 chicks fledged per pair per year. Juveniles commonly remained with their parents on their natal territory during their first winter. From 1999, monitoring was less intensive as we continued collecting data on dispersal, age at first breeding, survival, and pair-bond retention. Natal dispersal values ranged from 0–109 km, with most birds breeding within 60 km of their natal site. As with many oystercatcher species, maturity is delayed, and birds in our study area first bred at between 4 and 8 years of age. There was a high level of mate-fidelity, with one pair-bond lasting 16 consecutive years, but divorce was not uncommon. Once established on a territory, adults were highly sedentary. Annual survival rates of adults and pre-breeders were very high, and the local population had the capacity to grow by about 5% per year. Birds breeding at low-lying sites often lost nests to flooding, and this threat is almost certain to be exacerbated by ongoing climate change.

Dowding, J.E.; Chamberlin, S.P. 2025. Aspects of the biology and ecology of variable oystercatchers (*Haematopus unicolor*) on the east coast of North Auckland, New Zealand. *Notornis 72(1)*: 1–13. (https://doi.org/10.63172/018611hhprfu).

Keywords: variable oystercatcher, *Haematopus unicolor*, adult survival, chick growth, natal dispersal, age at first breeding, productivity, pair-bonds

INTRODUCTION

The oystercatchers comprise a cosmopolitan genus (*Haematopus*) of shorebirds found on all continents except Antarctica (Heppleston 1973). Currently, 11 extant species are recognised by most authorities (Clements *et al*. 2023; Gill *et al*. 2023).

The variable oystercatcher (*H. unicolor*, VOC) is one of three oystercatchers endemic to New Zealand. It is found around much of the coastline of the mainland and its off-shore islands, but is sparsely distributed in some regions and is absent from the outlying island groups (Robertson *et al*. 2007). The east coast of the northern North Island has long been recognised as a major stronghold—there are significant numbers of pairs or individuals present in or near most of the larger east coast estuaries in Northland, Auckland, Coromandel Peninsula, and the Bay of Plenty during both the breeding and non-breeding seasons (Baker 1973a; Sagar *et al*. 1999; Dowding & Moore 2006).

All other oystercatcher species are either pied or all black, while the VOC is polymorphic, with plumage ranging from pied through a series of intermediate ('smudgy') plumages to all black (Dowding 2014). In the past, this caused confusion and resulted in a variety of taxonomic treatments, including the suggestion that intermediate birds were hybrids between pied and black species or subspecies (Oliver 1955). In some treatments, northern birds (pied, intermediate, and black) were named *reischeki*, and the all-black southern birds *unicolor*, treated either as full species (Falla 1939) or as subspecies (Baker 1972;

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Heppleston 1973). Since the third edition of the *Checklist of the birds of New Zealand*, all plumage phases of *reischeki*-type birds and *unicolor*-type birds have been included in the single monotypic species *H. unicolor* (Checklist Committee 1990). The plumage phases all inter-breed freely and non-assortatively (Baker 1973b).

The VOC population reached low numbers in the early 20th century, probably in part as a result of birds being shot for food (Baker 1973a; Heather & Robertson 1996). Numbers have increased substantially since the species was afforded legal protection in 1906 (Dowding & Murphy 2001; Miskelly 2014). Some of the possible reasons for the increase were discussed by Dowding (2014). The species is currently classified as 'At Risk (Recovering)' under the New Zealand threat-ranking scheme (Robertson *et al*. 2021) and as 'Least Concern' by BirdLife International (2024). A comparison of national shorebird counts from the period 1983–1994 with counts from the period 2005–2019 suggests that the population continues to grow (Riegen & Sagar 2020). There have been no robust estimates of population size recently; however, projecting from previous estimates and taking into account the rate of increase revealed by the national counts (Riegen & Sagar 2020), there were probably about 6000–7000 individuals in the population in 2024.

The main threats to the species include predation by mammalian and avian predators, loss of nests and small chicks to big tides and storm surges, and disturbance (including crushing of nests) caused by a range of human activities in the coastal zone. The relative importance of these threats is unclear, and probably varies by location (Dowding 2014).

In the late 1960s and early 1970s, Allan Baker gathered information on some aspects of the biology and ecology of VOCs, particularly plumage changes, morphometrics and sexing, the basic features of the breeding cycle, and some aspects of behaviour (Baker 1969, 1972, 1973a, b, 1974a, b). However, his study was predominantly a comparative exercise, aimed at clarifying the systematic status of all New Zealand oystercatchers. It did not focus exclusively on VOCs (and he treated *reischeki* and *unicolor* as separate taxa), and other aspects of their biology have remained largely unstudied (Dowding 2014). Recent studies, all in the South Island, have involved colour-banding or flagging projects in the Dunedin area (Schweigman 2002), at Kaikoura (Rowe 2008, 2011, 2019), and in the Nelson area (Cook *et al*. 2007; Melville *et al*. 2020).

From 1993–2000, we marked birds with individual colour-band combinations in a study area on the North Auckland east coast and monitored them to fill some of the gaps in our knowledge of the species. In this paper we report on measurements of birds and eggs in our study area, timing of breeding, chick growth, productivity, dispersal, age at first breeding, and survival rates. We also comment briefly on current and future threats to the species.

STUDY AREA & METHODS

Study area

The greater study area extended along the North Auckland east coast from Whangarei Harbour in the north to Waitemata Harbour, Auckland, in the south (Figure 1). Within that area, birds were banded, and monitoring was most intensive, at four core sites between 36°S and 37°S at which breeding was known to occur regularly.

The Pakiri River site (36°15'S, 174°44'E) has a low-lying sand-flat around the river mouth, backed by an extensive dune system with varying densities of vegetation, predominantly marram grass (*Ammophila arenaria*). During the period of intensive monitoring (1994/95 to 1998/99), there were usually 6–8 pairs of VOCs nesting at the site. There is a campground immediately behind the nesting area, which resulted in high levels of disturbance from people, dogs, horses, and quad bikes, particularly from late December to early February.

Omaha Spit (36°20'S, 174°47'E) forms a barrier at the entrance to Whangateau Harbour. The northern part of the spit consists of sand and shell and is stabilised by rock groynes. Low netting fences have been installed to trap sand and reduce erosion. Nearly all VOCs at this site nested on the distal section of the spit, within 700 m of the northern tip. Nesting occurred on the open beach and among the low, partly-vegetated dunes formed by the fences. During the period of intensive monitoring, 7–12 pairs nested on the spit at Omaha. Throughout the study, there was a high-water flock of juveniles and sub-adults at Omaha, typically numbering 20-40 birds. The spit is adjacent to a large inter-tidal area used for feeding by VOCs and a range of other shorebird species. Disturbance levels in the breeding area were moderately high, particularly in summer, due to the presence of a growing subdivision further south on the spit, and from recreational beach-users from further afield.

Tawharanui Regional Park (centred at 36°22'S, 174°50'E) includes a number of sandy beaches and small bays separated by stretches of rocky coastline and cliffs. Oystercatchers bred in a range of habitats; many used sandy beaches and the dunes behind them, others nested on gravel beaches or on grassy paddocks immediately behind beaches. During the period of intensive monitoring, 6–7 pairs of VOCs bred at Tawharanui.

At Wade River mouth (36°39'S, 174°44'E), VOCs nested on a low-lying chenier spit of shell and sand adjacent to a large inter-tidal area used for feeding. Initially, the spit had no vegetation and was isolated from the mainland at high water; as the study progressed, however, there was accretion of sand and gradual encroachment by mangroves (*Avicennia marina*), and the spit became attached to the mainland and progressively vegetated. During the period of intensive monitoring, 3 pairs of VOCs nested on the spit.

At the beginning of our study, all four sites were unmanaged; however, in the 1997/98 season, predator control, signage, fencing of nesting areas, and advocacy began at Omaha Spit. After most of our data had been collected, management was also instituted at Pakiri River (from 2003) and at Tawharanui (from 2004).

Methods

Juveniles and breeding adults were caught on noose-mats and unfledged chicks were caught by hand. Birds were individually colour-banded with a numbered metal band on the left tarsus, and three double wrap-around Darvic colour bands on the right tarsus. In some cases, smaller chicks were given metal bands only, and colour-bands were added later when the tarsus could accommodate three colour bands.

Monitoring was intensive from 1994/95 to 1998/99, while we collected data on clutch initiation and productivity, with the four core breeding sites normally visited at intervals of 2–5 days from late August to February. From 1999/00, visits were made at intervals of 2–4 weeks to continue collecting information on pair-bonds, survival, and dispersal. Data on chick growth were collected opportunistically throughout the study. Sightings and other observations were also provided by shorebird wardens at Omaha Spit, members of the Omaha Shorebird Protection Trust, staff and volunteers at Tawharanui Regional Park, Department of Conservation staff, and volunteer members of the Ornithological Society of New Zealand's (OSNZ) Northland, Auckland, and South Auckland branches.

All adults, eggs, and chicks measured were located between 36°S and 37°S. We measured total head length (tip of the bill to the back of the head, THL), bill length (exposed culmen), tarsus, and mid-toe & claw (MTC) with

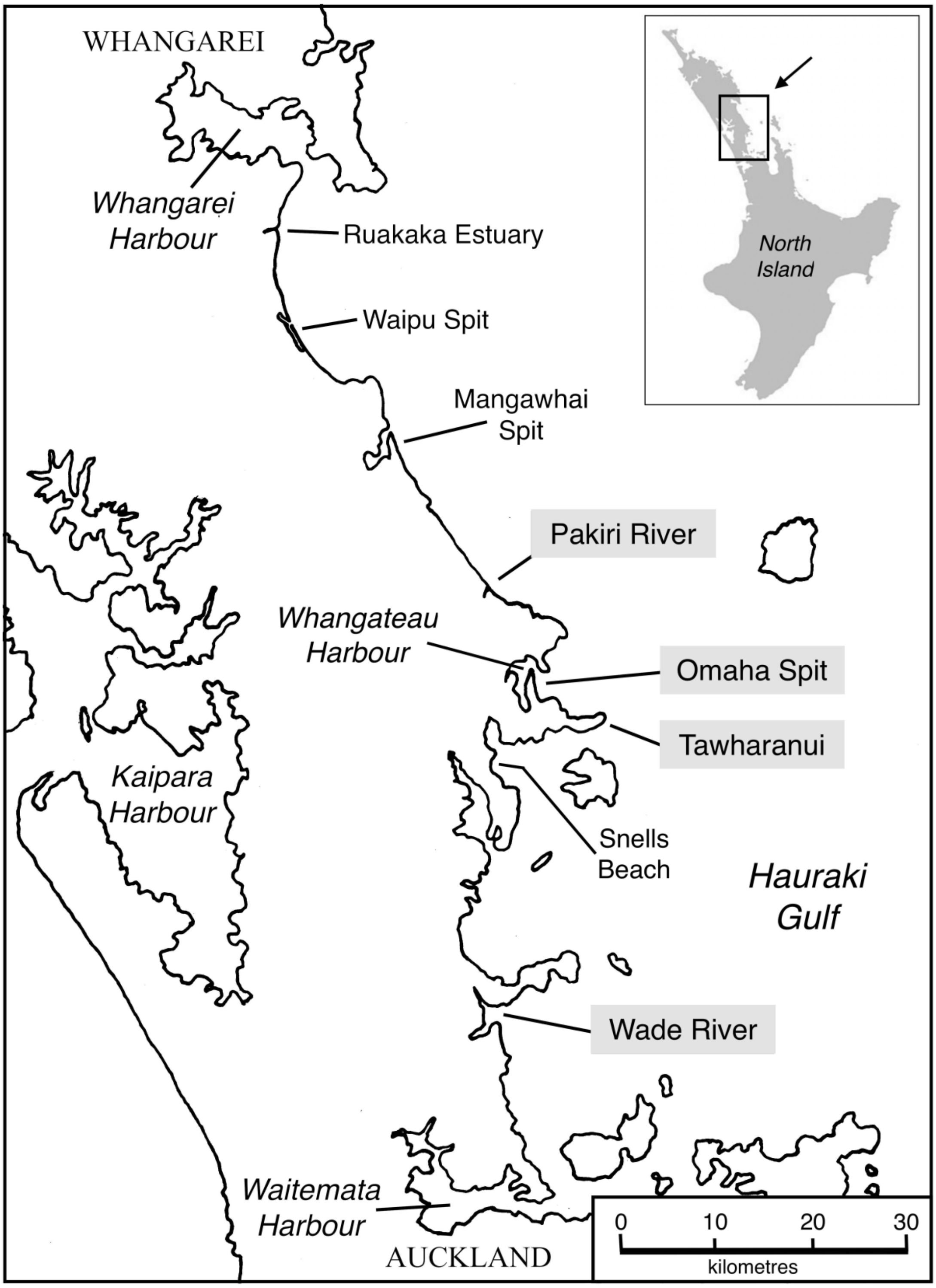

Figure 1. Map of the North Auckland study area showing the four core sites (highlighted) at which variable oystercatchers were banded, and other locations mentioned in the text.

Vernier calipers to the nearest 0.1 mm. Tail length was measured to the nearest 1 mm with calipers, and wing (flattened and straightened) to the nearest 1 mm with a wing ruler. Wing and tail measurements were excluded if the outer primaries or central rectrices respectively were in active moult. Weights of adults were recorded to the nearest 5 g using Pesola scales, and weights of chicks to the nearest 1, 2, or 5 g, depending on age. Weights of adults with incomplete clutches (i.e., birds that could have been gravid) were excluded. To reduce handling time, either during hot weather or when nests or chicks were present, not all measurements were taken from all birds handled. Chicks were only measured when their exact hatch date was known. Maximum length and width of eggs were measured to the nearest 0.1 mm with Vernier calipers. To calculate egg volume, we used the method of Hoyt (1979) and a volume coefficient (Kv) of 0.500, the value calculated for eggs of the Eurasian oystercatcher (*H. ostralegus*) by Jager *et al*. (2000).

At Pakiri River and Omaha Spit, pairs often nested close to each other and families could sometimes be difficult to identify with certainty. Pairs used to measure productivity therefore always had at least one bird individually colour-banded ('marked pairs'), and usually both ('banded pairs'). Determining whether chicks had fledged was made easier by the fact that VOC fledglings commonly remain with their parents for weeks or even months after fledging (see Results). In a few cases, where there was doubt about whether a large chick had fledged, the record was omitted. Productivity is therefore defined as the minimum number of chicks fledged per pair per year (CFP).

Definitions of dispersal were those of Greenwood & Harvey (1982). *Natal dispersal* is movement from the natal site to the site of first reproduction, and the subsequent movement of birds between breeding sites is termed *breeding dispersal*. *Effective dispersal* refers to either natal or breeding dispersal that is followed by successful reproduction. All dispersal values were straight-line distances measured to the nearest 1 km on Google Earth Pro. Because dispersal distributions of birds are usually highly skewed towards the origin, medians are a more useful measure of typical distances than means (Greenwood & Harvey 1982), and both are given. There were a number of occasions when birds dispersed to a site but it was not certain they had bred there before they disappeared; those records were omitted.

Occasionally, it was not clear whether an individual was breeding or not (e.g., in some cases eggs could have been laid and lost between visits). Birds were therefore only included in the analysis of age at first breeding if (a) it was certain they were breeding (eggs or chicks were seen), and (b) if we knew their location in recent breeding seasons and knew they had not bred then. These constraints reduced our sample size but resulted in a more accurate estimate of age at first breeding.

Annual survival was determined as Minimum Number Alive by recording the presence or absence of colour-banded individuals in autumn (February to April) each year. In addition to monitoring at the four core sites, dedicated searches were undertaken at other known shorebird breeding and flocking sites between Whangarei and Auckland (including Ruakaka estuary, Waipu Spit, and Mangawhai Spit) between February and April each year. Other observers contributed sightings at other times of year and from outside the greater study area. Adult survival data were collected over a 12-year period from 1994–2005 inclusive. Average adult life-expectancy in years was calculated from annual mortality (m) using the formula (2-m)/2m (Lack 1954). Generation time and the intrinsic capacity for increase (r) of the population in our study area were calculated using the Lotka equation (Krebs 1994). The finite rate of increase/decrease (a measure of potential annual change in the population size) $\lambda = e^r$ (Krebs 1994).

Table 1. Morphometrics of breeding adult variable oystercatchers (sexes combined) in the North Auckland study area. All measurements except weight are in mm. *sd* = standard deviation of the mean, CV = Coefficient of Variation, n = sample size.

Measurement	Mean	*sd*	CV	Range	n
Bill length	86.3	6.4	7.36	72.7–99.6	98
Total head length	134.4	6.6	4.91	120.6–149.5	99
Tarsus length	60.0	1.9	3.12	54.4–63.7	86
Mid-toe & claw	49.4	1.8	3.56	46.0–53.1	51
Wing	282.3	7.2	2.56	268–305	47
Tail	103.9	3.7	3.58	99–113	18
Weight (g)	724.7	53.6	7.39	598–820	56

RESULTS

Morphometrics

Measurements of known adult birds (sexes combined) are shown in Table 1. We attempted to sex birds using the discriminant function derived by Baker (1974a) but were unsuccessful (see Discussion).

Measurements were made of 98 typical eggs and 2 abnormally small ('runt') eggs. Lengths of normal eggs averaged 59.9 mm (*sd* = 2.7, range = 54.0–65.6) and width averaged 40.4 mm (*sd* = 1.1, range = 37.5–42.6). The Coefficient of Variation (CV) was 4.5% for length and 2.7% for width. Elongation (length/width) averaged 1.49 (*sd* = 0.08, range = 1.31–1.67), and calculated volume averaged 48.8 ml (*sd* = 3.30, range = 39.2–56.6).

The two runt eggs were both chalky white with a very few small dark brown specks. They were from the same pair at Pakiri River in 1995; one was found on 10 November (later trampled by horses) and one was found in a different nest on 05 December. The second egg was found recently broken in the nest on 21 December and contained no yolk. Neither nest contained any normal eggs. Measurements of the runt eggs were 30.5 x 23.0 and 31.9 x 23.7 mm; the calculated volumes of these eggs were 16.5% and 18.4% respectively of the average volume of a normal egg. Both eggs were seen to be incubated, and the pair performed vigorous distraction displays when the nests were approached. The pair involved laid a clutch of normal eggs in the following breeding season.

Timing of breeding

Initiation dates of first clutches from the four breeding seasons 1994/95 – 1997/98 combined are shown in Figure 2, grouped into 7-day intervals. Of 74 known first clutches of banded or marked pairs, one (1.4%) was initiated in September, 26 (35.1%) in October, 38 (51.4%) in November, and 9 (12.2%) in December. All clutches found after 16 December laid by banded birds were replacement clutches. The 74 first clutches were from all four of our core sites (Pakiri River n = 20, Omaha Spit n = 31, Tawharanui n = 12, and Wade River n = 11). The median week of first-clutch initiation was week 7 (22–28 October) in 1994, 1995, and 1996. In 1997, the median was week 4.5 (04-11 October). This difference was significant (Mann-Whitney 2-tailed, $z = 3.327$, $P = 0.00087$).

Later observations in our study area revealed other clutches initiated in September. During the Department of Conservation's management programme for fairy terns (*Sternula nereis davisae*) at Pakiri River, a VOC nest was found on or about 07 September 2007, a full clutch of 3 eggs was laid between 05 and 12 September 2008, a 1-egg nest was found on 13 September 2008, two nests had hatched by 16 October 2009 (suggesting initiation in mid-September), and a 2-egg nest was laid in the first week of September 2010 (Eliane Lagnaz, Department of Conservation, *pers. comm.*). A clutch of 2 eggs was found at Omaha Spit on 17 September 2003 (Christine Zeiler, *pers. comm.*). Further afield, a brood of two small chicks at Onemana Beach, Coromandel Peninsula (37°09'S, 175°53'E) on 11 October 2002 (W. Hare, *pers. comm.*) indicates laying in early-mid September. The earliest clutch we have on record was at Tawharanui in 2009, when a full clutch of 3 eggs was found on 03 September (Sharon Kast, Tawharanui Open Sanctuary Society Inc., *pers. comm.*); the average interval between eggs in this species is 2 days (Baker 1969), suggesting that in this case clutch initiation occurred during the last few days of August at the latest.

Chick growth

We recorded a total of 48 sets of weights and measurements from 36 different chicks of known hatch dates. The earliest we recorded a chick flying was at age 39 days, but many could be caught by hand until about 43 days; four trapped at ages 45, 47, 48, and 50 days could all fly well enough to avoid capture by hand, suggesting that most chicks in our study area had fledged by about 44 days.

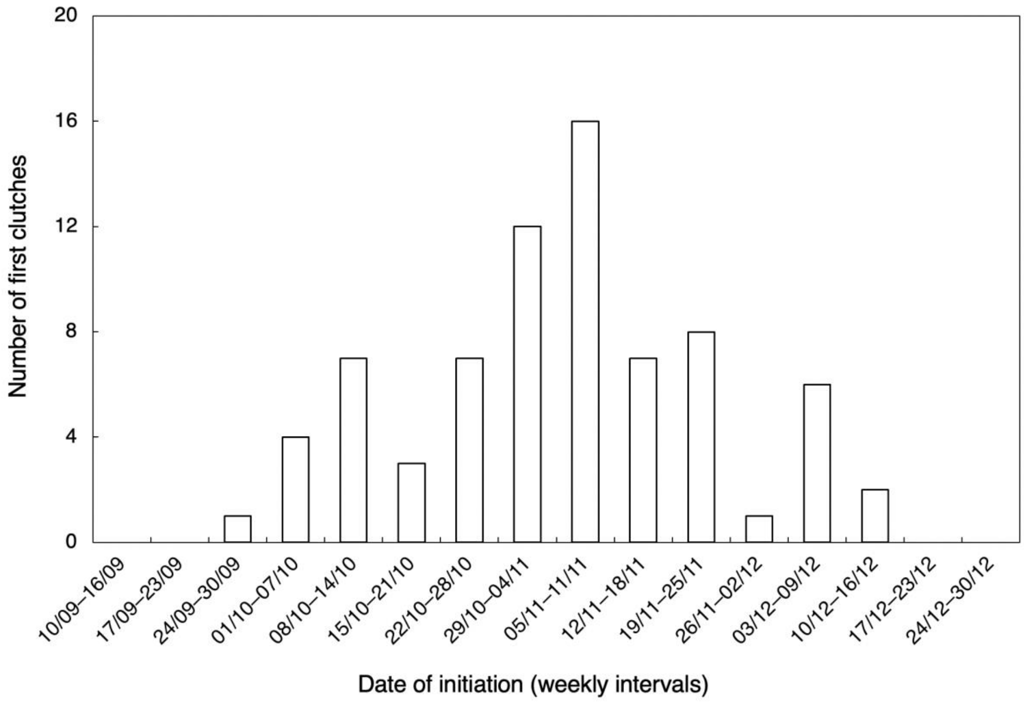

Figure 2. Timing of initiation of 74 first clutches by variable oystercatchers in the North Auckland study area. Results from 1994/95 (n = 12), 1995/96 (n = 23), 1996/97 (n = 23), and 1997/98 (n = 16) are combined and grouped into weekly intervals.

Weight
Chicks changed little in weight for several days following hatching. From 10 days to 43 days (just before fledging) weight gain averaged 12.8 g / day. Growth was most rapid between 10 and 35 days, averaging 15.3 g / day, and it then slowed before fledging occurred (Figure 3). Chicks typically fledged at between 450 and 550 g, or 62–76% of average adult weight.

Total head length
Growth in THL was the one measurement that appeared approximately linear from hatching to 43 days (Figure 4), and it averaged 1.41 mm / day. The highest value for THL that we recorded before fledging was 107.1 mm, about 80% of the average adult value. Among the four chicks aged 45–50 days that could just fly, THL averaged 104.7 mm, or 78% of the adult average. Of the measurements we took, THL provided the greatest ability to predict age ($R^2 = 0.96$).

Wing
As with weight, there was little change in wing length for about a week after hatching. From 10–43 days (immediately before fledging), wing growth was approximately linear and averaged 5.45 mm / day (Figure 5). The greatest wing length we recorded before fledging was 216 mm, or 77% of the average adult wing length. The four chicks aged 45–50 days that were just capable of sustained flight had wing lengths of 193–220 mm (68–78% of the adult average).

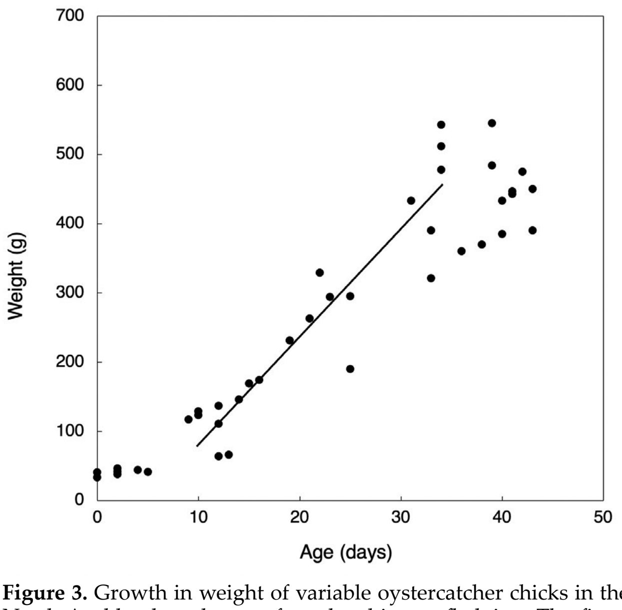

Figure 3. Growth in weight of variable oystercatcher chicks in the North Auckland study area from hatching to fledging. The fitted line shows the approximate period of fastest weight gain between 10 and 35 days.

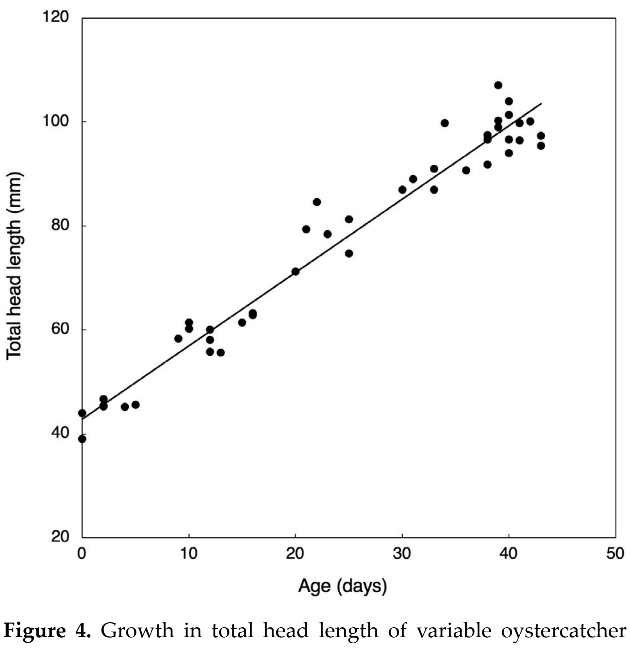

Figure 4. Growth in total head length of variable oystercatcher chicks in the North Auckland study area from hatching to fledging.

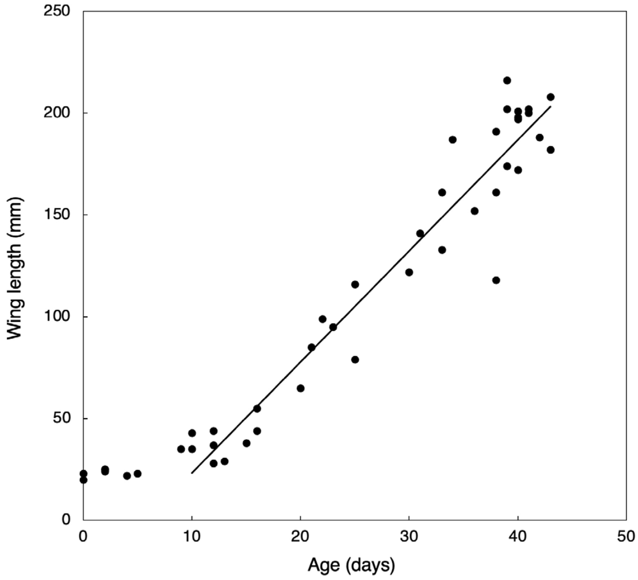

Figure 5. Growth in wing length of variable oystercatcher chicks in the North Auckland study area from hatching to fledging.

Foot growth
The feet are well developed at hatching, with tarsus length 25–30 mm, roughly 40–50% of the average adult value. From hatching to day 25, tarsus growth was approximately linear and averaged 1.0 mm / day. It then slowed markedly and chicks fledged with their tarsus length within the adult range.

Growth of MTC followed a similar pattern. It was 24–28 mm at hatch, about 50–55% of average adult length. From hatching to day 25, MTC growth was roughly linear and increased by an average of 0.75 mm / day. It then slowed substantially, and chicks fledged with MTC also within the adult range.

Variation in sibling weights
We recorded same-day weights of siblings in one 3-chick brood and ten 2-chick broods, and expressed each weight as a percentage of the weight of the heaviest chick in the brood (Table 2). There were a range of differences in sibling weights, but in seven of the ten 2-chick broods, weights were within about 10% of each other. However, we did witness occasional episodes of sibling rivalry, when a larger chick pecked at a smaller sibling or simply pushed it out of the way when a parent approached with food. Some of the intra-brood weight differences we observed may have been the result of sibling rivalry.

Post-fledging
Following fledging, some chicks remained on their natal territory, typically for 1–6 months. During this time, they were defended by their parents, and commonly still begged for food and were fed. At Omaha Spit, almost all chicks had fledged by late February; however, we regularly saw chicks still on their natal territories between March and August. In 2004, three pairs still had a single juvenile each with them on 12 September as the next breeding season approached. In the most extreme case, the pair K-5265 M-KWO and its unbanded mate had a chick that had fledged by 04 February 2002. It was recorded on its natal territory in each month through the winter; it was last seen there on 02 October (8 months after fledging), and by 22 October the parents were incubating a 3-egg clutch. After April, we only ever saw one juvenile with its parents, even when other siblings had fledged.

Table 2. Same-day weights of sibling variable oystercatcher chicks (g) in the North Auckland study area, with each weight also expressed as a percentage of the weight of the heaviest chick in the brood.

Ages (days)	Chick 1	Chick 2	Chick 3
2, 2	42 (100%)	38 (90.5%)	
4, 4	44 (100%)	41 (93.2%)	
13, 12	66 (100%)	64 (97.0%)	
13, 13	137 (100%)	111 (81.0%)	
21, 21	241 (100%)	216 (89.6%)	
21, 22	329 (100%)	263 (79.9%)	
25, 25, 23	295 (100%)	190 (64.4%)	164 (55.6%)
39, 38	446 (100%)	412 (92.4%)	
39, 40	543 (100%)	512 (94.3%)	
45, 45	505 (100%)	495 (98.0%)	
Unknown	403 (100%)	279 (69.2%)	

Table 3. Productivity (minimum number of chicks fledged per pair per year) of variable oystercatcher pairs breeding at the four core sites in the North Auckland study area.

Site (breeding seasons)	Chicks fledged	Pair-years	Average productivity
Pakiri River (1995/96–1998/99)	7	27	0.26
Omaha Spit (1993/94–1996/97)	10	35	0.32
Tawharanui (1994/95–1998/99)	15	32	0.47
Wade River (1994/95–1998/99)	14	15	0.83
Totals	**46**	**109**	**0.42**

Productivity
Minimum productivity at the four core study sites between 1993/94 and 1989/99 averaged 0.42 CFP (Table 3).

We did not attempt to quantify causes of breeding failure (and many were unknown), but two were obvious. Cat (*Felis catus*) tracks were often seen around failed nests, particularly at Pakiri River and Omaha Spit, and were also seen around two adults found freshly dead. High tides and storm surges washed out nests in low-lying areas, particularly at Pakiri River and Wade River. For example, a storm on 23 November 1995 flooded most of the nesting area at Pakiri, and four of five nests were lost. During the 1996/97 season, Cyclone Fergus passed over the study area on 30 December, followed by Cyclone Drena on 10–11 January; during that period, five of six nests at Pakiri River and all three at Wade River were lost to flooding.

We also recorded nests lost to crushing; based on tracks through the nests, they included one each lost to cattle and horses at Wade River, and three at Pakiri River, one each lost to horses, a quad bike, and people.

Productivity was highest at the Wade River site, but the average result there was particularly affected by the outcome of the 1994/95 season, when the three resident pairs fledged seven chicks between them for productivity of 2.33 CFP. Productivity was lowest at Pakiri River, possibly because in addition to being prone to flooding, disturbance levels were very high from late December onward because of the adjacent campground.

Natal dispersal
We recorded natal dispersal distances for 25 individuals, ranging from 0–109 km (mean = 27.6 km, median = 20 km). As is usual in birds, the distribution of these distances was skewed toward the origin (Figure 6, filled columns). Of the 25 birds, seven (28%) bred at their natal site, and 22 (88%) bred at or within 60 km of their natal site.

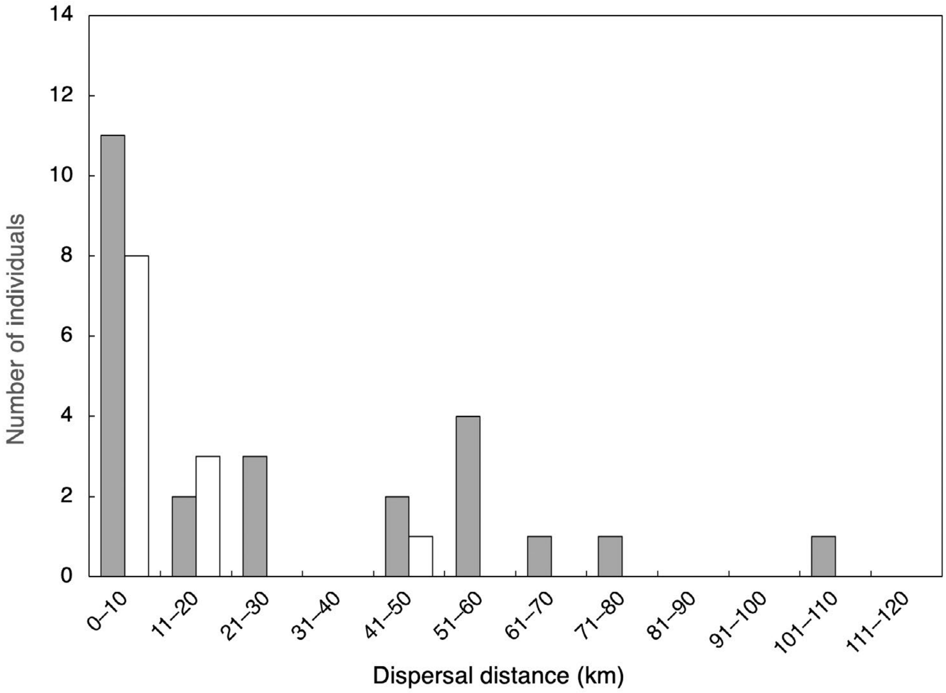

Figure 6. Dispersal of variable oystercatchers banded in the North Auckland study area. Filled columns show natal dispersal distances and open columns show breeding dispersal distances.

Age at first breeding
We recorded age at first breeding (AFB) for 18 individuals. Average AFB was 5.7 years (median = 6 years), with a range of 4–8 years (Figure 7). In three cases (two at Omaha Spit, one at Pakiri River), we recorded newly-formed pairs occupying and defending territories for a season without actually breeding. All three pairs prepared nest scrapes, displayed vigorously when we approached them, and engaged in territorial disputes with neighbouring pairs, but did not lay eggs until the following year.

Breeding dispersal and site-fidelity
We did not detect any cases of breeding dispersal by intact banded pairs. We documented 12 cases of breeding dispersal by individuals, with an average dispersal distance of 10.7 km (median = 6.0 km, range = 1–41 km). In 11 (92%) of the 12 cases dispersal distances were within 20 km (Figure 6, open columns). In three cases, breeding dispersal followed mate loss, and in seven cases it followed divorce. In two cases, the dispersing bird had an unbanded mate and we could not assign a reason for the dispersal.

Once established on a territory, VOCs in our study area showed very high site-fidelity, with adults at the four core sites generally remaining on territory year-round. We did detect occasional movements to nearby sites however, and these are summarised in Table 4. Of 58 banded breeding adults at the four sites, 44 (75.9%) were never seen away from their breeding site, and a further 10 (17.2%) were seen elsewhere only once. All of these trips appeared to be brief, and in most cases the next sighting was back at the bird's breeding site. In some cases, these movements coincided with other events. Of the two birds seen away from Omaha Spit for example, one was seen once at Pakiri River (10 km away) after its mate died and it returned to Omaha Spit within a month. The other left Omaha Spit following divorce and was found dead (of unknown causes) four months later at Snells Beach, 11 km to the south. Birds breeding at Tawharanui were more likely than birds at other sites to be detected elsewhere (Table 4), and all their movements (9 individuals, 15/15 sightings) were to Omaha, a distance of 5–7 km.

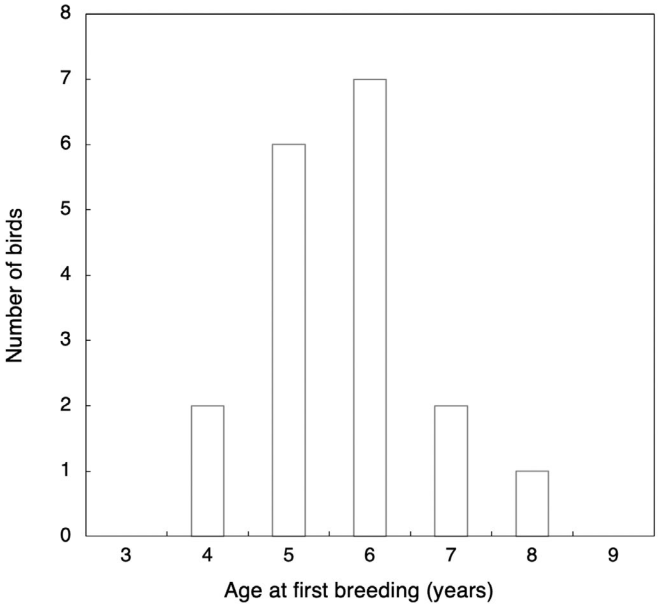

Figure 7. Age at first breeding of variable oystercatchers banded as chicks in the North Auckland study area.

Pair-bond survival
Between 1993 and 2010, 45 banded pairs were monitored for varying periods, for a total of 244 banded pair-years. Mate-fidelity was high—on average, 83% of pairs present in one breeding season were intact in the next. Three pairs were still intact at the end of the study. Of the 42 pair-bonds broken, 29 (69%) were a result of death, and 13 (31%) were a result of divorce, i.e. both birds were known alive but were no longer paired with each other. The longest pair-bond we detected lasted 16 consecutive years (K-5261 M-WRY and K-5280 M-WOW from 1994/95 to 2009/10 inclusive at Omaha Spit). We recorded seven other pair-bonds that lasted between 10 and 14 years; one was at Pakiri River, three at Omaha Spit, and three at Tawharanui.

Table 4. Site-fidelity of colour-banded adult variable oystercatchers breeding at the four core sites in the North Auckland study area, 1994–2010.

Breeding site	Number of birds	Total sightings	Sightings at breeding site	Sightings elsewhere	Number of birds seen elsewhere
Pakiri River	10	493	491	2	2
Omaha Spit	28	2668	2666	2	2
Tawharanui	12	533	518	15	9
Wade River	8	381	380	1	1
Totals	**58**	**4075**	**4055**	**20**	**14**

Survival and population trend

Annual adult survival rates in our study area are shown in Table 5. On average, survival of adults was very high (mean = 0.954, *sd* = 0.032) and suggested average adult life-expectancy of 21.2 years. Survival was also consistently high, with values between 0.9 and 1.0 in ten of the 11 years we measured it. Sample sizes of pre-breeders were smaller, but their survival was clearly also high: a minimum of 31 (83.8%) of 37 colour-banded fledged chicks survived to one year, 28 (90.3%) of 31 survived from one to two years of age, and 25 (89.3%) of 28 survived from two to three years of age.

Modelling our survival and productivity estimates resulted in a positive value of r (+0.0494), suggesting that our study population had the potential to grow by about 5.1% per annum. Sensitivity analysis indicated that with the very high survival rates we recorded, average productivity would have to fall below 0.22 CFP before the population started to decline. Using the same survival estimates, we calculated a generation time of 17.3 years for the species in our study area.

Table 5. Annual survival (Minimum Number Alive) of individually colour-banded adult variable oystercatchers in the North Auckland study area, 1994–2005.

Year	Number alive in year x	Number alive in year x+1	Annual survival
1994	22	21	0.955
1995	38	38	1.000
1996	55	54	0.982
1997	54	53	0.981
1998	56	54	0.964
1999	58	52	0.897
2000	59	57	0.966
2001	62	57	0.919
2002	59	58	0.983
2003	62	59	0.952
2004	61	56	0.918
Totals	**586**	**559**	**0.954**

DISCUSSION

Morphometrics

The measurements of adults we recorded are generally consistent with those previously published (Baker 1972; Marchant & Higgins 1993). However, our measurement of mid-toe was longer than Baker's because it included the claw, whereas he measured to the base of the claw (Baker 1972, Plate 8E). He also flattened the wing, but did not straighten it (Baker 1972, Plate 8F), and so our measurements of wing length were roughly 4–5% longer. Baker did not measure THL, and we note that it has a lower CV than bill length in our dataset (Table 1).

Our attempts to sex adults using Baker's (1974a) discriminant function, which requires measurement of bill length, depth, and width, were unsuccessful. We often measured both members of known breeding pairs, only to find that both appeared to be of the same sex (more often male) according to the function. Measuring bill length and depth are relatively straightforward, although values may be affected by wear of the bill tip and/or of the feathers at the base of the bill (Baker 1969; Marchant & Higgins 1993). We note that in our dataset bill length had the highest CV of all the linear measurements (Table 1). However, bill width changes quickly at the gape and we suspect our measurements of width were probably not taken at the same place on the bill as Baker's.

The egg dimensions we recorded in North Auckland (36°S–37°S) were very similar to those reported by Rowe (2008) in a sample of similar size (and using the same Kv) at Kaikoura (42.4°S). The average calculated volume of the two samples varied by only 1.67%, suggesting that there is little variation in egg size over the latitudinal range of the species.

We have found no published records of runt egg production by New Zealand birds. Runt eggs are typically produced when foreign material is present in a bird's oviduct, and albumin and a shell are deposited around the material instead of around a normal yolk. The size of the egg depends on how far down the oviduct the foreign material was located (C. Jeske, National Wetlands Research Center, U.S.A., *pers. comm.*). Runt eggs have been recorded in a wide range of species (Crick 1995), including at least three other oystercatcher species: *H. ater* (E. Nol, Trent University, Ontario, *pers. comm.*), *H. ostralegus* (C. Steel, University of Oslo, Norway, *pers. comm.*), and *H. bachmani* (B. Andres, U.S. Fish & Wildlife Service, Alaska, *pers. comm.*).

Timing of breeding

Baker (1969) noted that egg-laying by VOCs begins in October and cited the earliest record at that time as 22 October. He also commented that VOCs breed earlier in the southern South Island (October to February) than in the northern North Island (December to February). Marchant & Higgins (1993) stated that the species laid from mid-September, with a peak in November, and added "slightly later on NI", perhaps echoing Baker's comment. Our data from the northern North Island show that laying in that region also starts in September and peaks in November; in addition, we note that the clutch initiated at the end of August 2009 at Tawharanui (this study) appears to be the earliest on record nationwide. Within our greater study area, Hansen (2005) recorded an earliest laying date of 05 October at Waipu Spit, but noted that the hatch dates of some nests indicated that they were laid in September. We do not have dates for clutch initiation in the southern South Island; however, at Kaikoura, Rowe (2008) found that most eggs were laid in November and December, with the earliest on 19 October. The evidence available now seems to suggest, *contra* Baker (1969), that breeding does not begin later in the northern North Island than in the South Island, and may even begin earlier. It is also clear from our data that initiation of first clutches can be very protracted, occurring over a period of 3.5 months from the end of August to mid-December. First-clutch initiation in our study area appeared to be significantly earlier in 1997 than in the three previous years. The reason for this is unknown, and the result should perhaps be treated with caution, given the relatively small sample size in 1997 (n = 16 clutches).

Chick growth and post-fledging

With the exception of Rowe's (2008) data on rate of increase in bill length, there appears to be no published information on chick growth in VOCs. Chicks in our study area fledged at lower weights than adults and with shorter THL and wing, but with tarsus and MTC within the adult range. From hatching to fledging, values of THL showed the closest correlation with age, and that metric appeared to be the most useful predictor of age.

Oystercatchers are unusual among shorebirds in that they feed their chicks (e.g., Ens & Underhill 2014). In some broods of two or three chicks, sibling rivalry develops, with the first-hatched chick using its size advantage to obtain more food from the parents, leading to intra-brood differences in growth rates. Sibling rivalry has been documented in other oystercatcher species, including *H. ostralegus*, *H. bachmani*, and *H. moquini* (see Safriel 1981; Groves 1984; and Tjørve & Underhill 2009 respectively). We saw cases of sibling rivalry, and a few examples of large intra-brood differences in weight that might have been caused by rivalry, but in most broods there was relatively little difference in weight.

Oystercatcher chicks of a number of species have been reported to remain with their parents for extended periods after fledging. Examples included *H. ostralegus* (see Kersten & Brenninkmeijer 1995), and the sooty oystercatcher (*H. fuliginosus*) (see Hansen *et al*. 2014). We recorded many cases of juvenile VOCs remaining with their parents for 1–6 months during their first winter, and one case of a juvenile on its natal territory for 8 months after fledging. However, the fact that many juvenile VOCs survive without staying with their parents during their first winter, suggests that post-fledging parental care is involved, rather than strict dependency. The fact that we only ever saw single juveniles with their parents after April may have been because the parents were unable to feed and guard more than one juvenile in addition to feeding themselves and defending their territory.

Productivity

Values for productivity will inevitably vary between studies, depending on a wide range of factors, including location, the length of the study, the number of pairs involved, local predation and disturbance rates, and weather events. There are a few reports of VOC productivity in the order of 1.0 CFP (Fleming 1990; Michaux 2013); however, the average at unmanaged sites, over longer periods, and with more pairs appears to be considerably lower. At Kaikoura, Rowe (2008) monitored 4–6 pairs over 8 years and recorded average productivity of 0.47 CFP. That value is similar to the 0.42 CFP that we recorded while monitoring an average of 18 pairs annually over a 6-year period.

Loss of nests to flooding was common in our study area, particularly at the two low-lying sites (Pakiri River and Wade River). Similar losses of VOC nests to big tides have been reported elsewhere (Fleming 1990; Hansen 2005; Rowe 2008). Egg loss to tidal flooding has been recorded in oystercatcher species worldwide, including *H. palliatus*, *H. longirostris*, *H. bachmani*, and *H. chathamensis* (see Lauro & Burger 1989; Lauro & Nol 1993; Tessler *et al*. 2014; Moore 2014 respectively).

Whether a given level of productivity is high enough to ensure that the population will persist depends on the survival rates in that population (e.g., Dowding *et al*. 2020). Productivity of 0.42 CFP, in conjunction with the high levels of pre-breeding and adult survival that we recorded, was potentially high enough to enable strong growth in our local population.

Natal dispersal

While there have been a number of reports of young VOCs dispersing hundreds of kilometres from their natal site, there are almost no published natal dispersal distances for the species. Baker (1974b) recorded a few examples of extensive dispersal by young birds (some of which were considered 'doubtful' by Marchant & Higgins 1993), but did not record whether breeding occurred subsequently.

Near Dunedin, one bird bred *c*. 30 km from its natal site at 5 years old (P. Schweigman, *pers*. *comm*.). Rowe (2019) recorded a number of his banded birds breeding at their natal site (Kaikoura); however, while some others were seen at sites distant from Kaikoura, monitoring was infrequent at those sites, and none of the birds was recorded breeding. Melville *et al*. (2020) recorded long-distance dispersal of two birds from the Nelson area, but again neither of them were recorded breeding elsewhere. Roberts & Dowding (2019) recorded a bird that bred 285 km from its natal site, but given the extended time between banding and its later identification (16 years), this distance could have consisted of natal dispersal followed by one or more breeding dispersal events.

In general, birds (including oystercatchers) show highly skewed patterns of natal dispersal, with most birds breeding relatively close to their natal site and a few dispersing longer distances (Greenwood & Harvey 1982; Paradis *et al*. 1998). Australian pied oystercatchers (*H. longirostris*) in Tasmania had an average natal dispersal distance of 9.2 km, and all bred within 30 km of their natal site (Taylor *et al*. 2014). The average in the American oystercatcher (*H. palliatus*) was 33.1 km, with a range of 3–120 km (Clay *et al*. 2014). The VOCs in our study area conformed to this general pattern, with an average of 27.6 km, and a large majority breeding within 60 km.

Natal dispersal distances can be influenced by many factors, including population density, habitat limitations, sex, timing of fledging, and flying ability (Greenwood 1980; Chu & Claramunt 2023), and could differ in different parts of a species' range. The greatest natal dispersal distance we detected (109 km) should be considered a minimum. As noted by Greenwood & Harvey (1982), studies of dispersal are often compromised by the limited size of the recovery area and may fail to detect longer-distance dispersers.

Age at first breeding

Most oystercatcher species worldwide show delayed maturation, and typically first breed at between 3 and 7 years of age (e.g., Harris 1970; Clay *et al*. 2014). In some species, breeding can be delayed further however, depending on population density and territory availability (Loewenthal 2007; van de Pol *et al*. 2014).

Among New Zealand species, South Island pied oystercatchers (*H. finschi*, SIPO) first breed at an average of 5 years (range 4–6) (Sagar & Veitch 2014) and Chatham Island oystercatchers at an average of 3.6 years (range 2–6) (Dowding *unpubl. data*). Baker (1969) assumed that SIPO breed at 3 years because they have attained adult plumage by that age, and suggested that VOCs "probably first breed at a similar age". Cook *et al*. (2007) reported two birds breeding at 2 years old, but that event was later considered atypical (D.S. Melville, *pers. comm*.).

Our findings (average AFB of 5.7 years, range 4–8 years) appear typical of the genus. We note that the density in our study population was higher than in some other parts of the country, and average AFB may be lower in areas with lower densities. However, Rowe (2019) reported one bird first breeding at 4 years, three at 5 years, and two at 7 years at Kaikoura. Although that sample was relatively small, the range and average are very similar to the values we recorded.

We recorded three pairs having a non-breeding 'honeymoon' year before breeding, a phenomenon that has also been documented in the American oystercatcher and the black oystercatcher (Palmer 1967).

With evidence now pointing to a typical AFB of 5–6 years for VOCs, a relatively high proportion of the population will be non-breeders. Estimates of the number of mature (breeding) individuals will therefore be considerably lower than the total population estimate, a fact that needs to be considered when assigning threat status to the species (I.U.C.N. 2022; Townsend *et al*. 2008).

Breeding dispersal

There appear to be no published data on breeding dispersal by VOCs. We note that Baker (1969) used the term 'breeding dispersal' to describe the movement of birds from their wintering grounds to their breeding grounds, and not *sensu* Greenwood & Harvey (1982). Because the VOCs in our study area showed very high fidelity to their breeding sites and many had long-term pair-bonds, we recorded few examples of breeding dispersal. As with natal dispersal distances, breeding dispersal distances were skewed toward the origin. They were also shorter than natal dispersal distances on average, as is usually the case with birds (Greenwood & Harvey 1982; Paradis *et al*. 1998).

Greenwood (1980) noted that most bird species show female-biased dispersal, with males showing higher philopatry. As we could not sex birds reliably (see above), we were unable to determine whether VOCs conform to this general pattern.

Site-fidelity and movement of adults

Some oystercatcher species, such as *H. ostralegus* and *H. finschi* are wholly or partially migratory as adults (Cramp & Simmons 1983; Sagar & Veitch 2014). Others, such as *H. moquini* and *H. fuliginosus* are sedentary as adults, or only undertake short, local movements (Hockey 1983; Hansen *et al*. 2009).

VOCs are non-migratory; however, while some adults remain on their territories year-round, some adults and pre-breeders move short distances, usually to favoured estuaries, to form autumn/winter post-breeding flocks (e.g., Baker 1969; Marchant & Higgins 1993; Dowding & Moore 2006). Possible regional differences in these seasonal movements (and the distances involved) are not well understood. The breeding adults at our four core sites all remained on territory year-round, and we found no evidence that any of them moved regularly, or for long periods, during the non-breeding season. The few movements that we detected were from Tawharanui to Omaha Spit; they were brief, and occurred during and outside the breeding season. Given the proximity of the two sites (5–7 km apart), we suspect that most of these movements were short foraging trips to take advantage of the extensive feeding opportunities available in Whangateau Harbour, adjacent to Omaha Spit.

Our study area has long had a dense population of VOCs, and with national population growth continuing there may be pressure on territories locally. The very high year-round site-fidelity we recorded may be because pairs risk losing their territories if they move to a wintering site.

We note that some of the movements of previously sedentary adults occurred following mate loss or divorce, a similar situation to that described for New Zealand dotterels (*Anarhynchus obscurus*) in the same area (Dowding & Chamberlin 1991).

Pair-bonds

Almost all the birds in our pair-bond study were banded as adults in existing pairs. Some had almost certainly been in those pairs for a number of years, and so some of the pair-bond durations we recorded will be minimum values. Given the very high level of adult survival we recorded, longer pair-bonds would very likely be detected with longer monitoring. More than two-thirds of the broken pair-bonds in our study resulted from death; however, divorce was not uncommon, in spite of the statement by Marchant & Higgins (1993) that it is rare in oystercatchers. Divorce has also been documented in *H. bachmani*, where 5% of returning banded birds changed mates from one year to the next (Tessler *et al*. 2014), and in *H. chathamensis* (Dowding *unpubl. data*).

Survival and population trend

Estimates of adult survival based on return rates of marked birds can under-estimate true survival (Méndez *et al*. 2018). However, banded VOCs are large, obvious birds with large colour-bands, they are highly sedentary and approachable, and we had a large network of observers in and around our study area. Annual survival of adults in our study may have been slightly under-estimated, but it was nevertheless very high. This was not a surprise, given that a number of VOCs over 30 years of age have been recorded, many of them at Waipu Spit within our greater study area (Roberts & Dowding 2019). In *H. o. ostralegus* annual adult survival can vary markedly, particularly in colder climates with occasional severe winters that cause very high mortality (Camphuysen *et al*. 1996; Duriez *et al*. 2012). Our study area was in a temperate zone without severe winters, and adult survival was consistently high. First-, second-, and third-year survival were also high, although we acknowledge that those values are based on smaller sample sizes; we record them in the apparent absence of any other published survival data for the species. At 0.838 and 0.903, first- and second-year survival respectively were substantially higher than the values of 0.5 and 0.8 recorded in a population of *H. ostralegus* (van de Pol *et al*. 2014) and of first-year survival of 0.60 in *H. moquini* (Loewenthal 2007). Our trend data are inevitably approximate, but suggest that the population in our study area had the capacity to grow rapidly (at about +5% per annum) at the time we collected the data. That level of potential growth is consistent with the belief that the VOC population continues to increase nationally (Dowding & Moore 2006; Riegen & Sagar 2020). However, as is the case with *H. palliatus* (Clay *et al*. 2014), the rate of population growth was most sensitive to adult and sub-adult survival, which may not be as high in other parts of the VOC's range as they were in our study area.

At 0.954, annual adult survival of VOCs is considerably higher than that of SIPO (0.892, Sagar *et al*. 2002). The fact that VOCs are highly sedentary and, unlike SIPO, do not undertake an annual migration, may contribute to their higher rate of adult survival. Like the VOC, the highly sedentary *H. moquini* has a very high (and similar) rate of adult survival at 0.96 (Loewenthal 2007).

With a generation time of 17.3 years, the three-generation period over which trends are estimated for threat-ranking purposes (I.U.C.N. 2022; Townsend *et al*. 2008) is about 52 years for this species. Our calculated generation time is much longer than the 10.35 years estimated for *H. unicolor* by Bird *et al*. (2020), where the values cited for maximum longevity and adult survival are both much too low (Roberts & Dowding 2019; this paper).

Conclusions

Many aspects of the biology and ecology of the variable oystercatcher are still not known in detail, and this endemic species provides numerous opportunities for further research. Our study has filled some gaps, particularly with regard to dispersal, age of first breeding, pair-bond retention, and survival rates, and has added to our knowledge of chick growth rates and productivity. All our results were recorded between 36°S and 37°S in the northern part of the species' range, which will allow for comparisons with data from other regions or latitudes. Given potential regional differences in climate, VOC population density, predator and competitor guilds, and disturbance levels, among other variables, it would not be surprising to see differences in demographics in other parts of the country. In addition, our productivity results were all recorded at unmanaged sites, and therefore provide a baseline for comparisons with productivity at managed sites.

Some basic information is still lacking. While the species apparently continues to increase in numbers and gives no cause for conservation concern, there is no accurate estimate of the current size of the population (Dowding 2022). This would provide a useful baseline against which to measure future change (Dowding 2014). Threats to the species include predation, inundation, and disturbance, but their relative importance is unclear (Dowding 2014). The VOC's breeding distribution is almost entirely coastal however, and current losses to inundation suggest it is likely to be further affected by sea-level rise and an increase in the frequency of storm events associated with global climate change. The vulnerability of the species to climate change has been recognised recently by the addition of the qualifier 'Climate Impact' (Rolfe *et al*. 2021) to its New Zealand threat ranking (Robertson *et al*. 2021). The adverse effects of climate change are likely to be exacerbated in some regions by an increase in disturbance levels and habitat degradation resulting from increasing development in the coastal zone and greater recreational use of the coastline as the human population grows (Dowding 2014). It has been suggested that this combination of climate change and increasing human pressure may provide the greatest future threat to oystercatcher species worldwide (Ens & Underhill 2014).

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Observations and dispersal of black-billed gulls (tarāpuka, *Chroicocephalus bulleri*) banded at North Canterbury, New Zealand, 1958–1974 and 1983

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Abstract: A total of 15,694 black-billed gulls (tarāpuka, *Chroicocephalus bulleri*) chicks were banded at six braided gravel-bed rivers in North Canterbury, New Zealand, from 1958 to 1983, and at least 1,754 later sightings of dead or alive birds were reported to the Banding Office. The main banding sites were the Ashley River and its major tributary, the Ōkūkū River; other banding was carried out on the Kowhai River near Kaikoura, Conway River, Waiau River, Waipara River, and Waimakariri River. Colonies typically shifted location between years, as flooding and weed growth affected the habitat and suitability for nesting. Up to 6 colonies were found on the Ashley River system in a season. Average size of all colonies was about 230 nests, with the largest reaching about 800 nests. Some birds were found at rivers apart from their natal rivers. Birds bred when as young as 2-years-old. The furthest sighting was at Firth of Thames, 736 km NE of the banding site; the southernmost was at Waipahi, Otago, 412 km SW of the banding site; and the oldest recovery was 22.1 years after banding. Band loss likely affected recovery rates, as the oldest bird found with an aluminium band was only 10.9 years-old.

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Keywords: black-billed gull, *Chroicocephalus bulleri*, band recoveries, dispersal, longevity, North Canterbury

INTRODUCTION

In the late 1950s through 1970s, Ken Rowe (my late father) held a general banding permit that allowed him to band most species apart from game birds. Banding was carried out at home, on rivers, coasts and on offshore islands. The aim of his programme was simple: band anything that could be caught, see what resulted, and make the data available for anyone who wished to use it. The best example was banding red-billed gulls (*Chroicocephalus novaehollandiae scopulinus*) at Kaikōura from 1959 to 1964, which progressed into a study being continued by Jim Mills through to the present day (e.g. Mills *et al*. 2018). I took over Ken Rowe's banding permit in later years, until the days of "band and fling" were over, and more focussed banding programmes were required. This paper is the last in a series in which information, mainly recovery and dispersal data, is presented from that banding programme in order to have it in the public domain. Previous papers in the series included three that reported similar information for black-backed gull (*Larus dominicanus*), red-billed gull, and white-fronted tern (*Sterna striata*) (see Rowe 2013, 2024a & b), which allow comparisons with black-billed gull band recoveries.

This paper presents data from band recoveries of the endemic black-billed gull (tarāpuka, *Chroicocephalus bulleri*) on North Canterbury rivers, mainly the Ashley River. Black-billed gulls are widely found in inland areas of New Zealand and are classified as "Near threatened" by BirdLife International (2024) and as "At risk: declining" under the New Zealand Threat Classification system (Robertson *et al.* 2021). Black-billed gulls have been banded in New Zealand from about 1950 (Cunningham 1951a). E.W Dawson appears to have banded the first black-billed gulls on the Ashley River, 304 in 1950-1951 (Cunningham 1951b; Dawson 1954). W.C. Clark and E.G. Turbott began banding

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Table 1. Locations of northern South Island black-billed gull colonies where chicks were banded, 1958 to 1974 and 1983.

Locality	Coordinates
Kowhai River – Kaikōura	42.415°S 173.631°E
Conway River	42.608°S 173.311°E – 42.616°S 173.467°E
Waiau River – opposite Gabriel's Gully	42.568°S 172.723°E
Waipara River – mouth	43.154°S 172.795°E
Ashley River – below gorge	43.232°S 172.235°E – 42.275°S 172.725°E
Ashley River – Ōkūkū River	43.154°S 172.404°E – 43.263°S 172.469°E
Ashley River – Lees Valley	43.143°S 172.213°E
Waimakariri River - gorge	43.360°S 172.054°E

black-billed gulls on the Ashley River in 1957-1958 (Kinsky 1958) and Ken Rowe in 1958-59. This paper provides longevity and dispersal data to supplement that collated in Higgins & Davies (1996) and McClellan & Habraken (2013).

METHODS

Black-billed gulls were banded on the braided, gravel-bed rivers listed in Table 1 from 1958 until 1974, and in 1983. Colonies outside the Ashley River system were found while travelling to Kaikōura to band red-billed gull chicks (Conway and Kowhai Rivers) or incidental to other activities. Those on the Ashley River, the closest to the author's home, were found whilst searching the river; multiple visits were made to most colonies to band the chicks. Chicks were captured by hand when still in their nests or nearby before they could fly. Aluminium size E butt bands were used from 1958 to 1967, harder-wearing monel bands were introduced in 1968, and stainless steel bands from 1972.

Ken Rowe's notebooks were not kept, and so banding and re-sighting / recovery data came from files held by the author or from Department of Conservation (DOC) Banding Office archives. Where locations of sightings were known to the author from Banding Office recovery slips, the distances from the banding sites were measured using Google Earth Pro™. For other records, the distances and directions calculated by the Banding Office record system were used. In the 1960s-70s, at least, many locations such as the Ashley / Ōkūkū Rivers confluence, 43°16'E 172°28'S, were rounded down to 10′ and coded as 431E 1722S (= 43.167°E 172.333S°) creating a potential error up to ± 23 km. Directions were given to ± 11.25° of arc, i.e. as SSW, which equates to about ± 20 km at 100 km distance.

Ages refer to the time difference between banding and reporting, not the hatching date. This time period will have a variable, inherent error and will underestimate age as chicks were banded from a few days after hatching when they were big enough for the band to stay on, through to almost flying. Studies quoted in Higgins & Davies (1996) give fledging between 20 and 24 days, while McClellan & Habraken (2013) give minimum fledging at 26 days.

RESULTS

A total of 15,734 black-billed gulls were banded (Table 2), including 13,102 on the Ashley River and its main tributary, the Ōkūkū River; 2,632 were banded on other rivers, mainly the Conway River. Non-flying chicks accounted for 15,694 of these banded birds, and 35 of the 40 adult birds were rebanded with stainless steel bands as the aluminium bands became worn. No banding was attempted from 1975 to 1982. On the Ashley River system, gull colonies were located anywhere between Lees Valley and the sea, and on the Ōkūkū River. While Table 2 shows nil bandings for 1968 and 1969, we did visit the Ashley River in these years as banded dotterels (*Anarhynchus bicinctus*) were banded in 1969 and black-backed gulls in 1968 (LKR *unpubl. data*). It is unlikely that we missed any colonies in these years, and any that were present must have failed as we did not find chicks to band; there are no paper records kept to confirm this.

Table 2. Numbers of black-billed gull chicks banded at North Canterbury colonies 1958 to 1974 and 1983. Each line represents one colony in the given year.

Locality	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1983
Kowhai River - Kaikoura		120																
Conway River			196	249	4	1,358		29						137				
								3										
Waiau R																77		
Waipara River – mouth									309									
Waimakariri River					150													
Ashley River system																		
Gorge to the sea	187	181	1,003	131	345	529	242	1,538	242	284			1,412	14	1,439	186		316
	119			32	155	385		294		198								
					117	268												
					29													
Ōkūkū River					1,587													
					506													
Lees Valley				6														
Total Ashley River	306	181	1,003	169	2,739	1,182	242	1,832	242	482			1,412	14	1,439	186		316

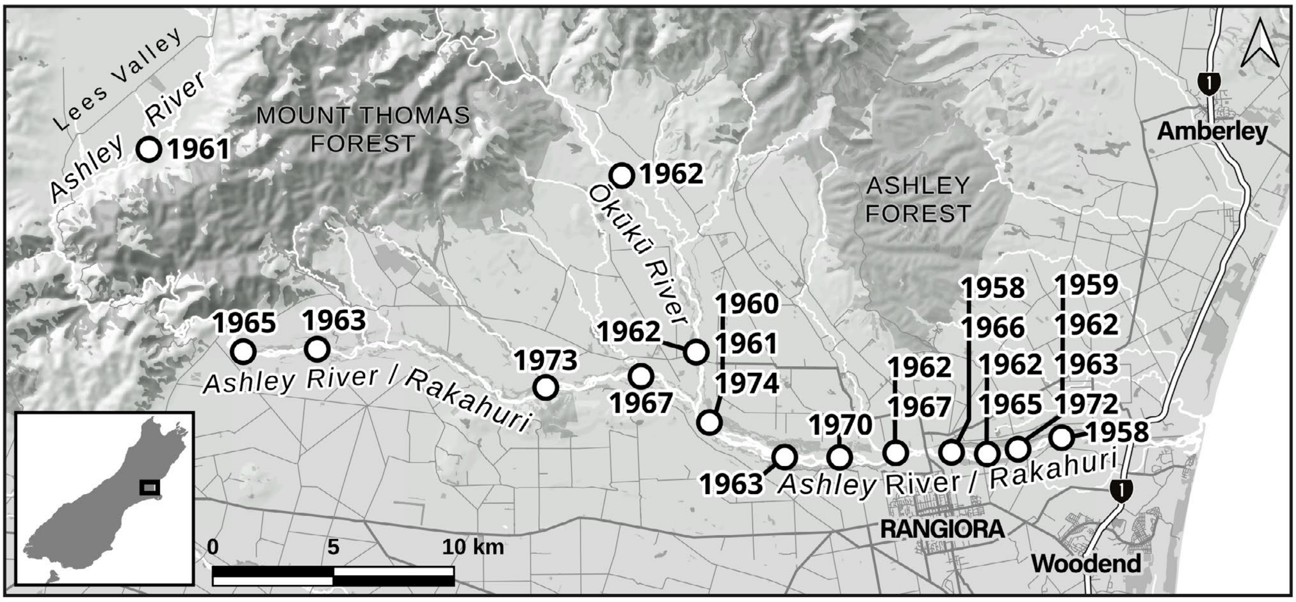

Figure 1. Ashley River showing locations of black-billed gull colonies between 1958 and 1974. Map created in QGIS, with data from the LINZ Data Service and OpenStreetMap Contributors, under CC BY 4.0 and ODbL respectively.

There was a large range in colony sizes – apart from 1968 and 1969 (when no chicks were banded), bandings at an individual colony ranged from 14 to 1,587. Bandings over 1,000 at a colony were: Ōkūkū River 1,587 (1962), and Ashley River 8 km upstream from the sea 1,538 (1965), 7.2 km upstream 1,439 (1972), 15.3 km upstream 1,412 (1970), 20 km upstream 1,357 (1974), opposite the Ōkūkū River 1,003 (1960). When the number of chicks banded each year from 1958 to 1974 were plotted as an X-Y graph, there was no trend with time (Olmstead and Tukey's corner test for association $S = 7 < S_{p=0.05} = 11$; Sokal & Rohlf 1981). Outside of the Ashley River, the largest banding operation was 1,358 chicks banded on the Conway River in 1963.

Post-banding records of black-billed gulls from the Ashley River (including the Ōkūkū River) totalled 1,670, with an additional 84 for birds banded on the other five rivers. The majority were sight records, at least 1,137. Of these, 992 sightings were made by J.R. (Dick) Jackson, mainly in Christchurch and its environs, but as far north as the Conway River, as far south as the Ashburton River, and inland up to the confluence of the Waimakariri and Hawdon Rivers.

Recoveries by banding location

1. Ashley River

More than one colony was found on the Ashley River system in any given season six times. The largest number of colonies was six in 1962 of which two were on the Ōkūkū River (Table 2). The Ashley River has a small, braided section in Lees Valley, about 65 km upstream from the sea and 23 km above Ashley Gorge. A small colony was found there in 1961 and six chicks were banded; one was sighted at Ashley Gorge two years later. The Ōkūkū River is the main tributary of the Ashley River joining about 22 km from the sea. There is a braided section about 13 km long where, in 1962, two colonies were found, OB at the road bridge 2 km upstream from the Ashley River and OH a further 8 km upstream at Hillside; 506 and 1,587 chicks were banded at OB and OH, respectively. On the main Ashley River, colonies were found from near the sea to below the Ashley Gorge, a stretch of 40 km; 11,003 birds were banded at 25 colonies between 1958 and 1983, (Table 2, Fig. 1).

From the 1,670 post-banding records of Ashley River birds, the furthest north a bird was found was the Firth of Thames, 736 km NE of the banding colony, and the southernmost was at Waipahi, South Otago, 412 km SW of the banding site (Table 3). Thirteen other birds were found at distances greater than 200 km from their natal Ashley River colonies − six in the North Island, seven around Blenheim and Nelson, and none in the lower South Island or West Coast (Tables 3 & 4). Five of the 17 birds found 101−200 km distant were at the Ashburton River, with the remainder spread between Kaikōura and the Conway River. Two birds seen 85 km from the coast at the confluence of the Waimakariri/Hawdon Rivers were the furthest recorded inland. The other 55 birds found 51−100 km distant were as far south as Ashburton and as far north as the Waiau River near Hanmer. The 1,440 records within 50 km of the banding sites (86% of the total) included 955 sight records by J.R. Jackson and 51 by unnamed observers, and 101 dead chicks at the colonies; these birds were found between Lake Ellesmere and Christchurch to the south to 10 km north of the Ashley River.

Juveniles departed the breeding colonies shortly after fledging, as shown by E25115 found dead 6 km from the Ōkūkū River colony only 14 days after banding; other birds were seen at Christchurch, 28–40 km from their colonies, 17 (E359), 20 (E24703), and 27 (E46356) days after banding. Other examples of quick dispersal were birds seen at Culverden (58 km NE) after 42 days (E24707), Tinwald (82 km SW) after 61 days (E19033), Motueka (247 km N) after 69 days (E95979 dead), and Levin (370 km NE) after 106 days (E45326 dead). Birds banded as chicks on the Ashley River were sighted on most rivers in the region (Table 5), with breeding confirmed at Kaikōura Peninsula, the Waiau River, the Waimakariri River at its confluence with the Hawdon River and in its lower reaches, and the Rakaia River.

The oldest recovery among the Ashley River birds, E80308 banded in 1970, was found dead aged 22.1 years at Amberley Beach, 23 km ENE of where it was banded (Table 6). The second oldest recovery, E95695 was found dead near Christchurch aged 18.2 years, and the oldest live bird (E100401) was seen at the Waiau River upstream of the Hanmer turnoff at age 16.0 years. Both bands (which were monel and stainless steel respectively) were noted as very worn.

Table 3. Records of black-billed gulls banded in North Canterbury, 1958–1974 and 1983, found > 200 km from their natal colonies.

Natal river	Sighting locality	Band	Date banded	Date found	Distance (Km)	Age (Years)	Status
Ashley River	Firth of Thames	E37749	7 Dec 1963	13 May 1972	736 NNE	8.4	Shot
Waipara River	Tutaekuri River	E46468	20 Nov 1966	11 Apr 1968	527 NE	1.4	Dead
Ōkūkū River	Waipahi, Otago	E24669	2 Dec 1962	20 Mar 1963	412 SW	0.3	Dead
Ōkūkū River	Wairarapa	E12048	11 Nov 1962	4 Oct 1963	408 NE	0.9	Dead
Ashley River	Levin	E45326	27 Nov 1965	12 Mar 1966	370 NE	0.3	Alive
Conway River	Herbertville Beach	E32619	10 Nov 1963	11 Apr 1966	358 NE	2.4	Alive
Conway River	Waitaki River	E3258	27 Nov 1960	11 Jul 1962	312 SW	1.6	Alive
Ashley River	Haitaitai	E25444	9 Nov 1963	17 May 1968	299 NE	4.5	Dead- car
Ashley River	Eastbourne	E76486	13 Nov 1970	10 Oct 1971	297 NE	0.9	Dead
Ashley River	Seatoun	E105355	21 Nov 1974	30 Apr 1988	291 NE	13.4	Alive
Ashley River	Oriental Bay	E7120	10 Dec 1960	2 Jun 1963	290 NE	2.5	Alive
Ashley River	Punga Cove	E100399	8 Nov 1974	23 Apr 1975	275 NNE	0.5	Dead
Kowhai River	Rangitata River	E3361	6 Dec 1959	21 Oct 1970	269 SW	10.9	Alive
Ashley River	Tory Channel	E100683	11 Nov 1974	15 Feb 1976	265 NNE	1.3	Dead
Ashley River	Motueka	E95979	19 Nov 1972	28 Jan 1973	247 N	0.2	Dead
Ashley River	Blenheim	E100340	8 Nov 1974	6 Dec 1979	230 NNE	5.1	Dead
Ashley River	Nelson	E45079	27 Nov 1969	8 Apr 1969	228 NE	3.4	Alive
Ashley River	Blenheim	E7759	10 Dec 1960	6 Dec 1963	227 NNE	3.0	Dead
Ashley River	Blenheim	E81587	11 Dec 1972	10 Mar 1980	220 NNE	7.3	Dead

Table 4 Distances moved by black-billed gulls after banding. Numbers in parentheses are % of birds banded. There were 141 records from the Ashley River with no localities/distances given.

				Post-banding records			
River	Chicks banded	Post-banding records	Individual birds	>200 km	101–200	51–100	0–50
Kowhai	120	10 (8.3)	10 (8.3)	1	6	0	3
Conway	1,976	69	65 (3.3)	2	26	5	36
Waiau	77	1	1 (1.3)	0	1	0	0
Waipara	309	4	4 (1.3)	1	0	0	3
Waimakariri	160	0	0	0	0	0	0
Ashley	13,062	1,670	1,183 (9.1)	15	17	57	1,440
Total	15,694	1,754	1,263 (8.1)	19	50	62	1,482

DOC supplied files contained 79 sightings of 60 breeding birds, all from the Ashley/ Ōkūkū Rivers system. Other birds were found on colonies in the breeding season, e.g. as given in Table 5, but with no indication of their breeding status. Thirty-four birds were 2-year-olds, of which 30 had eggs or chicks; the oldest was a 16-year-old. Thirty-three birds were breeding on their natal river, 27 more probably were but some could have been on the Waimakariri River, and the balance were at other rivers (Table 7). Birds were seen breeding on the Ashburton River (39813, 111 km SW), the Waiau River (E100401, 80 km NNE), and the confluence of the Waimakariri and Hawdon Rivers (E18595, 65 km WNW) indicating the presence of a colony there. Another bird, (E11848) was listed in DOC files as being seen with chicks 143 km NE of the Ōkūkū River bridge colony. Because the coordinates of the sighting location (43.330°S, 173.667°E) are rounded down the nearest 10′ (0.167°), this places the bird in a block SE of that point which includes the Kaikōura Peninsula red-billed gull colony where black-billed gulls have bred (LKR *pers. obs.*).

2. Conway River

Over six seasons between 1960 and 1971, 1,976 chicks were banded on the Conway River 3–12 km upriver from the coast, with two colonies present in 1965 (Table 2). The most chicks banded in a season at a colony was in 1963, when 1,358 chicks were banded in 1 day. There were 69 banded birds recorded later, with 31 being on the Conway River or at its mouth. Records away from the colonies were made between Herbertville Beach, East Coast North Island, 358 km NE of the banding sites, and the Waitaki River, 312 km SW (Table 3). One bird found at Blenheim and 25 near Christchurch were over 100 km from the Conway River; 4 of the birds between 50 and 100 km away were also near Christchurch, the other having travelled north. The oldest sighting was E32493 at Christchurch aged 7.4-years-old. Apart from on the Conway River, birds found during the breeding season were near/at colonies on the Ashley, Ōkūkū, and Waimakariri Rivers with no indication of their breeding status; three 9-month-old birds were found at Ashley Gorge at the start of a breeding season (Table 5). After fledging, birds soon left the colony with one found dead at Kaikōura 35 days after banding and others being sighted in Christchurch 3 months after banding.

3. Waipara River mouth

Black-billed gull chicks were banded near the Waipara River mouth solely in 1966 (309 chicks; Table 2). One of these was recovered nearly 15 months later at the mouth of the Tutaekuri River (527 km NE of the banding site;

Table 5. A selection of black-billed gull sightings at rivers other than natal rivers during the breeding season (Sep–Dec). Movements between the Ōkūkū and Ashley Rivers are not included as the Ōkūkū River is a tributary of the Ashley River.

Natal river	Resight river	Band no.	Date banded	Date found	Age (Years)	Breeding status
Kowhai River	Conway River	E3329	6 Dec 1959	8 Dec 1962	3.0	Unknown
		E3344	6 Dec 1959	8 Dec 1962	3.0	Unknown
		E3347	6 Dec 1959	8 Dec 1962	3.0	Unknown
		E3361	6 Dec 1959	21 Oct 1970	10.9	Unknown
Conway River	Ashley River	E5115	27 Nov 1961	18 Nov 1962	2.0	Unknown
	Ashley R−Gorge	E3210	27 Nov 1960	3 Nov 1963	2.9	Unknown
		E11210	26 Nov 1961	5 Sep 1964	2.8	Unknown
		E25965	10 Nov 1963	5 Sep 1964	0.8	Unknown
		E25975	10 Nov 1963	5 Sep 1964	0.8	Unknown
		E32833	10 Nov 1963	5 Sep 1964	0.8	Unknown
	Ōkūkū River	E3252	29 Nov 1960	4 Nov 1962	1.9	Unknown
	Waimakariri River	E37792	10 Nov 1963	15 Sep 1965	1.9	Unknown
Waipara River	Ashley River	E46730	20 Nov 1966	20 Dec 1972	6.1	Dead on colony
		E46739	20 Nov 1966	11 Nov 1970	4.0	Unknown
Ashley / Ōkūkū River	Kaikōura Peninsula	E11848	11 Nov 1962	12 Dec 1965	3.1	With chick
		E100401	11 Nov 1974	5 Nov 1990	16.0	Breeding
		E24483	2 Dec 1962	14 Nov 1964	2.0	Unknown
	Waimakariri River	38062	5 Dec 1958	6 Dec 1962	4.0	1 egg
		E7130	10 Dec 1960	24 Nov 1963	3.0	Unknown
		E7177	10 Dec 1960	11 Dec 1962	2.0	Unknown
		E7228	10 Dec 1960	2 Nov 1963	2.9	Unknown
		E7741	10 Dec 1960	7 Dec 1963	3.0	Breeding
		E7775	10 Dec 1960	24 Nov 1963	3.0	Breeding
		E7805	10 Dec 1960	2 Nov 1963	2.9	Breeding
		E7909	18 Dec 1960	20 Dec 1962	2.0	>1 egg
		E7997	18 Dec 1960	2 Nov 1963	2.9	Breeding
		E8004	10 Dec 1960	18 Dec 1962	2.0	1 egg
		E8064	10 Dec 1960	3 Nov 1963	2.9	Unknown
		E8075	10 Dec 1960	23 Nov 1963	3.0	Breeding
		E8078	10 Dec 1960	11 Dec 1962	2.0	Not Breedng
	Rakaia River	E76566	13 Nov 1970	10 Dec 1982	12.1	>1 egg
		E80872	16 Nov 1972	10 Dec 1982	10.1	>1 egg
		E100246	8 Nov 1974	10 Dec 1982	8.1	>1 egg
		E100421	11 Nov 1974	10 Dec 1982	8.1	1 egg
		E100477	11 Nov 1974	10 Dec 1982	8.1	>1 egg
		E100630	13 Nov 1974	10 Dec 1982	8.1	>1 egg
		E105109	15 Nov 1974	10 Dec 1982	8.1	>1 egg
	Ashburton River	39813	12 Dec 1958	2 Dec 1962	4.0	>1 egg
		39824	12 Dec 1958	2 Dec 1962	4.0	Unknown
		E7562	10 Dec 1960	2 Dec 1962	2.0	Not breeding

Table 6. Oldest sightings of black-billed gulls banded at the Ashley River.

Natal river	Resighting location	Band	Date banded	Date found	Age (Years)	Status
Ashley River	Amberley Beach	E80308	22 Nov 1970	6 Jan 1993	22.1	Recently dead
Ashley River	Christchurch−Templeton	E100973	13 Nov 1974	15 Oct 1995	20.9	Farm–band only in soil
Ashley River	Christchurch–New Brighton beach	E95695	19 Nov 1972	12 Jan 1991	18.2	Shot
Ashley River	Waiau River upstream of Hanmer turnoff	E100401	11 Nov 1974	5 Nov 1990	16.0	Sight
Ashley River	Central Christchurch	E81427	5 Dec 1972	1 May 1988	15.4	Sight
Ashley River	Central Christchurch	E81087	3 Nov 1972	24 Apr 1988	15.4	Sight
Ashley River	Waikuku Beach	E100934	13 Nov 1972	26 Jan 1990	15.2	Dead

Table 7. Sightings of breeding black-billed gulls banded on the Ashley and Ōkūkū Rivers and found breeding elsewhere, with breeding locality and age.

		Breeding locality								Age (Years)						
Breeding Status	**Total**	**Uncertain river**	**Ashley/ Ōkūkū Rivers**	**Kaikōura Peninsula**	**Waiau River**	**Waimakariri River**	**Hawdon River**	**Rakaia River**	**Ashburton River**	**2**	**3**	**4**	**8**	**10**	**12**	**16**
Breeding - no detail	32	21	5		1	5				3	27	1				1
With mate	3	1	2							3						
With 1 egg	16	1	12			2		1		10		5	1			
With > 1 egg	23	4	10			1	1	6	1	14		2	4	2	1	
With 1 chick	3		2	1						2	1					
With > 1 chick	2		2							2						
Total	79	27	33	1	1	8	1	7	1	34	28	8	5	2	1	1

Table 3). Another two were seen at Ashley River colonies, about 20 km SW, during breeding seasons, but with no record of their breeding status (Table 5).

4. Waimakariri River
During 1962, 150 chicks were banded on the Waimakariri River (Table 2); none was sighted subsequently.

5. Kōwhai River near Kaikōura
During 1959–1960, 120 chicks were banded near the SH1 road bridge, 0.4 km from the sea (Table 2); 10 of these chicks were subsequently recorded away from the Kowhai River. The only bird found over 200 km away from the colony was E3361 269 km SW, probably near the Rangitata River mouth given it was caught in a fishing line and this site was in the rectangle based on coordinates in the database (Tables 3 & 4). Six birds were found 101–200 km away (Table 4), five at Christchurch to the south and one at the Wairau River to the north. Three 3-year-old birds were sighted at the Conway River (Table 5). The oldest sighting was E3361 seen at the Rangitata River at almost 11-years-old.

6. Waiau River
Seventy-seven chicks were banded in 1973 opposite Gabriels Gully on SH7, 5 km above the Hanmer Springs turnoff and 62 km from the sea (Table 2). A bird found at Wakanui Beach, 177 km SSW of the banding site, 7 months after banding was the only subsequent record.

DISCUSSION

Site fidelity of black-billed gull colonies was low, with colonies found in different locations on a river from year to year. For example, in the Conway River, colonies were found 3 km from the sea, at Glen Colwyn 10 km upstream, and at Ferniehurst 15 km upstream. Only two colonies were found in the Ōkūkū River, both in 1962. In other years, these birds probably nested in the Ashley River where 1–4 colonies were found in any one year from Ashley Gorge down to 5 km from the sea, a distance of 35 km, and in Lees Valley (Fig. 1). Colony locations changed from year to year, probably due to changing habitat conditions as a result of flooding or weed encroachment (Beer 1966; McClellan 2009; McClellan & Habraken 2013).

Treating the numbers of chicks banded as a surrogate for colony population size, there was a large variation in the numbers of chicks produced. Four studies listed in Higgins & Davies (1996) plus that of McClellan (2009) had an average clutch size of 2.0 eggs. Assuming this average applied to the Ashley River, all eggs hatched and all chicks were banded, the six largest colonies would have been in the region of 500–800 nests (average about 700 nests), and the others between about 10 and 260 nests (average about 110 nests); the average for all colonies was about 230 nests. These ballpark figures will be underestimates to an unknown degree as some eggs would not have hatched, some chicks died before banding, and we did not band all chicks despite attempting to do so. The average Ashley River colony size, 230 nests, is 23% more than the average size from 5 censuses from 1995-96 to 2016-17 of Ashley River. However, Ashley River colonies were much smaller than the average size of all Canterbury colonies: 768 nests/colony (calculated from Tables 2 & 5 in Mischler 2018), and the super colony of about 7,500 nests on the Ashburton River in 2017 (Bell & Harborne 2019). Other super colonies have been noted on the Ashburton River in 2014 and the lower Rangitata River in 2015, each over 10,000 birds (McClellan & Habraken 2013), and in Southland where, for example, the Eyre Creek and Whitestone colonies were over 5000 birds in 2006 (McClellan 2009). No trend was detected in the numbers of chicks banded over time in the period 1958–1974 in the Ashley River, probably because of the large annual fluctuations shown in Table 2.

Sightings of Ashley River juveniles revealed that they leave their natal colony soon after fledging, with one seen off-colony only 14 days after banding as a chick, and others less than one month after. This fits the pattern of black-billed gulls rapidly abandoning the colony after breeding finishes (Higgins & Davies 1996; McClellan & Habraken 2013). Previous examples of black-billed gulls dispersing rapidly after fledging included one found dead at Waikuku Beach 27 km away 37 days after banding (Kinsky 1957), one found at Pelorus Sound 54 days after it was banded on the Wairau River 64 km away, one found at Island Cliff 69 days and 240 km from the Aparima River, and one that moved from Oreti River to Christchurch (450 km) within 85 days (Kinsky 1963).

Sightings of birds banded in this study revealed that individuals bred at colonies up to 135 km from where they fledged. The furthest of these was one that nested next to a red-billed gull colony at Kaikōura Peninsula, 135 km away from the banding site. The longest river to river movements were from the Ashley River system to the Ashburton River (110 km SSW) and the Hawdon River mouth (65km WNW). This may not be unusual as a bird from the Ashley River was previously reported at the Waipara River (Dawson 1954) and McClellan (2009) reported extensive movements of black-billed gulls between rivers in Southland. Similarly, red-billed gulls have been shown to disperse and breed away from their natal colonies (Mills 1970; Rowe 2024b).

Black-billed gulls can start breeding in their second year (Heather & Robertson 2005; McClellan & Habraken 2013), though this is based on very few records. A bird banded on the Ashley River was found nesting at the Waipara River as a 2-year-old (Bull 1953; Dawson 1954) as were other 2-year-olds at the natal colony (Dawson 1954). McClellan (2009) found 2-year-olds breeding in her Southland study. This study provides additional support for these findings, with 34 records of 2-year-old gulls found breeding at natal and non-natal rivers.

The furthest distance a bird from this study was found away from its natal colony was 736 km that E37749 travelled from the Ashley River to the Firth of Thames, a distance 31% more than the maximum dispersal of 560 km given in McClellan & Habraken (2013); the second furthest was E46468 from the Waipara River to the Tutaekuri River (527 km). These distances are comparable to those travelled by Southland birds to Ngakutu Bay near Picton, about 700 km, and Goose Bay near Kaikoura, about 570 km (McClellan 2009). Other long distance recoveries included 480 km from Aparima River north to Christchurch, 470 km from Ashley River to Wellington, and 450 km from Oreti River to Christchurch (Kinsky 1961, 1962). The longest distances travelled by black-billed gulls banded in North Canterbury cover a similar range to that reported for red-billed gulls banded at Kaikōura Peninsula, about Auckland in the north to Stewart Island in the south (Rowe 2024b).

The oldest of the banded chicks found was a dead bird aged 22.1 years-old, which is less than the maximum longevity of 27.3 years given by McClellan & Habraken (2013) and the maximum of 28.2 years for a red-billed gull at Kaikōura (Rowe 2024b). Age records in this study have to be qualified by the band types used, which were mainly less durable aluminium. Mills (1972) has shown that for red-billed gulls losses occurred after 4 years for butt-to-butt aluminium bands, which limited reliable re-sighting duration estimates unless birds were rebanded with stainless steel band; losses of aluminium H bands occurred after 6 years. Black-billed gulls in Southland have been shown to lose metal bands at ages between 7 and 9 years (McClellan 2009). The oldest recovery of an aluminium banded bird in this study was 10.9 years, which suggests that band loss may have occurred. Only seven birds of the 15,734 banded in this study were recovered over 15-years-old, the oldest (at 22.1 years) had a monel band that was reported as very worn, as was the oldest stainless steel band recovered (on a bird shot aged 18.2 years).

In summary, black-billed gulls colonies in North Canterbury rivers move up and down stream from season to season, individuals have been shown to move distances up to 736 km, and to live up to 22 years. They have bred at 2-years-old and many have been found at sites other than their natal rivers. McClellan (2009) postulated that dispersal by Southland black-billed gulls meant they could constitute a single intermixing population, and movements by black-billed gulls banded in Canterbury support this.

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Breeding seabird assemblage of Rapa, Austral Islands, Eastern Polynesia

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Abstract: Rapa Island, located in Eastern Polynesia, hosts 12 species of breeding seabirds, now primarily found on its ten peripheral islets. These seabirds face various threats, such as invasive mammals that prey on eggs and chicks, as well as invasive plants that encroach upon and degrade their breeding habitats. Major island restoration projects are currently underway on several islets, focusing on the removal of invasive mammals and plants. We present data collected here between 2017 and 2024 and, together with published and unpublished surveys since 1921, compile details on the distribution, population, and breeding seasons of these seabird species.

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INTRODUCTION

Rapa (27°35′S 144°20′W) is the southernmost inhabited island of the Austral archipelago, and is surrounded by ten islets (Figs 1 & 2). It is a mountainous volcanic island, with Mount Perau (650 m) as its highest point. Rapa is home to approximately 500 inhabitants, distributed across two villages (A'urei and Area). The island has been relatively well-surveyed by ornithologists due to the presence of two endemic species, a storm petrel and a shearwater (Thibault & Varney 1991; Shirihai *et al*. 2017). Some ornithologists have visited Morotiri (formerly Marotiri), also known as Bass Rocks, located 83 km southeast of Rapa (Gaskin 2007; Flood *et al.* 2021).

Rapa's seabirds face a range of threats, including invasive mammals that prey on eggs and chicks, as well as invasive plants that encroach on breeding habitats and provide additional seasonal food sources for Pacific rat (*Rattus exulans*). Major island restoration projects are currently underway on several islets and the main island, focusing on the removal of invasive mammals and plants. These efforts are managed by the Polynesian Ornithology Society (SOP-Manu) in collaboration with its partners, BirdLife International, and the local Rapa NGO Raumatariki.

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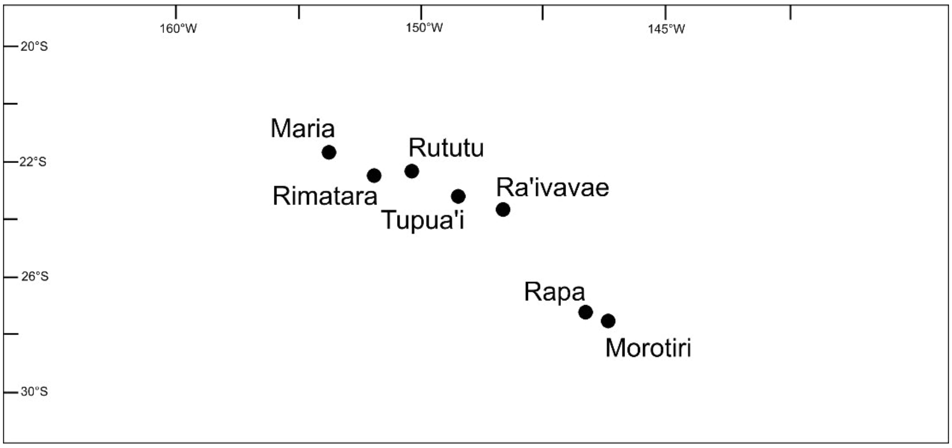

Figure 1. Spatial arrangement of the Austral Islands, showing the locations of Rapa and Morotiri.

Figure 2. Map of Rapa and surrounding islets (islets named in white, not italics).

Since 2017, SOP-Manu has supported the Rapa community in restoring uninhabited islets to protect seabirds by removing goats and working towards the eradication of rats, which was successfully achieved on some islets in November 2023 (Table 1). During this conservation work, additional studies on seabirds were conducted between 2019 and 2024, to further inform strategies for protecting these species in the future.

In this paper, we combine historical and recent findings from Rapa to update the list of 12 breeding seabird species, to provide estimates of their breeding populations, to establish a breeding phenology calendar, and, using sporadic historical data collected over the past century, to infer long-term population trends for these species. None of the seabirds are abundant, including the two local endemics (Rapa shearwater *Puffinus myrtae* and white-bellied storm petrel *Fregetta grallaria titan*), both of which are of conservation concern.

METHODS

Historical visits

In the 19th century, Captain Frederick W. Hutton brought back a fruit dove specimen, which Finsch (1874) described as a new species (*Ptilinopus huttoni*). However, it remains unknown whether other birds, particularly seabirds, were collected during this visit. Vine Hall (1869), in his description of Rapa, only mentions, "*there are a few fowls, wild in the bush* [fruit dove?], *some widgeon* [Pacific black-duck *Anas superciliosa*], *and of course sea-gulls* [noddies and petrels?]." It was not until the Whitney South Seas Expedition (WSSE), organised by the American Museum

Table 1. Characteristics of islets surrounding Rapa (2024 data). Goats have been removed from all islets; however, they remain on Rapa (along with cats, dogs, cows, and horses).

Islet/Island	Area (ha)	Altitude (m)	Distance offshore (m)	Breeding seabirds	Pacific rat presence
Aturapa	1.94	44	187	Yes	Unknown
Karapoo Koio (= Iti)	2.27	130	63	Yes	Absent
Karapoo Rahi (= Nui)	10.21	215	28	Yes	Present
Rapa Iti	4.24	85	57	Yes	Eradicated
Rarapai	1.29	53	115	Yes	Absent
Tapiko	0.32	20	66	Yes	Absent
Tapu'i	0.94	27	141	No	Present
Tarakoi	1.92	64	213	Yes	Absent
Tauturou	20.09	151	383	Yes	Eradicated
Tuamotu	0.29	13	17	No	Unknown
Rapa (main island)	4,000	650		Yes	Present

Table 2. Temporal spread of observation (and specimen collection) dates on Rapa and surrounding islets.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sources and observers
1921				X									WSSE, AMNH (R.H. Beck & E. Quayle)
1922		X											WSSE, AMNH (R.H. Beck & E. Quayle)
1925				X									BMNH (H.J. Kelsall *in* Bourne 1959)
1934												X	BMNH (Crocker Exp.)
1968				X	X								MNHN (Lacan ms)
1974										X	X	X	EPHE-MNHN (J.-C. Thibault *pers. obs*)
1984	X	X											Ehrhardt (1986)
1989												X	Thibault & Varney (1991); Seitre & Seitre (1991)
1990	X												Thibault & Varney (1991)
1993		X											A. Guillemont (*pers. comm.* to VB)
2002			X	X								X	K. Wood (unpubl. data); B. Fontaine (*pers. comm.* to J-CT)
2017			X	X									Butaud *et al.* (2018)
2019			X					X	X		X	X	Thibault & Withers (*pers. obs*), Shirihai (*pers. obs*)
2020							X						Withers *et al.* (*pers. obs*)
2021					X	X							Withers *et al.* (*pers. obs*)
2022							X	X					Withers & Luta (*pers. obs*)
2023				X			X				X	X	Withers *et al.* (*pers. obs*)
2024				X			X			X	X		Withers *et al.* (*pers. obs*)

of Natural History (New York) at the beginning of the 20th century, that the first inventory of the avifauna was conducted. The WSSE visited Rapa 14–20 Apr 1921 and 15–26 Feb 1922. Ernest Quayle (1921, 1922) mentioned the two islets, Rapa Iti (noting the presence of goats) and Tauturou (noting the presence of rabbits last recorded in 1988); however, he likely only visited Karapoo Koio (the only islet that he mentioned specifically). His colleague Beck (1921-22) visited and collected specimens on other islets without specifying their names (likely including Tarakoi). Few naturalists visited the islands during the 20th and early 21st centuries, until 2017, when the Société d'Ornithologie de Polynésie began eliminating invasive species from the islets for the conservation of seabirds and coastal vegetation (Table 2).

Modern data collection

Data were collected during visits to the islets by the authors between 1974 and 2024, as well as by analysing the field journals of WSSE collectors and the few publications dedicated to the birds of Rapa. Label information from preserved bird specimens deposited in museums also provided valuable information (including 183 petrel specimens held by American Museum of Natural History (AMNH), New York; Natural History Museum (BMNH), Tring, England; Leiden; Harvard; Yale Peabody; Smithsonian National Museum of Natural History (USNM) Washington; and Muséum national d'histoire naturelle (MNHN), Paris). Bird nomenclature follows the list compiled by Gill *et al.* (2024). Local bird names were recorded from community members during stays in Rapa. In recent surveys, bird numbers were estimated by counting individuals, nests with eggs, or chicks during daytime observations. The numbers of several petrel species were assessed by counting the number of nests or burrows within quadrats as follows: white-bellied storm-petrel nests in 3 quadrats of 728 m² on Tarakoi; black-winged petrel (*Pterodroma nigripennis*) burrows in 10 quadrats of 100 m² on Tauturou in 1989 and 1990; Murphy's petrel (*Pt. ultima*) in ten randomly selected quadrats, each covering an area of 400 m², on Tauturou in 2019. In areas of the quadrats where vegetation exceeded 1.5 m in height, the presence of petrels was checked using the "war-whoop" method (Tennyson & Taylor 1990). The Murphy's petrel population (and 95% confidence interval for the mean) on Tauturou was calculated based on the island's area of 20.09 ha minus 25% [an estimate of the area where the strawberry guava (*Psidium cattleyanum*) grove and the Pacific Island silvergrass (*Miscanthus floridulus*) are too dense for the Murphy's petrels]. Since 2019, burrow contents have been assessed using an endoscope (Bosch & Bluefire), automatic capture cameras (Reconyx), and SMA automatic audio recorders. Chick development was classified into three stages: 1 = Fully covered in down; 2 = Body covered in down, but feathers begin emerging on wings and tail; 3 = Mainly feathered, with some down remaining on various parts of the body, particularly the back and head.

For each of the 12 breeding seabird species on Rapa, we first present the chronology and trends of the data, followed by the breeding periods, and finally, general remarks on their habitat. These observations are supplemented with data collected at sea off Rapa (Flood *et al.* 2021) and on the Morotiri Rocks (Gaskin 2007 and *pers. comm.* to J-CT 2006).

RESULTS

Red-tailed tropicbird (*Phaethon rubricauda*) tavake

Pre-European remains were found in archeological excavations on Rapa (Tennyson & Anderson 2012). **1921-1922**. Noted inland on Rapa as a breeder performing aerial displays (at least one group of 12–15 individuals), and breeder on Karapoo Koio (a large chick in a cave). **1974**. Nesting occurred on Rapa's coastal cliffs [Autea, Makatea (about 100 individuals), Rukuanga (about 100 individuals)], and inland in low numbers (Aurei: *c.* 50 individuals). Breeding sites on islets included on Karapoo Koio, Karapoo Rahi (several dozen pairs), Rapa Iti, Rarapai, Tarakoi, Tauturou. **1989-1990**. Breeding on Rapa, primarily on the large cliffs and in certain inland areas (Aurei, Ana Rua). Also bred on Tarakoi (8–15 pairs), Rarapai (5 pairs), Rapa Iti (5–10 pairs), Karapoo Koio (5–10 pairs), and Karapoo Rahi (10–30 pairs). The overall population was estimated at *c.* 1,000 pairs. **2017–2024**. Abundant in the cliffs of Rapa where several hundred breeders were recorded; also found on most islets (Karapoo Rahi, Karapoo Koio, Rapa Iti, Rarapai, Tapiko, Tarakoi, Tauturou); the largest colony is currently situated on Tauturou (100–500 pairs), with numbers elsewhere varying from several pairs to several

Table 3. Monthly calendar of breeding activities for seabirds on Rapa. Pale grey = adults present; dark grey = eggs and/or chicks recorded; **?** = insufficient data.

Species		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Red-tailed tropicbird	adults	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey
	eggs/chicks	dark grey	dark grey	dark grey	dark grey	dark grey	dark grey	dark grey	dark grey	dark grey	dark grey	dark grey	dark grey
White-bellied storm-petrel	adults	pale grey	pale grey	pale grey	pale grey	**?**	pale grey	pale grey	pale grey	**?**	pale grey	pale grey	pale grey
	eggs/chicks	dark grey	dark grey	dark grey	dark grey		dark grey	dark grey			dark grey	dark grey	dark grey
Polynesian storm-petrel	adults	**?**				**?**	pale grey	pale grey	pale grey	**?**	pale grey	pale grey	pale grey
	eggs/chicks							dark grey	dark grey		dark grey	dark grey	dark grey
Murphy's petrel	adults			pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	
	eggs/chicks				dark grey	dark grey	dark grey	dark grey	dark grey	dark grey	dark grey		
Kermadec petrel	adults	pale grey	pale grey	pale grey	pale grey		pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey
	eggs/chicks	dark grey	dark grey	dark grey	dark grey		dark grey	dark grey				dark grey	dark grey
Black-winged petrel	adults	**?**	pale grey	pale grey	pale grey							pale grey	pale grey
	eggs/chicks		dark grey	dark grey	**?**								dark grey
Rapa shearwater	adults			pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey		
	eggs/chicks								dark grey	dark grey	dark grey		
Christmas shearwater	adults	**?**	pale grey	pale grey	pale grey	**?**	**?**	**?**	**?**	pale grey	pale grey		pale grey
	eggs/chicks		dark grey	dark grey	dark grey						dark grey		dark grey
Grey noddy	adults	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey
	eggs/chicks	**?**	**?**	**?**	**?**	**?**	dark grey		dark grey	**?**	dark grey	dark grey	dark grey
Brown noddy	adults	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey				pale grey	pale grey	pale grey
	eggs/chicks	**?**	dark grey									dark grey	dark grey
White tern	adults	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey	pale grey
	eggs/chicks	**?**	dark grey	dark grey						**?**	dark grey	dark grey	dark grey

tens of pairs. The distribution has remained unchanged between 1974 and 2024; however, there are few census data.

Red-tailed tropicbirds breed year-round on Rapa, with no peak breeding season detected (Table 3). Nests were situated on ledges in cliffs, in caves, and in rock shelters.

White-bellied storm-petrel (*Fregetta grallaria titan*) kōru'e

This subspecies, endemic to Rapa and Morotiri, was described by Murphy (1928). It is larger than other *grallaria* subspecies, but is genetically closely related to other *grallaria* taxa (Cibois *et al*. 2015).

Pre-European bone remains were found in archeological excavations on Rapa (Tennyson & Anderson 2012). **1922**. Collected by the WSSE on Karapoo Koio: "*On the grassy slopes, mostly in the grass or in slightly excavated holes beneath clumps of grass or weeds, we found the petrel*, F. grallaria, *nesting in abundance*" (Quayle 1922). **1974**. Small breeding populations were recorded on Karapoo Koio, Rarapai, Tarakoi, and Rapa Iti (with only one occupied nest). Sites were shared with the Polynesian storm-petrel (*Nesofregetta fuliginosa*) on Rarapai and Tarakoi. **1989–1990**. Recorded on Karapoo Koio (observed during the day overflying the island), Rapa Iti (one observed in flight), Rarapai (both islets: 20 empty nests, 11 occupied nests), Tapiko (one pair, 13 empty nests), and Tarakoi (357 occupied nests; with 95% confidence limits of 288–412). **2017–2024**. Recorded on Karapoo Koio (exact number unknown), Rarapai (> 10 pairs), Tapiko (20–50 pairs), and Tarakoi (20–50 pairs). The birds were observed at various times during the night on Tauturou and Rapa Iti, but no nests were found. Breeding inland on Rapa is almost certain (although no nest found), since several tens of flying storm petrels were observed at night 9–10 Dec 2019, at an elevation of approximately 600 m, on the ridge between Mount Perau and Mount Karere. The population on the islets is fewer than 200 pairs; it remains unknown on Rapa. Maximum numbers seen at sea during chumming operations in Nov -Dec 2019 off Rapa were 120 on 12 November, 70 on 18 Nov, >100 on 3 December, and 60 off Morotiri on 24 November (Flood *et al.* 2021).

Individuals visit colonies every month of the year (Table 3). Laying typically begins in the second half of October; however, the influx to the colonies in November and December does not necessarily result in an increase in egg laying. Possible inter-annual variations are noted, such as in Feb 1922, when the WSSE mainly found nests with "*fresh*" eggs. A low number of chicks were found in the nests during each visit from March to July (two chicks were collected by WSSE in April). Number of breeding pairs (either with eggs or chicks) has remained very low, although the number of individuals visiting the islets can reach several hundred, especially in December. For instance, on the night of 24 Dec 1989, at around 7:00 PM, several hundred individuals were observed circling Tarakoi, with some displaying moulting of flight feathers. An hiatus at the colonies is noted during the southern winter, although some birds visit the islets at night (e.g., August 2019 when birds arrived in low numbers – a maximum of tens – at nightfall and left the island before sunrise). On Tarakoi in December 1989, the majority of nests were found under or against rocks (42 of 79), 24 were under grass, 9 were in small caves and 4 were without any protection.

Polynesian storm-petrel (*Nesofregetta fuliginosa*) kōru'e

Different populations vary significantly in colouration (Crossin 1974) and in size (Holyoak & Thibault 1984), with a cline from the largest individuals in Rapa to the smallest in the Marquesas islands. Only one plumage variant, the pale morph, was encountered on Rapa.

1921–1922. Not recorded by the WSSE, birds being probably absent at the time of their visit (February and April). **1974**. Breeders on Tarakoi, Rarapai, and possibly Karapoo Koio. **1989–1990**. Breeders observed on Rarapai

(25–99 pairs), Tarakoi (10–99 pairs), possibly Tapiko and Karapoo Koio (individuals observed in flight, but no nests found). **2002**. A partial census recorded 12 occupied nests on Tarakoi (B. Fontaine, *pers. comm*. to J-CT, 2002). **2017–2024**. Breeders observed on Rarapai and Tarakoi. Additionally observed on Tapiko on 2 Jun 2021, where an adult was found dead alongside a chick. Overall, the estimated number was less than 100 pairs. Breeding likely occurred on Morotiri with up to 5 birds seen between the rocks (Chris Gaskin, *pers. comm*. to J-CT, 2006). Maximum numbers seen at sea during chumming operations in Nov–Dec 2019 off Rapa were 240 on 12 Nov, and 30 off Morotiri on 24 Nov 2024 (Flood *et al*. 2021).

Birds were absent from colonies at least from February to April. Laying mainly occurs from July to December. In 1974, we noted eggs on 17 Oct, eggs and chicks at all stages on 7 Nov, although the number decreased on 6 Dec; in 1989, only chicks were present during the second half of December. Elsewhere, the breeding period is related to latitude; egg-laying is spread throughout all months near the equator in Line and Phoenix Islands (Crossin 1974), and Marquesas (Holyoak & Thibault 1984); it is seasonal and shorter on southern islands, such as Gambier (Lacan & Mougin 1974; Holyoak & Thibault 1984), and Rapa (Table 3). Nests were found from just a few metres above sea level to the top of the islets. They were positioned against rocks, within narrow cavities, and were always concealed by vegetation. However, often the tail and wings of the birds protruded into the open. Nests were composed of a few dry grasses or twigs. The nesting sites do not differ from those of the white-bellied storm-petrel.

Murphy's petrel (*Pterodroma ultima*) ʼeūpo
1921-22. Two individuals collected by the WSSE on Rapa on 4 Apr 1921 were misidentified as *Pt. solandri* (Quayle 1921). During the second WSSE trip to Rapa 16–27 Feb 1922, they searched unsuccessfully for the "*blue shearwater*" or "*blue-faced shearwater*" [likely *Pt. ultima*] (Quayle 1922). During the same trip, 44 specimens were collected off Morotiri on 27 Feb 1922. **1974**. Visits were conducted at the end of the breeding season, coinciding with the departure of birds for migration. A few pairs and large chicks were observed on the following islets: Karapoo Koio, Rapa Iti, Tapiko, and Tauturou. **1989–1990**. Breeders on Rarapai (25–99 pairs), Tarakoi (10–99 pairs), perhaps Tapiko and Karapoo Koio (some seen in flight, but no count). **2017–2024**. The first comprehensive censuses were undertaken during 2019–2023, during the breeding period. The species breeds on islets but apparently not on Rapa itself. Breeding populations were observed on Karapoo Rahi (more than 40 pairs), Karapoo Koio (20–50 pairs), Rapa Iti (30–50 pairs), Rarapai (5–20 pairs), Tapiko (5–20 pairs), Tarakoi (*c*. 10 pairs), and Tauturou, which serves as the main breeding site. In August 2019, the population estimate for Tauturou was 2,863 ± 916 pairs. The estimate is derived from the number of active nests, including eggs, chicks, and juveniles, and therefore does not account for failed breeders. On Morotiri, several 100s of pairs were seen in September (Chris Gaskin, *pers. comm*. to J-CT, 2006), 1000s of birds were seen by G. Wragg in Apr-May 1999 (Anon. 2002); however, only a few birds were seen in November 1989 (Zimmer 1992) and 5-6 individuals in October & November 2019 (Flood *et al*. 2021).

Absent from breeding sites from November (last record on 6 December) to late February (first record on 16 March on Rapa islets). First eggs were laid at the beginning of April (Table 3). Nests were in the open in eroded areas, or hidden under ferns, guava trees, or among sparse *Miscanthus* grasses.

Kermadec petrel (*Pterodroma neglecta*) kea
Pre-European bone remains were found in archeological excavations on Rapa (Tennyson & Anderson 2012). **1921–1922**. Collected by the WSSE from the coastal cliffs of Rapa (Makatea) and on islets in April 1921 (10+) and February 1922 (30+). **1974**. Rapa: aerial displays of several dozens of birds observed (likely breeding) on the hills and cliffs of Makatea, Maurua, and Pukumaru. On the islets, found breeding on Tauturou and Karapoo Koio. **1989–1990**. Breeding mainly on islets, also on certain cliffs on Rapa (Makatea, Tevaiputa), and on rocky faces and slopes inland (Aurei, Pukumaru, Mauroa, Perau). Total population estimated at less than 1,000 pairs, with the main colony on Karapoo Rahi (100–500 pairs). **2002**. Up to five pairs displaying together by day on the crests of mounts Perau and Maugaoa (B. Fontaine, *pers. comm*. to J-CT, 2002). **2017–2024**. Breeding inland and on sea-cliffs of Rapa, but mainly on islets. Tauturou and Karapoo Koio were the main breeding sites and the total population was estimated at less than 1,000 pairs. On Tauturou 50–100 pairs were found in December 2019; however, 280 and 300 individuals were counted on 13-14 Mar 2019, and 100 chicks plus 60 incubating birds on 22 Mar 2021 (Withers *et al*. 2021). On Morotiri, suspected breeding on South and West rocks on 16 Dec 1991 (Seitre & Seitre 1991); only a single bird was seen during a landing on South-East Islet on 22 Sep 2006 (Chris Gaskin, *pers. comm*. to J-CT, 2006). Maximum numbers seen at sea during chumming operations in Nov-Dec 2019 off Rapa were 20 on 26 November as well as on 14 December, with 3–20 individuals seen daily (Flood *et al*. 2021).

On Tauturou, nests were on the ground beneath bushes, like Murphy's petrel's. Breeds year round: eggs and chicks recorded most months of the year, with peaks of presence in Nov-Dec, mainly with eggs (1989, 2019, and 2023); in January (1990) and February (1922) with eggs and chicks; and in Feb–Apr with older chicks (2019 & 2021). In Aug–Oct small numbers were noted, although one chick at stage 3 was recorded in August 2019. In addition, there are inter-annual differences in the breeding periods: during 27–29 Mar 2017, 100–200 individuals were observed; however, no eggs or chicks were seen (Butaud *et al*. 2018), while on 13 Mar 2019, on Tauturou, 280 individuals were counted, with 300 on 14 Mar, mainly with chicks in stages 1 and 2 (Table 3).

Black-winged petrel (*Pterodroma nigripennis*) tītī
Pre-European bone remains were found in archeological excavations on Rapa (Tennyson & Anderson 2012). **1921–1922**. Not noted by the WSSE in April 1921, and more intriguingly not noted in February 1922, during a period when the petrels should have been present on their breeding sites (15–25 February); however, it is uncertain whether Quayle landed on the main breeding sites (Rapa Iti, Tauturou); three specimens were collected at sea on 27 February off the Morotiri rocks, where the collectors could not land due to rough seas (Quayle 1922). The vernacular name in the Rapa language (tītī) was not noted by Quayle in his journal, nor recorded in April 1921 by the anthropologist Stokes (1955). The absence of any record on Rapa itself suggests that birds were not present at that time, since the WSSE members should have noticed their aerial display or presence at sea, as they did on Morotiri. **1974**. Breeding occurred on Rapa Iti and Tauturou. No counts were made; however, the birds were reoccupying sites left vacant by Rapa shearwaters. **1989**. A count conducted in December provided an estimate for the colony on Rapa Iti of *c*. 34–50 pairs, and 657 pairs on Tauturou (with 95% confidence limits ranging from 185 to 1645); the species

was not recorded on Karapoo Koio and Karapoo Rahi. On Tauturou, three sites with burrows occupied by petrels (either this species or Rapa shearwaters) were located: 1) at the top two-thirds of the slope facing Tapiko, 2) below the ridge facing south-southeast, and 3) in the center, facing north, below the ridge; the latter two sites had the largest number of burrows. On Rapa Iti, the burrows were located on the ridge and on the less steep eastern face. **2017–2024**. Found on three islets: Karapoo Koio (first and only record of some displaying birds on 4 Dec 2019), Rapa Iti, and Tauturou. Numbers seemed stable between 1974 and 2024; however, no count of occupied burrows was made during 2017–2024. The population, taking into account the number of displaying birds and frequented burrows, is estimated at *c*. 1,000 pairs. Maximum numbers seen at sea during chumming operations off Rapa in Nov-Dec 2019 were 35 on 26 November (Flood *et al.* 2021).

Highly seasonal. Arrival on breeding sites (Tauturou) recorded from 30 Oct (2024). Laying occurs in December (based on eggs found in burrows on 25 Dec 1989). The last records were on 30 Apr & 3 May 2020, by an automatic camera in front of a burrow on Tauturou (Table 3). The breeding phenology of the isolated population of black-winged petrel on Rapa is very similar to that recorded in Western Pacific waters (BirdLife Australia 2023a; Rayner *et al*. 2023). The same burrows are used successively by black-winged petrels and Rapa shearwaters. On Tauturou, most burrows were located under the grove of introduced strawberry guava at the summit of the islet (southern face), while others were dug directly into the ground, beneath rocks, or within shrubby vegetation. On Rapa Iti, the burrows were mainly in areas with soft soil covered by sparse vegetation, which has become increasingly rare due to overgrazing by goats. The burrows were up to a metre long, narrow, sometimes straight, more often with a bend; the nest was a chamber, lined with twigs and grass found nearby. Density of burrows is higher where the soil is soft.

Wedge-tailed shearwater (*Ardenna pacifica*)
Not recorded as a breeder before a single observation of a large chick in a burrow on Karapoo Koio on 3 Apr 2017. At sea, the species was often observed in Oct & Nov 2019, with up to 80 on 24 November, and 13–30 per day during chumming operations (Flood *et al*. 2021).

Christmas shearwater (*Puffinus nativitatis*)
1922. Several adults and one chick were collected by the WSSE on Karapoo Koio islet. **1974**. A bird incubating an egg in a rocky shelter on Karapoo Koio. **1989–1990**. Breeding on Tarakoi (5–10 pairs), Karapoo Koio (>100 pairs), Karapoo Rahi (>10 pairs) and perhaps a few pairs on Tauturou. **2017–2024**. Karapoo Koio (recorded in 2019, population size unknown); Karapoo Rahi (not recorded; however, the islet was rarely visited during the species' breeding period); Tarakoi (not recorded; a burrow found in July 2020 may have been of this species); one heard at Rapa Iti (2019); Tauturou (several breeders recorded in 2023). Population number probably less than 100 pairs, possibly declining. Maximum numbers seen at sea during chumming operations in Nov-Dec 2019 off Rapa were 150 on 3 December; 300 were seen in Morotiri on 24 November, and 100s were seen on the rocks in the evening on 23 November (Flood *et al.* 2021).

Little information is available on the timing of breeding. Probably a summer breeder on Rapa, with clutches observed as early as October and December (Table 3). Gaskin (2007) found adults incubating on Morotiri in late September 2006. The breeding period is also condensed in the Gambier Islands, with nesting beginning Sep–Nov, and juveniles fledging Feb–Mar (Lacan & Mougin 1974). Further north, Christmas shearwaters breed year-round on Kiritimati in the Line Islands (Schreiber & Ashmole 1970), and on Ra'ivavae Island in the Austral Islands, eggs were recorded in November and chicks in December (Bretagnolle *et al*. in press).

Rapa shearwater (*Puffinus myrtae*) kākikāki
Endemic to Rapa; probably breed also on Morotiri where data are restricted to birds seen at sea (Gaskin 2007).

Pre-European bone remains were found in archeological excavations on Rapa (Tennyson & Anderson 2012), although we cannot exclude that shearwaters were caught on the islets. **1921–1925**. Not collected by the WSSE in February or April; one collected by Kelsall (St. George Scientific Expedition) in April 1925. **1974**. Noted on the following islets: Karapoo Koio (a few pairs), Rapa Iti (three sites totaling around 60 pairs), and Tauturou (150–250 occupied burrows estimated). **1989**. No records were made because the visit was while the shearwaters were absent from breeding sites. **2017–2024**. Recorded on Karapoo Koio (at least 14 burrows), Karapoo Rahi (at least 5 burrows), Tauturou (less than 20 burrows), and Rapa Iti. On the latter islet in 2019–2024, endoscopic inspections of the 60 visible burrows revealed that no more than ten burrows were frequented by Rapa shearwaters, with fewer than 50 birds observed at the site (heard flying in the evening and morning). The total breeding population is less than 100 pairs.

Breeding is probably highly seasonal but there are few data (Table 3). The birds are absent from the colonies in December & January, probably departing in late October or early November [a single individual was seen at sea during chumming operations in Nov-Dec 2019 off Rapa (Flood *et al.* 2021)]. Breeders are present in March: an individual equipped with a GLS the previous year returned on 4 Mar 2020 (Jiguet *et al*. 2024). An image taken on 14 Mar 2019, and video recorded between 15 & 31 Mar 2017, showed two birds in flight and two on the ground (between 4:30 AM and 5:15 AM). A few data on incubation (in July) and chick rearing (from August to October) were obtained (Table 3). Habitat identical to that of black-winged petrel.

Grey noddy (*Anous albivittus*) pararaki
Pre-European bone remains were found in archeological excavations on Rapa (Tennyson & Anderson 2012). **1922**. Quayle (1922) reported isolated individuals and small flocks on Rapa. **1968**. Considered the most abundant of the three tern species, distributed in groups of two to three individuals on most cliffs of main island, with a high concentration on Karapoo Koio islet (Lacan ms). **1974**. Breeding occurred on the cliffs of Rapa, the islets Karapoo Koio and Karapoo Rahi (number unknown), Rapa Iti (several dozen pairs), Rarapai (less than 10 pairs), Tapiko (a few pairs), Tarakoi (several 100 pairs), and Tauturou (a few pairs). **1989-1990** & **2017–2024**. Breeding distribution and numbers are presented in Table 4. The total population was probably a few 100 pairs. In 2024, one year after rat eradication on Rapa Iti, nests with chicks and eggs were found in more easily reachable places, suggesting that predation pressure on the birds has decreased. Maximum numbers seen at sea during chumming operations in Nov-Dec 2019 off Rapa were several 100s on 12 November. There were up to 2000 on Morotiri on 23 & 24 November (Flood *et al.* 2021).

Grey noddies were present year-round on the shores of Rapa and its islets. Eggs and chicks were observed on all visits, with a peak of breeding activity in Oct–Nov (Table 3).

Table 4. Comparison of grey noddy populations on islets off Rapa between 1989 and 2017–2024. (X = 1–10, XX = 11–100, XXX = >100 pairs, and ? = present but number unknown).

Islets	1989	2017–2024
Karapoo Rahi	?	X
Rarapai	XX	X
Tapiko	?	X
Tauturou	XX	X
Karapoo Koio	XX	XX
Rapa Iti	XX	XX
Tarakoi	XXX	XXX
Aturapa		?

Brown noddy (*Anous stolidus*) goio
Pre-European bone remains were found in archeological excavations on Rapa (Tennyson & Anderson 2012). **1922**. Many eggs and chicks were observed on Karapoo Koio. (Quayle 1922). **1968**. Lacan (ms) reported breeding on two islets: Karapoo Koio and Rapa Iti, but without specifying any number. **1974**, **1989**, **2017–2024**. Breeding distribution and numbers on islets are presented in Table 5. Breeding observed in limited numbers on the cliffs of Rapa (Makatea, Iri) and mainly on the islets. No differences were observed in the sites occupied between the visits of 1974 and those of 2017–24. Most sites had colonies less than 100 pairs. Unfortunately, the main breeding site (Karapoo Koio) could not be surveyed during the breeding season from 2017 to 2024. Maximum numbers seen at sea during chumming operations during Nov-Dec 2019 off Rapa were 100s on 12 November; and several 100s off Morotiri on 23 & 24 November (Flood *et al.* 2021).

Table 5. Comparison of brown noddy populations between 1974, 1989 and 2017–2024 (X = 1–10, XX = 11–100, XXX = >100 pairs, and ?= present but number unknown).

Islets	1974	1989	2017–2024
Karapoo Rahi	?	XX	XX
Rarapai	?	XX	XX
Tapiko		XX	XX
Tarakoi	XXX	XX	XX
Tauturou	XX	XX	XX
Karapoo Koio	?	XXX	?
Rapa Iti	X	XX	XX

The breeding season for brown noddies was seasonal and condensed during the austral summer (Table 3).

White tern (*Gygis alba*) taketake
Pre-European bone remains were found in archeological excavations on Rapa (Tennyson & Anderson 2012). **1921–22**. The main information concerning this species found in Quayle's journal (16 Feb 1922, p. 304) concerns Rapa: "*The little white terns were rather plentiful above the timbered ravines*". They were also noted flying above a wooded slope of Rapa Iti (seen from a boat, p. 315). **1968**. The Karapoo Rahi forest appears to be the main site frequented by this tern. **1974**. Breeding observed on Rapa, on the rocky faces of Aurei (20–30 pairs). On the islets, nests were found on Tauturou (*c.* 100 pairs in the littoral grove), Karapoo Rahi (several dozen pairs in the grove), and Rapa Iti (15–20 pairs). **1989**, **2017–2024**. Breeding distribution and numbers on islets are presented in Table 6. Noted in the village of Aurei (20–30 pairs), and in very limited numbers in Rapa's forests, except in one locality (Ma'i'i) where it is relatively numerous (several tens of pairs), although in smaller numbers than the abundance observed by the WSSE in 1922. On Karapoo Rahi several 100 individuals in 1968, 1989, and 2002, but only about ten pairs in 2017–24 due to disappearance of the forest cover (see Discussion). Conversely, there is an increase on Rapa Iti, Karapoo Koio, and Tarakoi. The maximum number seen at sea during chumming operations in Nov-Dec 2019 off Rapa was 30 on 12 November (Flood *et al.* 2021).

Table 6. Comparison of white tern populations between 1989 and 2017–2024. (X = 1–10, XX = 11–100), XXX = >100 pairs, and ? = present but number unknown).

Islets	1989	2017–2024
Karapoo Rahi	XXX	X
Tauturou	XX	XX
Karapoo Koio		X
Rapa Iti	X	XX
Tarakoi		XX

White tern breeding is seasonal, occurring during the austral summer (Table 3), although one chick was recorded in April 1921. It breeds mainly in *Pandanus tectorius* trees and forests on islets and in ravines on the main island, but also directly on ledges in cliffs.

DISCUSSION

Trends over a century

The species list of breeding seabirds on Rapa has increased slightly over time, as the WSSE (Whitney South Sea Expedition) missed four species: Rapa shearwater (discovered in 1925), Polynesian storm-petrel and black-winged petrel (1974), and wedge-tailed shearwater (2017). Similarly, only the Christmas shearwater, Murphy's petrel, and Polynesian storm-petrel were absent from archaeological bone deposits (Tennyson & Anderson 2012).

The distribution and population size of a few species appear to have remained stable over the period considered (Table 7): red-tailed tropicbird, Murphy's petrel, and Kermadec petrel. Unfortunately, for storm-petrels, while their distribution has not changed since 1974, their numbers seem to have decreased. The abundance observed by Quayle in 1922 was not recorded a century later. Rapa shearwater is presumed extinct on Rapa's main island, although burrows of an unidentified seabird were found in 2019 at the top of a coastal cliff (Haiva Narii, *pers. comm.* to TW, 2019). On Rapa Iti and Tauturou, a sharp decline in the main populations of the Rapa shearwater occurred between 1974 and 2017–2024.

Black-winged petrels have possibly colonised (or recolonised) recently. Bones found in archaeological deposits indicate that the species was present before or during the early period of human settlement (Tennyson & Anderson 2012). However, it was not observed by the WSSE on Rapa in April 1921 or in February 1922 (although it was recorded offshore near Morotiri). In Eastern Polynesia, ancient extinctions of this species have been documented, notably in the Cook Islands, where this was attributed to Polynesian harvesting (Steadman 2006). We suggest that the species became extinct on Rapa and has recently recolonised the island, as it has done more recently on Rapa Nui (Barros & Schmitt 2013) and Ra'ivavae (Bretagnolle *et al.* in press). Since 1974, its distribution and likely its numbers have remained stable on Tauturou and Rapa Iti, and in 2019 it was observed on a third islet.

Table 7. Numbers and trends of breeding seabirds on Rapa and adjacent islets (2017–2024) expressed in breeding pairs. – = species not recorded, ? = present, but number unknown.

Species	Karapoo Koio	Karapoo Rahi	Rapa Iti	Rarapai	Tapiko	Tarakoi	Tauturou	Rapa	Total	Trend
Red-tailed tropicbird	5–10	25–50	25–50	5	?	8–15	100–500	?	*c.* 1000	stable
White-bellied storm-petrel	?	–	1+	30–50	20–50	350–500	–	100–500	500–1000+	probable decline
Polynesian storm-petrel	?	–	–	25–100	1+	11–100	–	–	250–500	probable decline
Murphy's petrel	20–50	50	30–50	5–20	5–20	10	3000–4000	–	4000–5000	probably stable
Kermadec petrel	11–100	100–500	1–10	–	–	–	250–500	100–250	1000	probably stable, or increase
Black-winged petrel	1+	–	200–500	–	–	–	200–500	–	1000	probably stable
Wedge-tailed shearwater	1+	–	–	–	–	–	–	–	–	unknown
Christmas shearwater	?	–	?	–	–	present	?	–	< 100?	possible decline
Rapa shearwater	15–20	5–10	< 10	–	–	–	< 20	–	< 100	sharp decline, at least since 1974
Grey noddy	11–100	1–10	40–50	10	10	200–500	5	?	1000–2000	possible decline
Brown noddy	?	11–100	25–50	11–100	11–100	11–100	11–100	?	500–1000	probable decline
White tern	1–10	25–50	15–25	–	–	11–100	100	50–100	250–500	probable decline

However, the absence of chicks in nests during surveys conducted between March and April from 2019 to 2023—despite fledging in New Zealand/Aotearoa occurring in early May (BirdLife Australia, 2023a)—suggests significant rat predation on chicks.

Discovery of a wedge-tailed shearwater pair breeding in 2017 extends its range in Eastern Polynesia nearly 500 km further south (Thibault & Cibois 2017), although it breeds at more southern latitudes in Australia and New Zealand (BirdLife Australia 2023b). Finally, a decline in white terns and brown noddies was observed on the islets.

Ecological segregation

The three tern species bred in wooded areas (brown noddy, white tern) and on cliffs (grey noddy, brown noddy, white tern). The two storm-petrel species occupied the same sites, with partially overlapping breeding periods. The two ground-nesting species, Murphy's and Kermadec petrels, shared the same islets. However, while Murphy's petrels were confined to the islets, Kermadec petrels also nested on coastal cliffs and in the interior of the main island. Both species had their highest populations on the same islet (Tauturou); however, their breeding seasons were complementary: Murphy's petrel bred from April to November, while Kermadec petrel bred predominantly from November to April.

The complementary use of the same sites was even more pronounced in the case of Rapa shearwater and black-winged petrel. These species shared the same burrows on the same islets, with black-winged petrels breeding from November to April and Rapa shearwater from April to October. On Lord Howe Island (Australia), Hutton & Priddel (2002) reported aggressive interactions between black-winged petrel and little shearwater (*Puffinus assimilis*) that used the same burrows at complementary breeding periods.

Invasive plants

The vegetation on the main island has declined significantly due to fires and grazing by cows, horses, and goats (Meyer 2011; Motley *et al*. 2014). The islets retaining the largest proportional cover of natural vegetation are the smallest ones, such as Tapiko and Tuamotu; these islets probably never supported goats. Other small islets, such as Rarapai and Karapoo Koio, are largely overrun by the invasive plant *Commelina diffusa*.

The islets that feature the largest areas of native habitats, such as semi-dry forests and cliff vegetation, are Karapoo Rahi, Tauturou, and Rapa Iti (Butaud *et al*. 2018). However, due to over-browsing by goats and possibly fires, Karapoo Rahi has lost most of its forest. A photograph from 1980 shows its western face almost entirely wooded from sea level to the summit, whereas by 2017 only a few pandanus plants remained (Paulay 1982; Butaud *et al*. 2018). On most islets, the introduction of goats resulted in the destruction and disappearance of forests. On Tarakoi, temporary cultivation (e.g., in 1993 by A. Guillemont) promoted the spread of invasive exotic plants (*Commelina diffusa*, *Melinis minutiflora*) and likely contributed to a decline in the populations of the two storm-petrel species.

Introduced mammals

Attacks by Pacific rats on Rapa shearwater chicks, as well as harassment of adults during incubation (recorded on camera traps), have been identified as the main causes of this species' decline. Whether such predation has occurred for centuries or is a recent phenomenon linked to the disappearance of forests on the islets remains unknown. Notably, invasive guava on Tauturou, which was rare in the 1970s–1980s, is now abundant. Its fruiting is highly seasonal, potentially causing a spike in rat populations during the austral summer. Outside this season, however, rats may face food shortages and consequently prey on petrel chicks, as has been documented elsewhere (see Caut *et al*. 2008). In addition to reducing vegetation, goat trampling may also compact the soil, limiting the availability of soft ground necessary for burrow digging. Rapa shearwaters may also face threats from fisheries activities within their foraging or non-breeding ranges at sea (see Hatch *et al*. 2016 and Uhlmann 2003, for other seabird species). To investigate this possibility, 10 Rapa shearwaters were equipped with GLS dataloggers in August 2019. Although only one individual was successfully recaptured with its GLS functioning, the recorded foraging site was clearly outside major commercial fishing routes (Jiguet *et al*. 2024; P. Dufour, *pers. comm*. to VB, 2024). This suggests that land-based threats during the breeding season are the primary factors driving the decline of Rapa shearwater populations.

Conservation actions

Restoring island habitats and engaging local communities in conservation efforts are key elements to improve conservation and management of seabirds (Rodriguez *et al*. 2019). During the first assessment trip in 2017 by SOP-Manu, ship rats (*Rattus rattus*) were absent; however, three islets (Tauturou, Karapoo Rahi, and Rapa Iti) had feral goats and Polynesian rats (Butaud *et al*. 2018). Since then, SOP-Manu has partnered with Raumatariki, a local environmental NGO in Rapa, to advise and assist the Rapa community in restoring the uninhabited *motu* (islets in Polynesian) and protecting their unique assemblage of seabirds.

With the agreement of the "Tomite Rahi" (the council of elders Toohitu and the Rapa town hall), and the goat owners, and with the help of the local population, feral goats were removed from Tauturou and Karapoo Rahi in 2019, and from Rapa Iti in 2021. Rats were eradicated from Tauturou and Rapa Iti in Nov–Dec 2023 by a team from SOP-Manu, assisted by local volunteers and rope-climbing professionals.

Since 2017, but likely for much longer, storm-petrels, Rapa shearwaters, and even Murphy's and Kermadec petrels have been found grounded beneath public streetlights. Some of these birds were rescued, while others were likely taken by cats or dogs. Reducing the intensity of street lighting and turning it off during the middle of the night could help mitigate this cause of mortality.

Conclusion

This synthesis highlights significant gaps in knowledge, both temporally and geographically, particularly in Rapa's inland areas, where breeding sites and perhaps even new seabird species remain to be discovered. The seabird population of the Morotiri rocks has been insufficiently surveyed due to the challenges of landing there (Quayle 1922; *pers. obs*.), and very few naturalists have ever set foot on these rocks (Fosberg 1972; Gaskin 2007). The seabird assemblage on Morotiri appears similar to that of Rapa and its islets, with additional potential breeders such as sooty terns (*Onychoprion fuscatus*) (Thibault & Cibois 2017). The birds are safe from disturbance on these rocks; however, their total area is small, totaling less than 10 ha for the three main rocks. Nesting space for burrow-nesting species, such as Rapa shearwater and black-winged petrel, is likely limited by a scarcity of loose soil. Similarly, the number of storm-petrels may be constrained by the lack of ground vegetation under which they typically establish their nests.

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Birds of Te Araroa Trail – Aotearoa New Zealand's long pathway

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Abstract: Te Araroa Trail runs for more than 3,200 km between Cape Reinga and Bluff, along the length of Aotearoa New Zealand's two main islands. All birds seen and heard along the trail during the austral summer were counted in 1,720 contiguous transects during 124 days of walking from north to south between 2 November 2023 and 11 March 2024 (84.7% of transects were 2 km long). A total of 106,207 birds of 107 species were counted during daylight transects, at a mean encounter rate of 32.6 individuals per km. The highest counts were for house sparrow (*Passer domesticus* – 12,517 birds), chaffinch (*Fringilla coelebs* – 5,806), and red-billed gull (*Chroicocephalus novaehollandiae* – 5,427). The species recorded most frequently were chaffinch (62.3% of transects), silvereye (*Zosterops lateralis* – 58.5%), and Eurasian blackbird (*Turdus merula* – 56.7%). Bird communities are summarised and compared for 19 sections covering the entirety of the trail, providing a baseline for comparisons within regions and over time. Northern and/or southern limits are presented for 30 species with restricted distributions. Comparison of counts along sections of the trail that were trapped (233 km, including 22.4% of forest) with counts from untrapped forest sections revealed that tūī (*Prosthemadera novaeseelandiae*), kererū (*Hemiphaga novaeseelandiae*), and New Zealand fantails (*Rhipidura fuliginosa*) were more abundant where predator control was undertaken. Twenty of the fantails seen in the South Island were black morph (5.6%), with the remaining 339 (94.4%) pied morph, indicating that the proportion of black morph birds has been stable over the past two decades. In addition to describing bird communities likely to be encountered on different sections of Te Araroa Trail, this account (and the dataset it is based on) provides a baseline for comparing New Zealand bird communities over time and space.

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Keywords: abundance, bird community, eBird, frequency of occurrence, New Zealand Bird Atlas Scheme, predator control, Te Araroa Trail

INTRODUCTION

Te Araroa Trail was opened in 2011, creating a continuous walking trail stretching for more than 3,000 km along the length of Aotearoa New Zealand's two main islands (Chapple 2017). The trail is predominantly coastal north of Auckland, and predominantly inland between Auckland and Bluff (Fig. 1). Although about 2,000 people walk the trail every year (Chapple 2017), there was little information available on the birds of the trail before 2023.

I walked the trail from north to south between 2 Nov 2023 and 11 Mar 2024, identifying and counting every bird seen and heard along the route. This information was summarised in a series of Te Papa blogs covering 19 contiguous sections that were separated by towns, cities, or other frequently used resupply or access points along the trail (https://blog.tepapa.govt.nz/tag/te-araroa-trail/). These same sections are used here as a framework to describe and contrast bird communities along a linear transect running the length of the country (Fig. 1).

Counts were a mixture of travelling counts (transects) and stationary counts, with the latter mainly undertaken at night, targeting nocturnal birds. All data were entered into eBird (Sullivan *et al*. 2009) and contributed to the 2019–2024 New Zealand Bird Atlas Scheme. Only data from diurnal transects are considered herein.

Records were kept of the presence of well-maintained predator traps along the trail, to determine whether trapping provided a measurable difference to encounter rates of endemic forest birds. Within the South Island, records were kept of the colour morph of all New Zealand fantails (pīwakawaka, *Rhipidura fuliginosa*) that were seen (pied vs black), to allow comparison with previous island-wide estimates of the proportion of black fantails (Craig 1972; Atkinson & Briskie 2007). Black morph fantails are rarely encountered in the North Island (Higgins *et al*. 2006; Heather & Robertson 2015).

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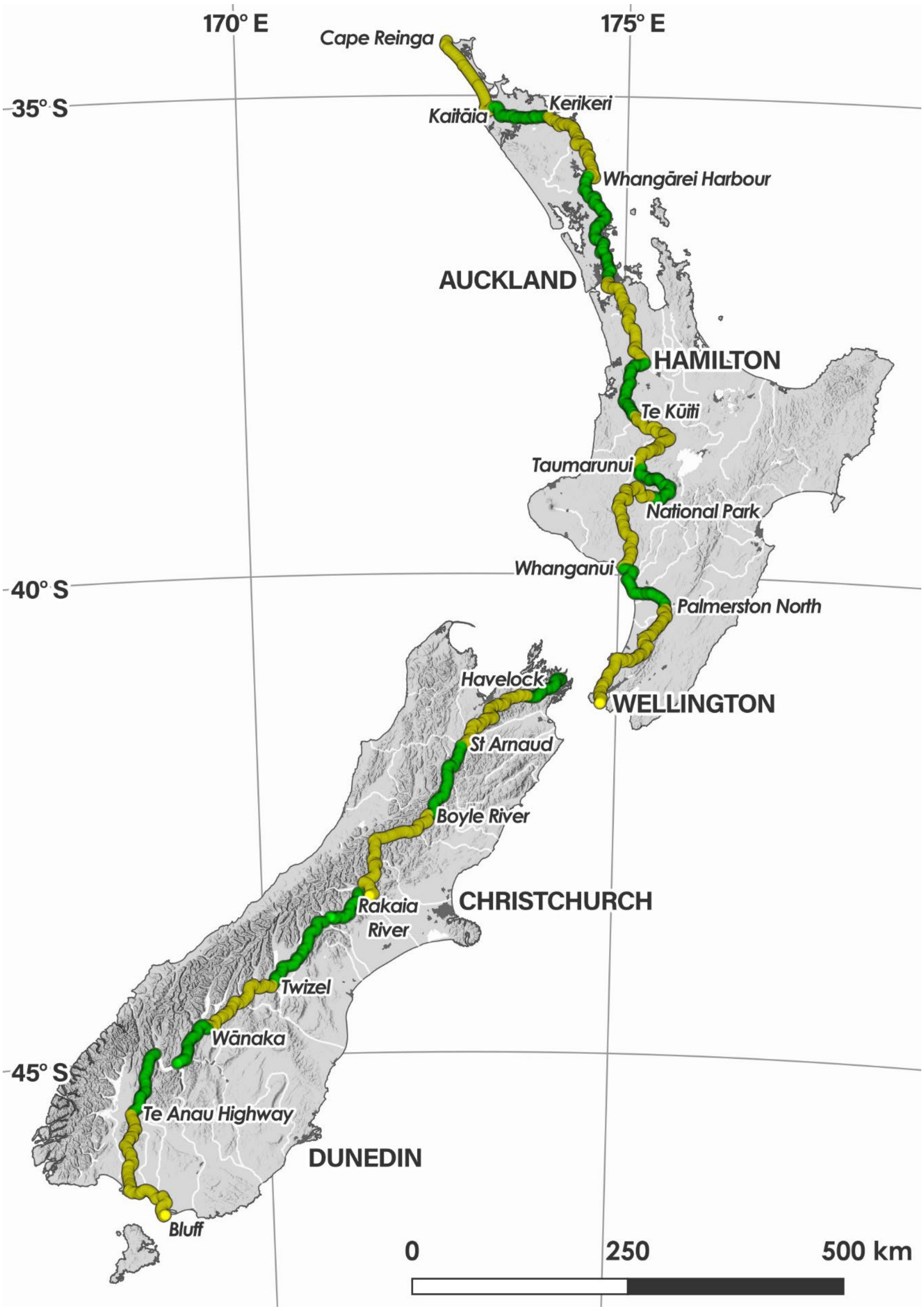

Figure 1. Te Araroa Trail, based on 1,720 mid-transect waypoints (most transects were 2 km in length). Alternating bands of yellow and green waypoints are used to separate the 19 trail sections referred to in the text, with labelled place names showing start and end points for each section (plus an additional two major cities). Map created in QGIS, with data from the LINZ Data Service, under CC BY 4.0 licence.

In addition to describing bird communities likely to be encountered on different sections of Te Araroa Trail, and the differences between them, this account (and the dataset it is based on) provides a baseline for comparing New Zealand bird communities over time and space.

METHODS

Count methodology

All birds seen or heard while walking Te Araroa Trail were recorded as unbounded counts (Hartley & Greene 2012) in contiguous transects that were mainly 2 km long (84.7% of transects), as measured with a GPS-enabled Garmin Instinct wristwatch that was programmed to give an alert at every kilometre. A new transect was started at any major habitat boundary (Table 1) and counts were terminated before dusk, with a new transect initiated the following morning. Mid-transect waypoints (1 km from the start) were recorded for each transect. Any count data from transects less than 0.5 km in length were added to the previous transect, and so transects were 0.5–2.4 km in length. The first transect each day was started at least 30 minutes after daybreak to avoid counting birds calling during the dawn chorus (the earliest counts were initiated at 06:25

Table 1. Cumulative lengths (km) of broad habitat categories along 19 contiguous sections of Te Araroa Trail. See Methods for definitions of habitat categories Coast and Open.

	Length (km)	Habitat (km)				
Section		Coast	Farm	Forest	Open	Urban
Cape Reinga to Kaitāia	127.3	98.1	13.0	0	12.8	3.4
Kaitāia to Kerikeri	117.2	0	58.4	57.8	0	1.0
Kerikeri to Whangārei Harbour	183.7	31.3	113.2	37.7	0	1.5
Whangārei Harbour to Auckland	225.7	68.7	95.8	31.0	0	30.2
Auckland to Hamilton	185.6	10.0	137.5	15.7	0	22.4
Hamilton to Te Kūiti	115.0	0	76.9	36.9	0	1.2
Te Kūiti to Taumarunui	170.1	0	85.0	78.9	0	6.2
Taumarunui to National Park	129.0	0	36.7	65.7	24.6	2.0
National Park to Whanganui*	213.1	0	120.8	58.4	0	1.4
Whanganui to Palmerston North	121.0	19.5	85.7	4.1	0	11.7
Palmerston North to Wellington	254.7	19.4	71.2	132.7	15.1	16.3
Cook Strait to Havelock	96.1	9.5	5.8	80.8	0	0
Havelock to St Arnaud	181.2	2.0	37.6	116.7	23.7	1.2
St Arnaud to Boyle River	126.9	0	0	74.9	52.0	0
Boyle River to Rakaia River	208.2	0	34.6	95.7	77.9	0
Rakaia River to Twizel	209.0	0	12.0	1.0	195.0	1.0
Twizel to Wānaka	151.1	0	0	20.6	129.0	1.5
Wānaka to Te Anau Highway	200.9	0	8.0	45.7	147.2	0
Te Anau Highway to Bluff	240.9	47.8	51.6	83.8	57.7	0
Total	3256.7	306.3	1043.8	1038.1	735.0	101.0

*Plus 32.5 km of River

New Zealand Daylight Saving Time in late December, with incremental changes from 06:50 in early November to 07:20 in early March). Binoculars (8 x magnification) were used to aid identification when required when walking, but were not generally used to detect birds. The exception to this was at lakes and estuaries with large numbers of wetland birds, where binoculars were used to locate, identify and count birds.

No attempt was made to separate birds seen from those heard, with the exception of New Zealand fantails in the South Island, where birds seen were recorded separately by colour morph (pied fantail vs black fantail), and birds that were heard only were recorded as 'fantail' without further qualification.

Trail sections and major habitat types

Counts were grouped into 19 sections to facilitate comparisons of bird communities between different parts of Te Araroa Trail (Fig. 1 and Table 1). The dominant habitat for each transect was recorded, using six broad habitat categories: Coast, Farm, Forest, Open (not intensively farmed, vegetation <2 m tall), River, and Urban (Table 1). 'Coast' was used only when the tideline was visible and less than 200 m from the trail. 'Open' included high country farms with low stocking rates, where the vegetation was dominated by tussock grasses. The only transects that were dominated by 'River' were 17 contiguous transects (32.5 km) that were transited by canoe on the Whanganui River, between Mangapurua and Pipiriki. None of the 2-km long transects were dominated by horticulture or lakes. Urban trail section ends were generally at the point of the trail closest to the town centre (exceptions were the 'Auckland' break at Onehunga, and the 'Palmerston North' break at Massey University campus).

Comparisons of bird communities between sections and habitats

Birds recorded in each of the 19 sections were converted into encounter rates (birds per kilometre = birds/km) to facilitate comparisons between sections. The full list of 107 species and their encounter rates were compared between all sections using Bray-Curtis dissimilarity indices (Bray & Curtis 1957) in order to determine overall similarities between bird communities throughout the country, and to identify any sections with strongly distinct bird communities. Bray-Curtis indices were also used to compare bird communities between islands and habitats. In these comparisons, North Island robin (toutouwai, *Petroica longipes*) and South Island robin (kakaruai, *P. australis*) were treated as if they were the same species, meaning that encounter rates for 106 'species' were compared.

Encounter rates of endemic forest birds in the presence or absence of predator trapping

Kill-traps targeting mustelids (*Mustela* spp, principally stoat *M. erminea*) and rats (*Rattus* spp, principally ship rat *R. rattus*) were encountered frequently in forested sections of Te Araroa Trail, typically spaced about 200 m apart. The two main stoat and rat trap types along Te Araroa were DOC200 traps inside wooden boxes, and Goodnature A24 resetting traps. Any transect with four or more recently-maintained, set traps was recorded as 'Trapped', allowing comparison of bird encounter rates along Trapped vs Untrapped forest sections. As some endemic forest birds are rare or absent in parts of the country (e.g. long-tailed cuckoo | koekoeā, kākā, yellow-crowned parakeet | kākāriki, rifleman | tītitipounamu, bellbird | korimako, whitehead | pōpokotea, and North Island robin north of Hamilton), comparisons for each species were limited to sections where the target species was recorded in three or more transects within the section.

Scientific names

Scientific names for all bird species encountered along Te Araroa Trail (including those mentioned in the text and tables) are provided in Appendix 1.

RESULTS

Most abundant and most frequently observed bird species

A total of 106,207 birds of 107 species were counted during 3,256.7 km of daylight transects along the length of Te Araroa Trail, at a mean encounter rate of 32.6 birds/km. The full data set is provided in Supplementary materials, with data for the ten most abundant and most frequently observed species (overall, and separately by island) summarised in Tables 2 & 3.

House sparrow | tiu was the most abundant species counted (particularly in the North Island), followed by chaffinch |pahirini, red-billed gull | tarāpunga, and silvereye | tauhou (Table 2). House sparrow, chaffinch, and silvereye were the only species that were among the 'top ten' species by total count for both islands (Table 2B & C). Birds were nearly twice as abundant along North Island sections of Te Araroa Trail (41.3 birds/km vs 21.3 birds/km in the South Island), with five species recorded there at more than 1.87 birds/km (this was the maximum encounter rate for any species averaged across the South Island; Table 2B & C). Six of the species listed in Table 2 were recorded in flocks or colonies exceeding 500 individuals, with single-transect counts of 2,500 for bar-tailed godwit | kuaka and red-billed gull, 2,100 for southern black-backed gull | karoro, 1,452 for Canada goose | kuihi, 1,400 for grey teal | tētē-moroiti, and 733 and 576 for South Island pied oystercatcher | tōrea.

Chaffinch was the most frequently encountered species (62.3% of checklists), followed by silvereye and Eurasian blackbird | manu pango (Table 3). Eurasian blackbird was the most frequently encountered species in the North Island (74.4% of checklists), and silvereye was the most frequent in the South Island (54.6% of checklists). These three species plus New Zealand fantail and grey warbler | riroriro were among the top ten species by frequency of occurrence in both islands (Table 3), with fantail the most frequently encountered endemic species (47.2% of checklists).

Table 2. The ten most abundant bird species along Te Araroa Trail. A. The entire trail (3256.7 km). B. North Island (1842.4 km). C. South Island (1414.3 km).

A. Entire Te Araroa Trail	Count	Birds/km
House sparrow	12,517	3.84
Chaffinch	5,806	1.78
Red-billed gull	5,427	1.67
Silvereye	5,381	1.65
Southern black-backed gull	4,589	1.41
Common starling	4,467	1.37
European goldfinch	4,256	1.31
Eurasian blackbird	4,019	1.23
Common myna	3,406	1.05
Bar-tailed godwit	3,245	1.00
B. North Island	**Count**	**Birds/km**
House sparrow	10,921	5.93
Red-billed gull	4,865	2.64
Chaffinch	4,115	2.23
Southern black-backed gull	4,054	2.20
Common starling	3,599	1.95
European goldfinch	3,437	1.87
Common myna	3,406	1.85
Eurasian blackbird	3,389	1.84
Bar-tailed godwit	3,215	1.75
Silvereye	2,740	1.49
C. South Island	**Count**	**Birds/km**
Silvereye	2,641	1.87
Grey teal	1,981	1.40
Canada goose	1,956	1.38
Chaffinch	1,691	1.20
Bellbird	1,619	1.14
House sparrow	1,596	1.13
Tomtit	1,287	0.91
Mallard	1,126	0.80
Common redpoll	1,124	0.79
South Island pied oystercatcher	1,108	0.78

Table 3. The ten most frequently observed bird species along Te Araroa Trail, expressed as the number and percentage of diurnal transects where the species was recorded. A. The entire trail (3256.7 km, 1720 transects). B. North Island (1842.4 km, 976 transects). C. South Island (1414.3 km, 744 transects).

A. Entire Te Araroa Trail	Present	%
Chaffinch	1,071	62.3
Silvereye	1,007	58.5
Eurasian blackbird	976	56.7
New Zealand fantail	811	47.2
Grey warbler	705	41.0
House sparrow	693	40.3
Song thrush	674	39.2
Bellbird	650	37.8
European goldfinch	646	37.6
Tūī	644	37.4
B. North Island	**Present**	**%**
Eurasian blackbird	726	74.4
Chaffinch	704	72.1
Silvereye	601	61.6
Tūī	592	60.7
New Zealand fantail	590	60.5
House sparrow	552	56.6
Grey warbler	518	53.1
Song thrush	506	51.8
Goldfinch	494	50.6
Welcome swallow	480	49.2
C. South Island	**Present**	**%**
Silvereye	406	54.6
Chaffinch	367	49.3
Bellbird	344	46.2
Tomtit	260	34.9
Eurasian blackbird	250	33.6
Common redpoll	221	29.7
New Zealand fantail	221	29.7
Dunnock	218	29.3
Yellowhammer	204	27.4
Grey warbler	187	25.1

Bellbird (37.8% of checklists) and tūī (37.4%) were the most frequently recorded members of endemic genera (Table 3), and whitehead (a North Island endemic species) was the most frequently recorded member of a New Zealand endemic family (15.1% of North Island transects, and 8.5% overall).

Bird communities of different major habitats

The major habitats for the most part had distinct bird communities, with just two species occurring among the 'top ten' by abundance in four of the five habitats (house sparrow and silvereye), and another three species featuring in three habitats (chaffinch, common starling | tāringi, and Eurasian blackbird; Table 4). Coastal habitat was most distinct, with six species that were not shared with the 'top ten' of any other habitat (Table 4).

Habitats were more similar based on the bird species observed most frequently, with Eurasian blackbird featuring in the 'top ten' for all five habitats, three species featuring in four habitats (chaffinch, European goldfinch | kōurarini, and silvereye), and another three species featuring in three habitats (house sparrow, song thrush | manu-kai-hua-rakau, and welcome swallow | warou; Table 4). Farm and Urban habitats both featured all seven of these shared most-frequent species, with Coast, Forest, and Open all featuring four of them.

	Coast	Urban	Farm	Open
Urban	0.72			
Farm	0.73	0.47		
Open	0.81	0.77	0.61	
Forest	0.91	0.82	0.65	0.60

Figure 2. Bray-Curtis index comparison of bird communities in the five main habitats along Te Araroa Trail. A lower score indicates greater similarity between bird communities.

The distinctiveness of coastal habitat was also apparent when all 106 species' encounter rates were compared across habitats using Bray-Curtis indices (average score of 0.79 for Coast, cf. 0.62 to 0.75 for the four other habitats; Fig. 2). Farm and Urban were the most similar habitats, with seven 'top ten' species by both frequency and abundance in common and a Bray-Curtis index of 0.47 (Table 4 and Fig. 2).

Bird communities in the same habitat compared between North Island and South Island were more similar, particularly for Farm (Bray-Curtis index of 0.39) and Forest (0.41). Remaining between-island Bray-Curtis indices were 0.60 for Open and 0.67 for Coast, and 0.56 for all habitats combined (Urban was not compared, as Te Araroa Trail passed through only 3.7 km of Urban habitat in the South Island; Table 1).

Bird communities of each section

Refer to Table 1 for the extent of major habitats in each section.

Cape Reinga to Kaitāia (127.3 km, 69 transects)

The northernmost section was the most distinct in terms of landscapes and habitats, as it was dominated by coast (77%; Table 1) and had no forest. This was reflected in its bird community, which differed markedly from other sections (mean Bray-Curtis index = 0.76; Fig. 3). The most abundant species were white-fronted tern | tara, red-billed gull, and southern black-backed gull, and the most frequent species were southern black-backed gull, Eurasian skylark | kairaka, and yellowhammer | hurukōwhai (Appendix 2, Table 2.01). Prominent headlands at Cape Reinga and Maunganui Bluff provided sightings of three seabird species that were not encountered elsewhere on Te Araroa Trail (fluttering shearwater | pakahā, Buller's shearwater | rako, and flesh-footed shearwater | toanui), plus a single vagrant common tern was seen north of Maunganui Bluff (accepted Unusual Bird Report 2024/059). In addition,

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
2	0.691																	
3	0.656	0.258																
4	0.670	0.427	0.177															
5	0.811	0.627	0.226	0.270														
6	0.743	0.281	0.270	0.364	0.394													
7	0.803	0.411	0.160	0.266	0.300	0.215												
8	0.779	0.410	0.270	0.370	0.408	0.145	0.151											
9	0.789	0.394	0.172	0.165	0.294	0.301	0.141	0.240										
10	0.811	0.660	0.401	0.438	0.344	0.283	0.364	0.326	0.416									
11	0.540	0.460	0.231	0.158	0.322	0.377	0.251	0.344	0.157	0.441								
12	0.732	0.518	0.377	0.477	0.489	0.259	0.352	0.264	0.401	0.415	0.474							
13	0.759	0.546	0.156	0.259	0.306	0.307	0.129	0.222	0.148	0.418	0.242	0.326						
14	0.901	0.702	0.321	0.426	0.456	0.221	0.250	0.127	0.314	0.370	0.399	0.243	0.211					
15	0.857	0.635	0.194	0.210	0.329	0.359	0.181	0.275	0.090	0.460	0.191	0.390	0.098	0.238				
16	0.771	0.634	0.189	0.199	0.315	0.374	0.215	0.319	0.114	0.452	0.198	0.414	0.134	0.289	0.074			
17	0.744	0.543	0.231	0.323	0.342	0.251	0.172	0.182	0.242	0.347	0.314	0.306	0.156	0.176	0.215	0.211		
18	0.769	0.541	0.168	0.209	0.309	0.340	0.176	0.277	0.112	0.439	0.199	0.386	0.105	0.270	0.076	0.066	0.177	
19	0.758	0.729	0.284	0.228	0.345	0.462	0.316	0.411	0.217	0.509	0.168	0.469	0.268	0.408	0.213	0.186	0.324	0.211

Figure 3. Bray-Curtis dissimilarity index comparison of bird communities in 19 contiguous sections along Te Araroa Trail, arranged from north (1) to south. A hypothetical score of 0 would indicate two sections having identical communities (both species composition and encounter rates); a score of 1 would indicate no overlap in species composition. Lighter colours indicate greater similarity. Cells above the line are comparisons between North Island sections; cells to the right of the line are comparisons between South Island sections; cells within the rectangle are comparisons between North Island and South Island sections. 1 = Cape Reinga to Kaitāia, 2 = Kaitāia to Kerikeri, 3 = Kerikeri to Whangārei Harbour, 4 = Whangārei Harbour to Auckland, 5 = Auckland to Hamilton, 6 = Hamilton to Te Kūiti, 7 = Te Kūiti to Taumarunui, 8 = Taumarunui to National Park, 9 = National Park to Whanganui, 10= Whanganui to Palmerston North, 11 = Palmerston North to Wellington, 12 = Meretoto / Ship Cove to Havelock, 13 = Havelock to St Arnaud, 14 = St Arnaud to Boyle River, 15 = Boyle River to Rakaia River, 16 = Rakaia River to Twizel, 17 = Twizel to Wānaka, 18 = Wānaka to Te Anau highway (SH94), 19 = Te Anau highway to Bluff.

Table 4. The ten most abundant and ten most frequent bird species in each of the five main habitats along Te Araroa Trail. '%' is the percentage of diurnal transects where the species was recorded for each habitat, '% rank' is the frequency of occurrence ranking for each species within each habitat. A. Coast (306.3 km, 168 transects). B. Farm (1043.8 km, 548 transects). C. Urban (101.0 km, 59 transects). D. Forest (1042.9 km, 551 transects). E. Open (735.0 km, 383 transects).

A. Coast	Birds/km	Rank	%	% rank
Red-billed gull	15.40	1	53.0	2
Southern black-backed gull	11.78	2	82.1	1
Bar-tailed godwit	10.51	3	11.9	30
Grey teal	6.40	4	3.0	45
South Island pied oystercatcher	5.35	5	19.6	16
House sparrow	4.21	6	46.4	4
White-fronted tern	3.92	7	17.9	19
Black swan	2.62	8	8.9	36
Black-billed gull	2.14	9	7.7	37
Variable oystercatcher	1.95	10	51.2	3
Common starling	1.56	11	31.0	8
European goldfinch	0.79	15	28.6	9
Eurasian blackbird	0.66	17	32.7	7
Eurasian skylark	0.56	21	39.9	5
Welcome swallow	0.50	23	33.3	6
Caspian tern	0.26	34	28.0	10

B. Farm	Birds/km	Rank	%	% rank
House sparrow	7.50	1	80.7	2
European goldfinch	3.11	2	75.2	4
Chaffinch	3.03	3	85.4	1
Common starling	2.67	4	56.8	11
Common myna	2.53	5	46.9	16
Eurasian blackbird	2.04	6	76.6	3
Silvereye	1.79	7	68.8	6
Mallard	1.59	8	29.4	22
Yellowhammer	1.38	9	59.1	9
Welcome swallow	1.30	10	63.9	8
Australian magpie	1.29	11	57.3	10
Song thrush	1.23	13	69.0	5
New Zealand fantail	1.02	15	65.9	7

C. Urban	Birds/km	Rank	%	% rank
House sparrow	22.73	1	100.0	1
Common starling	6.03	2	83.1	3
Red-billed gull	4.63	3	28.8	15
Eurasian blackbird	4.50	4	89.8	2
Common myna	3.57	5	67.8	4
Mallard	2.45	6	22.0	16
Rock pigeon	2.24	7	42.4	12
Tūī	2.01	8	66.1	6
European goldfinch	1.36	9	55.9	8
Silvereye	1.09	10	59.3	7
Welcome swallow	0.98	11	55.9	9
Chaffinch	0.95	12	47.5	10
Song thrush	0.94	13	67.8	5

Table 4. *continued*

D. Forest	Birds/km	Rank	%	% rank
Silvereye	2.14	1	73.1	1
Tomtit	1.74	2	69.7	2
Bellbird	1.74	3	67.2	3
Chaffinch	1.55	4	66.1	4
New Zealand fantail	1.00	5	64.2	5
Grey warbler	0.94	6	62.8	6
Whitehead	0.88	7	21.4	12
Eurasian blackbird	0.87	8	59.0	7
Tūī	0.72	9	42.1	8
Robin (two species combined)	0.49	10	27.8	10
Song thrush	0.28	12	26.9	9

E. Open	Birds/km	Rank	%	% rank
Canada goose	2.46	1	7.8	27
Silvereye	1.42	2	42.8	2
Chaffinch	1.14	3	45.2	1
House sparrow	1.08	4	17.2	16
Common redpoll	0.87	5	33.2	5
Southern black-backed gull	0.77	6	21.4	10
Black-billed gull	0.75	7	3.4	31
Common starling	0.73	8	10.7	23
European greenfinch	0.66	9	22.2	9
Yellowhammer	0.64	10	37.6	4
European goldfinch	0.56	13	22.7	8
Dunnock	0.53	14	41.8	3
Bellbird	0.50	16	27.4	7
Eurasian blackbird	0.41	17	30.0	6

white-fronted tern, Caspian tern | taranui, and Australasian gannet | tākapu, were observed at higher densities than in other sections.

Kaitāia to Kerikeri (117.2 km, 60 transects)
The second-most northerly section had a bird community that differed markedly from all South Island sections (Fig. 3) due to the abundance of a range of species that are rare or absent in the South Island (including common myna | maina, eastern rosella | kākā uhi whero, common pheasant, wild turkey | korukoru, peafowl | pīkao, Barbary dove, brown quail | kuera, and spotted dove; Table 5). The most abundant species were house sparrow, common myna, and paradise shelduck | pūtangitangi, and the most frequent species were grey warbler, Eurasian blackbird, and New Zealand fantail (Appendix 2, Table 2.02). Paradise shelduck and greylag goose | kuihi were observed at higher densities than in other sections. The section produced the northernmost observations for wild turkey, peafowl, Barbary dove, spotted dove, and North Island robin (Table 5).

Kerikeri to Whangārei Harbour (183.7 km, 103 transects)
The most abundant species were common myna, house sparrow, and red-billed gull, and the most frequent species were chaffinch, Eurasian blackbird, and sacred kingfisher | kōtare (Appendix 2, Table 2.03). Pūkeko, grey warbler,

Table 5. Northern and/or southern limits for 30 bird species with restricted distributions observed on Te Araroa Trail. Latitudinal limits (N limit, S limit) are given in decimal degrees south. Additional species with restricted distributions were omitted from the table due to low encounter rates and/or if Te Araroa Trail didn't traverse suitable habitat near known limits of their distributions (e.g. kiwi species, whio, New Zealand dotterel, and spotted shag).

Species	N limit	Northernmost observation	S limit	Southernmost observation
Brown quail	–	[Occurs at or near Cape Reinga]	35.21	Puhoi
Common myna	–	[Occurs at or near Cape Reinga]	39.95	No. 2 Line, E of Whanganui
Common pheasant	–	[Occurs at or near Cape Reinga]	40.96	Queen Elizabeth Park, Raumati
Shining cuckoo[1]	–	[Occurs at or near Cape Reinga]	41.16	Spicer Forest, Porirua (10 January)
Eastern rosella	–	[Occurs at or near Cape Reinga]	41.28	Wellington Botanic Gardens
California quail	–	[Occurs at or near Cape Reinga]	45.01	Lake Hayes, Arrowtown
Wild turkey	35.18	Takahue, south-east of Kaitaia	38.97	Hikumutu Road , south of Taumarunui
Barbary dove	35.22	Kerikeri River	37.06	Porchester Road, Takanini
Spotted dove	35.22	Kerikeri River	38.27	SE of Waitomo
Peafowl	35.23	Upper Puketotara Track, W of Kerikeri	40.49	Gordon Kear Forest, S of Palmerston North
Brown teal	35.51	Whananaki, Northland	37.52	Waikato River north of Huntly
Fairy tern	36.13	Mangawhai estuary	36.24	Pakiri River mouth
Black-billed gull	36.96	Ambury Farm Park, Manukau Harbour	–	[Occurs on Rakiura / Stewart Island]
Bellbird	37.98	Mt Pirongia	–	[Occurs on Rakiura / Stewart Island]
Long-tailed cuckoo[1]	38.01	Mt Pirongia	42.72	East of Harper Pass (5 February)
Whitehead	38.12	Te Kauri Forest, west of Otorohanga	41.16	Spicer Forest, Porirua
North Island robin[2]	38.46	Mangaokewa Gorge, south of Te Kuiti	39.72	Whanganui River Road, near Atene
New Zealand falcon	38.46	Mangaokewa Gorge, south of Te Kuiti	45.88	Mt Linton Station, S of Takitimu Range
Common redpoll	38.48	Mangaokewa Road, N of Benneydale	–	[Occurs on Rakiura / Stewart Island]
Kākā[3]	38.51	Ngaherenga campsite, Pureora	45.32	South of South Mavora Lake
Yellow-crowned parakeet	38.51	Ngaherenga campsite, Pureora	45.71	SW of Aparima Hut, Takitimu Range
Rifleman	38.55	Mt Pureora	46.29	Turnbulls Track, Longwood Range
Black-fronted dotterel	39.79	Whanganui River, south of Parikino	40.07	Manawatu River, Palmerston North
Weka[4]	41.10	Ship Cove, Queen Charlotte Track	42.83	Lower Deception River, Otira
Brown creeper	41.10	Ship Cove, Queen Charlotte Track	–	[Occurs on Rakiura / Stewart Island]
Black-fronted tern	41.27	Lower Pelorus River, west of Havelock	–	[Occurs on Rakiura / Stewart Island]
South Island robin	41.36	Pelorus River, near Captain Creek	45.36	Kiwi Burn Hut, Mavora Valley
Kea	41.99	Upper Travers River, Nelson Lakes NP	43.62	Crooked Spur Hut, Two Thumb Range[5]
Cirl bunting	43.22	Harper Road, NW of Lake Henrietta	43.47	East of Lake Heron
Australasian crested grebe	43.24	Lake Selfe	45.04	Queenstown waterfront, Lake Wakatipu

[1]Both cuckoo species regularly occur much further south, but rarely call after the end of the breeding season.
[2]A single North Island robin seen off Blackbridge Road, Omahuta Forest (35.24°S) was likely derived from a 2009–10 translocation to adjacent Puketi Forest.
[3]Six kākā seen or heard along Te Whara Track, Bream Head (35.85°S) had likely colonised from Taranga / Hen Island.
[4]Ten weka seen or heard at Orongo Bay (35.29°S), south-east of Russell, were descendants of birds released nearby in 2002.
[5]Reported by several other Te Araroa walkers.

sacred kingfisher, New Zealand fantail, California quail | tikaokao, eastern rosella, brown teal | pāteke, Barbary dove, and shining cuckoo | pīpīwharauroa were observed at higher densities than in other sections. This was the only section where an Australasian bittern | matuku-hūrepo was seen (on a wetland behind the southern end of Ocean Beach), plus there was a vagrant wandering tattler on the adjacent coast (accepted Unusual Bird Report 2023/114). The section produced the northernmost observation of brown teal, weka, and kākā (Table 5).

Whangārei Harbour to Auckland (225.7 km, 130 transects)
While dominated by farmland (42%) and coast (30%), this was the most urban section (13%). The bird count was dominated by a red-billed gull colony estimated at 2,500 birds at Marsden Point, Whangārei Harbour. The most abundant species were red-billed gull, house sparrow, and common myna, and the most frequent species were Eurasian blackbird, common myna and house sparrow (Appendix 2, Table 2.04). Red-billed gull, tūī, variable oystercatcher | tōrea pango, New Zealand dotterel | tūturiwhatu, pied shag | kāruhiruhi, brown quail, and banded rail | moho pererū were observed at higher densities than in other sections, plus this was the only section where fairy tern | tara iti (two each at Mangawhai estuary and Pakiri River mouth) and a little egret (at Mangawhai estuary) were seen. The section produced the southernmost observation of brown quail (Table 5).

Auckland to Hamilton (185.6 km, 95 transects)
This section had the highest proportion of farmland (74%) and was the second-most urban section (12%). The most abundant species were house sparrow, bar-tailed godwit, and South Island pied oystercatcher, and the most frequent species were house sparrow, common myna, and Eurasian blackbird (Appendix 2, Table 2.05). The bird count included

large flocks of waders at Ambury Farm Park on the Manukau Harbour, which was the only site on Te Araroa Trail where red knot | huahou (300), wrybill | ngutu pare (30), and grey-tailed tattler (1) were recorded. In addition to these species, house sparrow, bar-tailed godwit, South Island pied oystercatcher, common myna, Eurasian blackbird, mallard | rakiraki, rock pigeon | kererū aropari, European greenfinch, song thrush, pied stilt | poaka, black shag | māpunga, spotted dove, little shag | kawaupaka, and little black shag | kawau tūī were observed at higher densities than in other sections, and a single vagrant chestnut-breasted shelduck was seen beside the Waikato River south of Meremere (accepted Unusual Bird Report 2024/058). The section produced the northernmost observation of black-billed gull | tarāpuka, and the southernmost observations for Barbary dove and brown teal (Table 5).

Hamilton to Te Kūiti (115 km, 62 transects)
The most abundant species were house sparrow, chaffinch, and common starling, and the most frequent species were chaffinch, Eurasian blackbird, tūī, grey warbler, and New Zealand fantail (Appendix 2, Table 2.06). Australian magpie | makipai, common pheasant, and wild turkey were observed at higher densities than in other sections. The section produced the northernmost observations for bellbird, long-tailed cuckoo, and whitehead, and the southernmost observation of spotted dove (Table 5).

Te Kūiti to Taumarunui (170.1 km, 88 transects)
The most abundant species were chaffinch, whitehead, and European goldfinch, and the most frequent species were chaffinch, Eurasian blackbird, and grey warbler (Appendix 2, Table 2.07). Chaffinch, whitehead, yellowhammer, and kākā were observed at higher densities than in other sections. The section produced the northernmost observations for New Zealand falcon | kārearea, common redpoll, yellow-crowned parakeet, and rifleman, and the southernmost observation of wild turkey (Table 5). The section also produced the second-most northern observations for North Island robin (after one in Omahuta forest west of Kerikeri) and kākā (after six at Bream Head, Whangārei).

Taumarunui to National Park (132.8 km, 67 transects)
The most abundant species were chaffinch, silvereye, and house sparrow, and the most frequent species were chaffinch, Eurasian blackbird, and silvereye (Appendix 2, Table 2.08). Long-tailed cuckoo, fernbird | mātātā, and whio | blue duck were observed at higher densities than in other sections.

National Park to Whanganui (213.1 km, 112 transects)
The most abundant species were chaffinch, silvereye, and house sparrow, and the most frequent species were chaffinch, Eurasian blackbird, and bellbird (Appendix 2, Table 2.09). This was the only section where nankeen night herons | Umu kotuku were seen (at Jerusalem and Upokongaro), plus welcome swallow, North Island robin, peafowl, and grey duck | pārera were observed at higher densities than in other sections. The section produced the northernmost observation of black-fronted dotterel, and the southernmost observation of North Island robin (Table 5).

Whanganui to Palmerston North (121 km, 63 transects)
The most abundant species were southern black-backed gull, house sparrow, and common starling, and the most frequent species were house sparrow, European goldfinch, common starling, chaffinch, and Eurasian skylark (Appendix 2, Table 2.10). There was a large southern black-backed gull breeding colony on the coast west of Koitiata (2,100 birds estimated), plus common starling, European goldfinch, Eurasian skylark, spur-winged plover, swamp harrier | kāhu, and black-fronted dotterel were also observed at higher densities than in other sections. The section produced the southernmost observations for common myna and black-fronted dotterel (Table 5).

Palmerston North to Wellington (259.5 km, 132 transects)
The most abundant species were house sparrow, red-billed gull, and southern black-backed gull, and the most frequent species were Eurasian blackbird, chaffinch, and tūī (Appendix 2, Table 2.11). This was the only section where a red-crowned parakeet | kakariki was recorded (in Wellington Botanic Garden, likely from the nearby Zealandia fenced sanctuary), plus kererū | New Zealand pigeon were observed at higher densities than in other sections. The section produced the southernmost observations for peafowl, common pheasant, shining cuckoo, whitehead, and eastern rosella (Table 5).

Meretoto / Ship Cove to Havelock (96.1 km, 51 transects)
This was the most-forested section (81%), plus there were many birds using estuarine habitat at Okiwa Bay, Mahakipawa Arm, and near Havelock. The most abundant species were silvereye, bellbird, and house sparrow, and the most frequent species were silvereye, bellbird, and Eurasian blackbird (Appendix 2, Table 2.12). Bellbird, white-faced heron | matuku moana, royal spoonbill | kōtuku ngutupapa, weka, and brown creeper | pīpipi were observed at higher densities than in other sections. The section produced the northernmost observations of brown creeper, and the second-most northerly observations of weka (after ten at Orongo Bay, south-east of Russell; Table 5).

Havelock to St Arnaud (181.2 km, 99 transects)
The most abundant species were silvereye, bellbird, and tomtit, and the most frequent species were silvereye, bellbird, and New Zealand fantail (Appendix 2, Table 2.13). Silvereye was observed at a higher density than in other sections. The section produced the northernmost observations for black-fronted tern and South Island robin (Table 5).

St Arnaud to Boyle River (127.9 km, 65 transects)
The most abundant species were silvereye, chaffinch, and bellbird, and the most frequent species were silvereye, tomtit | miromiro, and bellbird (Appendix 2, Table 2.14). Tomtit and rifleman were observed at higher densities than in other sections. The section produced the northernmost observation of kea (Table 5).

Boyle River to Rakaia River (209.2 km, 110 transects)
The most abundant species were silvereye, chaffinch, and bellbird, and the most frequent species were chaffinch, silvereye, and bellbird (Appendix 2, Table 2.15). This was the only section where a kōtuku | white heron was seen (at the head of Lake Sumner), plus South Island robin and kea were observed at higher densities than in other sections. The section produced the southernmost observations for long-tailed-cuckoo and weka, and the northernmost observation of Australasian crested grebe | pūteketeke (Table 5).

Rakaia River to Twizel (209.0 km, 108 transects)
From Rakaia River south, the next three sections were predominantly open country (73 to 93%; Table 1) and had similar bird communities to each other (Bray-Curtis indices as low as 0.066; Fig. 3). The most abundant species for this section were Canada goose, yellowhammer, and paradise shelduck, and the most frequent species were yellowhammer, dunnock, common redpoll, and Eurasian skylark (Appendix 2, Table 2.16). It was the only section where cirl buntings were recorded (4 individuals), plus New Zealand pipit | pīhoihoi was observed at a higher density than in other sections. The section produced the southernmost observation of kea (Table 5).

Twizel to Wānaka (151.1 km, 79 transects)
The most abundant species were silvereye, black-billed gull, and European greenfinch, and the most frequent species were chaffinch, silvereye, and dunnock (Appendix 2, Table 2.17). This was the only section where a kakī | black stilt was seen (on the Ohau River), plus black-billed gull, dunnock, banded dotterel | pohowera, and New Zealand falcon were observed at higher densities than in other sections.

Wānaka to Te Anau highway (200.9 km, 105 transects)
The most abundant species were New Zealand scaup | pāpango, silvereye, and house sparrow, and the most frequent species were chaffinch, silvereye, dunnock, and Eurasian blackbird (Appendix 2, Table 2.18). New Zealand scaup, Australasian crested grebe, yellow-crowned parakeet, and Australian coot were observed at higher densities than in other sections. The section produced the southernmost observations for California quail, Australasian crested grebe, kākā, and South Island robin (Table 5).

Te Anau highway to Bluff (240.9 km, 129 transects)
The most abundant species were grey teal, Canada goose, and South Island pied oystercatcher, and the most frequent species were bellbird, tomtit, chaffinch, Eurasian blackbird, dunnock, and grey warbler (Appendix 2, Table 2.19). The counts were dominated by large numbers of waterfowl and waders on the New River and Aparima River estuaries and at the western end of Oreti Beach. This was the only section where sooty shearwater | tītī (154), spotted shag | kawau tikitiki (2), Foveaux shag | mapo (1), and little owl | ruru nohinohi (1) were recorded, plus grey teal, Canada goose, black swan | kakīanau, common redpoll, Australasian shoveler | kuruwhengi, ruddy turnstone, and black-fronted tern | tarapirohe, were observed at higher densities than in other sections. The section produced the southernmost observations for yellow-crowned parakeet, New Zealand falcon, and rifleman (Table 5).

Apparent responses to predator trapping
The presence or absence of predator traps along forested sections of Te Araroa Trail made little apparent difference to encounter rates for most species of native forest bird species (Table 6). The only species that showed an apparent positive response to predator trapping were tūī, kererū, and New Zealand fantail. Tūī had 90% higher counts at trapped sites (P <0.001), kererū counts were 68% higher (P=0.025), and New Zealand fantail counts were 27% higher (P=0.048).

Two species showed an apparent negative response to predator trapping (Table 6), with bellbird counts 20% lower at trapped sites (P=0.043), and weka counts 83% lower (P=0.011). Eleven other native forest bird species showed no significant difference in encounter rates between trapped and untrapped sections of Te Araroa Trail (Table 6). Encounter rates for kiwi and whio were too low to be included in analyses.

Fantail colour morphs
A total of 359 New Zealand fantails were seen in the South Island, of which 20 (5.6%) were of the black morph (Table 7). The highest proportions of black morph fantails were encountered in the final section (Te Anau Highway to Bluff, 11.8%) and along the Queen Charlotte Walkway and on to Havelock (10.0%). There were very few black morph fantails in inland Canterbury and Otago, with just 2 (1.7%) seen along 568 km of Te Araroa Trail between Boyle River and Wānaka (Table 7).

Table 6. Encounter rates of endemic forest birds (birds/km) at forested sites with or without predator trapping along Te Araroa Trail. Survey lengths differ for each species dependent on whether the species was recorded in three or more transects within each section (see Methods). Species are arranged in descending order of the extent of their apparent benefit (or not) from predator trapping.

Species	Distance (km)		Encounter rate			
	Trapped	Untrapped	Trapped	Untrapped	t	P
Tūī	182.2	671.5	1.38 ± 1.52	0.72 ± 1.31	3.81	<0.01
Kererū	164.4	727.4	0.36 ± 0.55	0.21 ± 0.49	2.26	0.03
New Zealand fantail	232.5	800.5	1.21 ± 1.28	0.95 ± 1.20	1.99	0.05
Kākā	66.7	153.6	0.66 ± 1.47	0.21 ± 0.73	1.71	NS
Whitehead	90.5	282.1	3.27 ± 4.07	2.12 ± 3.57	1.71	NS
North Island robin	71.5	131.5	1.73 ± 1.85	1.50 ± 2.04	0.59	NS
Yellow-crowned parakeet	66.7	153.6	0.32 ± 0.72	0.27 ± 0.87	0.34	NS
Grey warbler	232.5	800.5	0.99 ± 1.16	0.96 ± 1.22	0.24	NS
Rifleman	109.1	461.0	0.25 ± 0.93	0.20 ± 0.62	0.32	NS
South Island robin	80.6	252.4	0.54 ± 0.67	0.54 ± 0.86	0.06	NS
Shining cuckoo	141.4	373.4	0.13 ± 0.26	0.15 ± 0.36	-0.36	NS
Long-tailed cuckoo	130.3	398.0	0.25 ± 0.55	0.28 ± 0.54	-0.37	NS
Brown creeper	91.1	427.1	0.22 ± 0.54	0.26 ± 0.72	-0.41	NS
Tomtit	232.5	800.5	1.57 ± 1.53	1.78 ± 2.12	-1.23	NS
Bellbird	181.6	709.2	1.67 ± 1.72	2.09 ± 2.09	-2.04	0.04
Weka	57.2	194.2	0.03 ± 0.13	0.21 ± 0.63	-2.58	0.01

Table 7. Encounter rates and colour morphs of New Zealand fantails along South Island sections of Te Araroa Trail, January to March 2024. '% black' was calculated from the number of birds that were seen and identified to colour morph.

Section	Heard	Pied	Black	% black
Cook Strait to Havelock	15	27	3	10.0
Havelock to St Arnaud	24	52	4	7.1
St Arnaud to Boyle River	10	47	2	4.1
Boyle River to Rakaia River	34	63	1	1.6
Rakaia River to Twizel	1	4	0	0
Twizel to Wānaka	10	51	1	1.9
Wānaka to Te Anau Highway	14	50	3	5.7
Te Anau Highway to Bluff	14	45	6	11.8
Total	122	339	20	5.6

DISCUSSION

Characteristic bird species and communities of Te Araroa Trail

The primary purpose of this account is to provide a resource for Te Araroa Trail walkers with an interest in birds. While full details of species encountered on the trail during the 2023–24 season can be explored in Supplementary materials, the tables in Appendix 2 (summarising the ten most abundant and ten most frequently observed species for each of 19 sections of the trail) identify 43 species that are readily encountered along Te Araroa Trail, and their relative numbers and frequency of occurrence. Summaries of where the highest densities for each species were encountered (in the individual section accounts) provide information on where an additional 41 bird species are most likely to be encountered.

In addition to describing birds likely to be encountered along Te Araroa Trail, this account provides a semi-quantified description of bird communities along the full length of Aotearoa New Zealand's two main islands. Previous attempts to describe birds of the entire country were based on multi-observer atlas schemes, which presented maps based on individual species' presence or absence in submitted checklists (Bull *et al.* 1985; Robertson *et al.* 2007). These atlas scheme reports provided spatial representations of species' distributions that greatly expand on the data captured by a single observer along a linear transect. However, they were limited in their ability to present data on relative abundance within or between species. Bull *et al.* (1985) used simple presence versus absence in 10,000 yard grid squares, while Robertson *et al.* (2007) used dots of four different sizes to show how frequently each species was reported from each 10,000 metre grid square. Neither of these first two atlas schemes presented data on species abundance by time, distance or area, although Robertson *et al.* (2007: 391–404) included maps of species richness, based on the number of bird taxa per grid square.

Bird count data collected from Te Araroa Trail were submitted to the third Birds New Zealand atlas scheme (2019–2024) via eBird (Sullivan *et al*. 2009). The third atlas protocols encouraged participants to record search effort data (Crowe & Bell 2019), which will allow "heat maps" to be produced showing both distribution and abundance for each species (Fink *et al.* 2023; Birds New Zealand website, NZ Birds Atlas Scheme, viewed 24 Jul 2024). However, there is no easy way to convert raster layers from heat maps back into 'birds per km' or to compare relative densities between species from heat maps in order to compare bird communities between sites.

Frequency data (cf. abundance data) are more readily extracted from the first two New Zealand bird atlas schemes (Table 8). Bull *et al.* (1985) and Robertson *et al.* (2007) reported the same top 8 species for the entire country when ranked by frequency of observation (Table 8). These 8 species were among the 14 most-frequently observed species on Te Araroa Trail, which traversed a higher proportion of forest (32%) than is typical for New Zealand as a whole (23%; Robertson *et al.* 2007). Silvereye, New Zealand fantail, bellbird, and tūī (which are primarily forest-dwelling species) all ranked higher along Te Araroa Trail compared to the two atlases (Table 8). Chaffinch was the most frequently observed species on Te Araroa Trail (62.3% of checklists) and the first atlas (92.6% of squares; Bull *et al.* 1985), and was the second-most frequently observed species in the second atlas (89.5% of squares, cf. 89.7% for Eurasian blackbird; Robertson *et al.* 2007). Note that squares in the atlas schemes received more search effort than the individual checklists from Te Araroa Trail, with a mean of 5.5 checklists per square during 1969–79 (Bull *et al.* 1985), and a mean of 10.3 checklists per square during 1999–2004 (Robertson *et al.* 2007).

Table 8. The ten most frequently observed bird species in Atlas 1 (Bull *et al.* 1985) and Atlas 2 (Robertson *et al.* 2007) compared to Te Araroa Trail (this study).

	Frequency rank		
Species	Atlas 1	Atlas 2	Te Araroa
Chaffinch	1	2	1
Eurasian blackbird	2	1	3
Grey warbler	3	3	5
Song thrush	4	5	7
Silvereye	5	4	2
Yellowhammer	6	7	12
New Zealand fantail	7	6	4
Common starling	8	8	14
Dunnock	9	13	18
Southern black-backed gull	10	12	20
European goldfinch	12	9	9
Welcome swallow	17	10	11
House sparrow	11	11	6
Bellbird	14	14	8
Tūī	15	16	10

Apparent responses to predator trapping

Bird count data in relation to the presence or absence of predator traps along Te Araroa Trail must be interpreted cautiously in the absence of information on the history and effectiveness of pest control at each site, and trend information indicating whether bird species were increasing or decreasing. However, the overall pattern of most forest bird species not being significantly more abundant at trapped sites, when data is pooled for the full length of their Te Araroa Trail distributions, suggests that existing trapping programmes along the trail generally do not suppress predator populations sufficiently to produce a measurable change in populations of most arboreal forest birds (cf. Fea *et al*. 2020; Binny *et al*. 2021).

The ship rat is the most widespread and abundant predator affecting New Zealand forest birds (Innes *et al.* 2010; Walker *et al.* 2019a & b). Ship rats in New Zealand forests have home ranges as small as 0.3 ha (Innes & Skipworth 1983; Dowding & Murphy 1994; Hooker & Innes 1995), requiring trap-spacing as dense as a 50 x 100 m grid in order to maintain low rat numbers (Predator Free NZ website, viewed 26 Jul 2024). Trap spacings encountered on Te Araroa Trail were typically about 200 m, which is the recommended spacing for stoat control (Predator Free NZ *ibid.*). Stoat control alone allows recovery of some large-bodied forest birds (particularly kiwi *Apteryx* spp; McLennan *et al.* 1996; Robertson & de Monchy 2012); however, this wide trap spacing is unlikely to benefit species that are vulnerable to ship rat predation.

Tūī and kererū were the species that showed the strongest evidence of a positive response to predator trapping along Te Araroa Trail. Both species are unusual in being members of endemic genera that have remained widespread on the mainland, including in some cities (Robertson *et al.* 2007; van Heezik *et al.* 2008; Brockie & Duncan 2012). Tūī, in particular, have recovered strongly in response to predator control at some unfenced sites (Miskelly 2018; Fitzgerald *et al*. 2019, 2021), as have kererū around Wellington city (Brockie & Duncan 2012; Miskelly 2018; McArthur *et al*. 2023). These studies support evidence from Te Araroa that tūī and kererū are less vulnerable to ship rat predation than smaller-bodied forest bird species, and are more likely to respond to wide-spaced predator trapping regimes than other diurnal forest bird species.

The apparent strong negative effect of predator trapping on weka is likely an artefact of weka having recently recolonised Nelson Lakes National Park (Peter Gaze and Erin Drummond *pers. comms*, 11 Jul & 4 Aug 2024), where traplines were already present. Two weka were recorded along 39.8 km of trapped transects in Nelson Lakes National Park (0.05 birds/km), which comprised 70% of trapped habitat for weka along Te Araroa Trail. A longer time series of counts is required to determine weka population trends at this site, and their response to predator trapping.

Fantail colour morphs

The proportion of black fantails observed along South Island sections of Te Araroa Trail (5.6% of 359 birds) was similar to the 4.9% of 470 birds that Atkinson & Briskie (2007) reported from 33 sites across the South Island in 2002. These two data points 22 years apart indicate that the proportion of black morph birds in the South Island population has stabilised after declining from *c*.12–13% reported by three studies based on field work undertaken between the late 1960s and 1978 (Caughley 1969; Craig 1972; Powlesland 1982). These proportions are much lower than those given in two recent field guides ("12–25%", Heather & Robertson 2015; and "Up to 25%", Scofield & Stephenson 2015).

Setting a baseline over time and space

Te Araroa Trail is recognised internationally as a highly regarded long-distance walking trail that samples an extraordinary diversity of habitats along a well-defined route (Chapple 2017; Zierold 2019; La Vigne 2020). This snapshot of the birds recorded on a 3,257 km transect along the length of the North and South Islands is intended as a baseline for future Te Araroa Trail walkers to assess changes in bird distribution and abundance along the entire trail or portions of it. The data presented in Appendix 2 and Supplementary materials could also provide a baseline for describing and comparing bird communities at other mainland sites.

The true value of this baseline may not become apparent for decades, until others repeat the counts, and interpret their findings in relation to environmental changes. Repeated surveys over long time scales have the potential to reveal changes in bird community structure and abundance in response to climate change, changes in human land use, or changes in predator communities (Russell *et al*. 2015; Iknayan & Beissinger 2020; Riddell *et al*. 2021).

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Appendix 1

Names and summary counts of all 111 bird species encountered on Te Araroa Trail, listed alphabetically by common name (following Checklist Committee 2024). Numbers in parentheses are the number of checklists where the species was recorded, followed by the total count (combining diurnal, nocturnal, transect and stationary counts).

Australasian bittern | matuku-hūrepo *Botaurus poiciloptilus* (1, 1); Australasian crested grebe | pūteketeke *Podiceps cristatus australis* (13, 82); Australasian gannet | tākapu *Morus serrator* (27, 62); Australasian shoveler | kuruwhengi *Spatula rhynchotis* (8, 168); Australian coot *Fulica atra australis* (8, 24); Australian magpie | makipae *Gymnorhina tibicen* (463, 1,714); banded dotterel | pohowera *Anarhynchus bicinctus* (17, 111); banded rail | moho pererū *Hypotaenidia philippensis* (6, 6); Barbary dove *Streptopelia risoria* (21, 56); bar-tailed godwit | kuaka *Limosa lapponica* (23, 3,245); bellbird | korimako *Anthornis melanura* (650, 2,692); black-billed gull | tarāpuka *Chroicocephalus bulleri* (29, 1,250); black-fronted dotterel *Elseyornis melanops* (4, 8); black-fronted tern | tarapirohe *Chlidonias albostriatus* (16, 149); black shag | māpunga *Phalacrocorax carbo* (85, 186); black swan | kakīānu *Cygnus atratus* (52, 1,161); brown creeper | pīpipi *Mohoua novaeseelandiae* (68, 147); brown quail | kuera *Synoicus ypsilophorus* (8, 12); brown teal | pāteke *Anas chlorotis* (5, 92); Buller's shearwater | rako *Ardenna bulleri* (2, 33); California quail | tikaokao *Callipepla californica* (186, 493); Canada goose | kuihi *Branta canadensis* (69, 2,106); Caspian tern | taranui *Hydroprogne caspia* (54, 108); chaffinch | pahirini *Fringilla coelebs* (1,071, 5,806); chestnut-breasted shelduck *Tadorna tadornoides* (1, 1); cirl bunting *Emberiza cirlus* (4, 4); common myna | maina *Acridotheres tristis* (378, 3,406); common pheasant *Phasianus colchicus* (224, 422); common redpoll *Acanthis flammea* (286, 1,350); common starling | tāringa *Sturnus vulgaris* (473, 4,467); common tern *Sterna hirundo* (1, 1); Cook's petrel | tītī *Pterodroma cookii* (1, 4); dunnock *Prunella modularis* (396, 771); eastern rosella | kākā uhi whero *Platycercus eximius* (213, 423); Eurasian blackbird | manu pango *Turdus merula* (976, 4,019); Eurasian skylark | kairaka *Alauda arvensis* (322, 946); European goldfinch | kōurarini *Carduelis carduelis* (646, 4,256); European greenfinch *Chloris chloris* (454, 1,949); fairy tern | tara iti *Sternula nereis* (2, 4); fernbird | mātātā *Poodytes punctatus* (22, 62); flesh-footed shearwater | toanui *Ardenna carneipes* (1, 6); fluttering shearwater | pakahā *Puffinus gavia* (2, 55); Foveaux shag | mapo *Leucocarbo stewarti* (1, 1); great spotted kiwi | roroa *Apteryx maxima* (3, 6); grey duck | pārera *Anas superciliosa* (10, 49); greylag goose | kuihi *Anser anser* (13, 262); grey-tailed tattler *Tringa brevipes* (1, 1); grey teal | tētē-moroiti *Anas gracilis* (14, 1,995); grey warbler | riroriro *Gerygone igata* (705, 1,690); helmeted guineafowl *Numida meleagris* (1, 5); house sparrow | tiu *Passer domesticus* (693, 12,517); kākā *Nestor meridionalis* (45, 165); kakariki | parakeet sp. *Cyanoramphus* sp. (1, 1); kakī | black stilt *Himantopus novaezelandiae* (1, 1); kea *Nestor notabilis* (5, 11); kererū | New Zealand pigeon *Hemiphaga novaeseelandiae* (210, 375); kōtuku | white heron *Ardea alba* (1, 1); little black shag | kawau tūī *Phalacrocorax sulcirostris* (2, 2); little egret *Egretta gazetta* (1, 1); little owl | ruru nohinohi *Athene noctua* (1, 1); little shag | kawaupaka *Microcarbo melanoleucos* (88, 166); long-tailed cuckoo | koekoeā *Eudynamys taitensis* (99, 171); mallard | rakiraki *Anas platyrhynchos* (276, 2,896); nankeen night heron | Umu kōtuku *Nycticorax caledonicus* (3, 7); New Zealand dabchick | weweia *Poliocephalus rufopectus* (2, 2); New Zealand dotterel | tūturiwhatu *Anarhynchus obscurus* (31, 133); New Zealand falcon | kārearea *Falco novaeseelandiae* (41, 55); New Zealand fantail | pīwakawaka *Rhipidura fuliginosa* (811, 2,258); New Zealand pipit | pīhoihoi *Anthus novaeseelandiae* (108, 198); New Zealand scaup | pāpango *Aythya novaeseelandiae* (52, 698); North Island brown kiwi | kiwi-nui *Apteryx mantelli* (6, 13); North Island robin | toutouwai *Petroica longipes* (87, 369); paradise shelduck | pūtangitangi *Tadorna variegata* (243, 1,995); peafowl | pīkao *Pavo cristatus* (47, 175); pied shag | kāruhiruhi *Phalacrocorax varius* (56, 174); pied stilt | poaka *Himantopus himantopus leucocephalus* (60, 320); pūkeko *Porphyrio melanotus* (213, 887); red-billed gull | tarāpunga *Chroicocephalus novaehollandiae scopulinus* (139, 5,427); red-crowned parakeet | kākāriki *Cyanoramphus novaezelandiae* (1, 1); red knot | huahou *Calidris canutus* (1, 300); reef heron | matuku moana *Egretta sacra* (2, 2); rifleman | tītitipounamu *Acanthisitta chloris* (49, 132); rock pigeon | kererū aropari *Columba livia* (97, 1,120); royal spoonbill | kōtuku ngutupapa *Platalea regia* (20, 177); ruddy turnstone *Arenaria interpres* (8, 90); ruru | morepork | *Ninox novaeseelandiae* (47, 95); sacred kingfisher | kotare *Todiramphus sanctus* (429, 993); shining cuckoo | pīpīwharauroa *Chrysococcyx lucidus* (153, 226); silvereye | tauhou *Zosterops lateralis* (1,007, 5,381); song thrush | manu-kai-hua-rakau *Turdus philomelos* (674, 1,890); sooty shearwater | tītī *Ardenna grisea* (3, 154); southern black-backed gull | karoro *Larus dominicanus* (341, 4,589); South Island pied oystercatcher | tōrea *Haematopus finschi* (41, 2,245); South Island robin | kakaruai *Petroica australis* (107, 226); spotted dove *Streptopelia chinensis* (70, 153); spotted shag | kawau tikitiki *Phalacrocorax punctatus* (1, 2); spur-winged plover *Vanellus miles* (265, 1,198); swamp harrier | kāhu *Circus approximans* (264, 350); tomtit | miromiro *Petroica macrocephala* (504, 2,130); tūī *Prosthemadera novaeseelandiae* (644, 2,202); variable oystercatcher | tōrea pango *Haematopus unicolor* (110, 680); wandering tattler *Tringa incana* (1, 1); weka *Gallirallus australis* (26, 66); welcome swallow | warou *Hirundo neoxena* (625, 2,157); whio | blue duck *Hymenolaimus malacorhynchus* (3, 7); white-faced heron | matuku moana *Egretta novaehollandiae* (138, 434); white-fronted tern | tara *Sterna striata* (36, 1,224); whitehead | pōpokotea *Mohoua albicilla* (147, 1,004); wild turkey | korukoru *Meleagris gallopavo* (20, 109); wrybill | ngutu pare *Anarhynchus frontalis* (1, 30); yellow-crowned parakeet | kākāriki *Cyanoramphus auriceps* (30, 73); yellowhammer | hurukōwhai *Emberiza citrinella* (572, 2,156).

Appendix 2

The ten most abundant and ten most frequently observed bird species along 19 contiguous sections comprising the entire Te Araroa Trail. '%' is the percentage of transects where a species was recorded in each section, and '% rank' is the ranking order by frequency of occurrence (1 = the most frequently encountered species).

Table 2.01. Cape Reinga to Kaitāia (127.3 km, 69 transects).

Species	Birds/km	Rank	%	% rank
White-fronted tern	5.66	1	17.4	11
Red-billed gull	3.05	2	23.2	8
Southern black-backed gull	2.51	3	78.3	1
House sparrow	1.76	4	20.3	9=
Common myna	1.34	5	27.5	5=
European goldfinch	0.77	6	24.6	7
Eurasian skylark	0.76	7	50.7	2
Welcome swallow	0.47	8	31.9	4
Common starling	0.44	9	13.0	14
Fluttering shearwater	0.43	10	2.9	30
Yellowhammer	0.35	11	42.0	3
Eurasian blackbird	0.27	12	20.3	9=
Caspian tern	0.24	15	27.5	5=

Table 2.02. Kaitāia to Kerikeri (117.2 km, 60 transects).

Species	Birds/ km	Rank	%	% rank
House sparrow	3.44	1	55.0	9
Common myna	3.11	2	75.0	4
Paradise shelduck	1.72	3	31.7	14
Eurasian blackbird	1.51	4	76.7	2=
Silvereye	1.48	5	71.7	5
New Zealand fantail	1.25	6	76.7	2=
Grey warbler	1.22	7	85.0	1
Chaffinch	1.16	8	65.0	6
European goldfinch	1.07	9	48.3	11
Tūī	1.00	10	63.3	7
Song thrush	0.77	12	50.0	10
Sacred kingfisher	0.64	14	56.7	8

Table 2.03. Kerikeri to Whangārei Harbour (183.7 km, 103 transects).

Species	Birds/ km	Rank	%	% rank
Common myna	4.25	1	72.8	6
House sparrow	3.42	2	62.1	8
Red-billed gull	2.13	3	26.2	20
Chaffinch	2.07	4	79.6	1
Pūkeko	1.68	5	45.6	12
Eurasian blackbird	1.49	6	75.7	2
Tūī	1.48	7	74.8	4=
Grey warbler	1.47	8	74.8	4=
Bar-tailed godwit	1.39	9	4.9	46
Sacred kingfisher	1.32	10	75.7	3
New Zealand fantail	1.26	11	69.9	7
Silvereye	1.13	13	60.2	9
Welcome swallow	0.81	15	58.3	10

Table 2.04. Whangārei Harbour to Auckland (225.7 km, 130 transects).

Species	Birds/ km	Rank	%	% rank
Red-billed gull	13.08	1	38.5	14
House sparrow	6.38	2	66.9	3
Common myna	3.13	3	71.5	2
Eurasian blackbird	2.65	4	77.7	1
Tūī	1.88	5	63.8	4
Bar-tailed godwit	1.84	6	6.2	40
Variable oystercatcher	1.74	7	30.8	16
Chaffinch	1.36	8	54.6	5
Rock pigeon	1.22	9	23.1	21
Common starling	1.19	10	40.8	13
Silvereye	1.03	12	53.1	6
Song thrush	0.93	13	49.2	8
New Zealand fantail	0.92	15=	51.5	7
Welcome swallow	0.92	15=	48.5	9=
Grey warbler	0.73	18	48.5	9=

Table 2.05. Auckland to Hamilton (185.6 km, 95 transects).

Species	Birds/ km	Rank	%	% rank
House sparrow	17.91	1	91.6	1
Bar-tailed godwit	13.62	2	4.2	38
South Island pied oystercatcher	5.81	3	4.2	38
Common myna	5.50	4	85.3	2
Common starling	5.11	5	82.1	4
European goldfinch	3.97	6	78.9	5
Eurasian blackbird	3.42	7	84.2	3
Mallard	3.20	8	33.7	20
Rock pigeon	3.12	9	26.3	25
European greenfinch	2.67	10	73.7	8=
Chaffinch	1.88	11	77.9	6
Silvereye	1.73	13	73.7	8=
Song thrush	1.56	15	74.7	7
Sacred kingfisher	1.02	18	69.5	10

Table 2.06. Hamilton to Te Kūiti (115 km, 62 transects).

Species	Birds/ km	Rank	%	% rank
House sparrow	4.16	1	51.6	10
Chaffinch	2.96	2	80.6	1
Common starling	2.18	3	38.7	16
European goldfinch	2.17	4	62.9	6=
Common myna	2.15	5	50.0	11
Australian magpie	1.90	6	62.9	6=
Yellowhammer	1.51	7	53.2	9
Eurasian blackbird	1.49	8	77.4	2
Tūī	1.17	9	71.0	3=
Silvereye	1.15	10	62.9	6=
Grey warbler	1.03	12	71.0	3=
New Zealand fantail	0.93	13	71.0	3=

Table 2.07. Te Kūiti to Taumarunui (170.1 km, 88 transects).

Species	Birds/ km	Rank	%	% rank
Chaffinch	3.97	1	92.0	1
Whitehead	2.92	2	46.6	16
European goldfinch	2.39	3	53.4	12=
House sparrow	2.32	4	47.7	15
Silvereye	2.25	5	76.1	4
Yellowhammer	1.70	6	60.2	8
Australian magpie	1.53	7	53.4	12=
Tūī	1.40	8	70.5	6=
Bellbird	1.23	9	70.5	6=
New Zealand fantail	1.22	10	73.9	5
Eurasian blackbird	1.21	11	84.1	2
Grey warbler	1.14	14	81.8	3
Welcome swallow	1.09	15	55.7	10
Song thrush	0.92	17	59.1	9

Table 2.08. Taumarunui to National Park (132.8 km, 67 transects).

Species	Birds/ km	Rank	%	% rank
Chaffinch	3.24	1	89.6	1
Silvereye	2.09	2	76.1	3
House sparrow	1.91	3	28.4	21
Eurasian blackbird	1.73	4	82.1	2
Whitehead	1.57	5	38.8	12
European goldfinch	1.39	6	29.9	18=
Tomtit	1.33	7	50.7	9=
Bellbird	1.26	8	64.2	5=
Common starling	1.11	9	29.9	18=
Common redpoll	1.09	10	41.8	11
Grey warbler	1.07	11	65.7	4
New Zealand fantail	1.05	12	64.2	5=
Song thrush	1.01	13	58.2	7
Tūī	0.81	15	55.2	8
Dunnock	0.47	19	50.7	9=

Table 2.09. National Park to Whanganui (213.1 km, 112 transects).

Species	Birds/ km	Rank	%	% rank
Chaffinch	3.38	1	86.6	1
Silvereye	2.23	2	73.2	5
House sparrow	2.11	3	43.8	14
Eurasian blackbird	2.00	4	83.9	2
Welcome swallow	1.74	5	65.2	7
Bellbird	1.60	6	83.0	3
Song thrush	1.25	7	69.6	6
European goldfinch	1.24	8	53.6	10
Yellowhammer	1.21	9	51.8	11
Australian magpie	1.06	10	54.5	9
Tūī	1.06	11	77.7	4
New Zealand fantail	0.87	12	64.3	8

Table 2.10. Whanganui to Palmerston North (121 km, 63 transects).

Species	Birds/ km	Rank	%	% rank
Southern black-backed gull	22.33	1	46.0	14
House sparrow	15.44	2	95.2	1
Common starling	7.53	3	74.6	3=
European goldfinch	5.90	4	90.5	2
Mallard	2.18	5	31.7	17
Eurasian blackbird	1.96	6	57.1	10
Chaffinch	1.79	7	74.6	3=
European greenfinch	1.64	8	60.3	9
Eurasian skylark	1.47	9	74.6	3=
Welcome swallow	1.45	10	66.7	6=
Australian magpie	1.32	11	66.7	6=
Song thrush	0.79	15	63.5	8

Table 2.11. Palmerston North to Wellington (259.5 km, 132 transects).

Species	Birds/ km	Rank	%	% rank
House sparrow	5.61	1	49.2	7
Red-billed gull	2.99	2	14.4	24
Southern black-backed gull	2.50	3	18.9	20
Chaffinch	2.11	4	73.5	2
Common starling	1.83	5	36.4	10
Eurasian blackbird	1.55	6	75.8	1
Tūī	1.51	7	67.4	3
Silvereye	1.50	8	60.6	5
White-fronted tern	1.44	9	3.0	42
European goldfinch	1.31	10	41.7	9
New Zealand fantail	1.14	11	65.9	4
Bellbird	1.01	12	57.6	6
Grey warbler	0.44	18	44.7	8

Table 2.12. Meretoto / Ship Cove to Havelock (96.1 km, 51 transects).

Species	Birds/ km	Rank	%	% rank
Silvereye	2.85	1	84.3	1=
Bellbird	2.28	2	84.3	1=
House sparrow	1.99	3	25.5	8
South Island pied oystercatcher	1.68	4	5.9	31=
Black swan	1.10	5	7.8	22=
Eurasian blackbird	0.98	6	62.7	3
Paradise shelduck	0.92	7	5.9	31=
White-faced heron	0.85	8	13.7	17
Chaffinch	0.80	9	56.9	4
Mallard	0.79	10	7.8	22=
New Zealand fantail	0.47	14	43.1	5=
Song thrush	0.43	17	37.3	7
European goldfinch	0.40	18	23.5	9=
Weka	0.29	20	23.5	9=
Grey warbler	0.26	22	43.1	5=
Welcome swallow	0.21	23	23.5	9=

Table 2.13. Havelock to St Arnaud (181.2 km, 99 transects).

Species	Birds/ km	Rank	%	% rank
Silvereye	3.80	1	82.8	1
Bellbird	2.12	2	70.7	2
Tomtit	1.49	3	40.4	4
European goldfinch	1.31	4	16.2	15
House sparrow	1.19	5	24.2	9
Mallard	0.88	6	9.1	23
Chaffinch	0.62	7	39.4	5
Common redpoll	0.56	8	31.3	7
Yellowhammer	0.52	9	19.2	13
Eurasian blackbird	0.49	10=	35.4	6
Welcome swallow	0.49	10=	30.3	8
New Zealand fantail	0.44	12	43.4	3
Song thrush	0.44	13	23.2	10

Table 2.14. St Arnaud to Boyle River (127.9 km, 65 transects).

Species	Birds/ km	Rank	%	% rank
Silvereye	2.08	1	75.4	1
Chaffinch	2.05	2	61.5	4
Bellbird	1.96	3	64.6	3
Tomtit	1.85	4	72.3	2
Canada goose	1.27	5	26.2	11
Common redpoll	0.78	6	35.4	7
Yellowhammer	0.56	7	30.8	9
New Zealand fantail	0.48	8	38.5	6
Song thrush	0.40	9	33.8	8
South Island robin	0.38	10	40.0	5
Grey warbler	0.24	15	27.7	10

Table 2.15. Boyle River to Rakaia River (209.2 km, 110 transects).

Species	Birds/ km	Rank	%	% rank
Silvereye	3.04	1	70.0	2=
Chaffinch	2.40	2	81.8	1
Bellbird	1.91	3	70.0	2=
Tomtit	1.85	4	61.8	4
Common redpoll	0.66	5	46.4	5
Mallard	0.61	6	8.2	29
Yellowhammer	0.59	7	33.6	9
Welcome swallow	0.57	8	30.9	10
New Zealand scaup	0.54	9	3.6	35
Eurasian blackbird	0.53	10	41.8	6
South Island robin	0.47	11=	40.9	7
New Zealand fantail	0.47	11=	40.0	8

Table 2.16. Rakaia River to Twizel (209.0 km, 108 transects).

Species	Birds/ km	Rank	%	% rank
Canada goose	1.08	1	9.3	21
Yellowhammer	1.05	2	44.4	1
Paradise shelduck	0.86	3	12.0	17
House sparrow	0.83	4	20.4	8=
Black-billed gull	0.72	5	2.8	31
Silvereye	0.68	6	22.2	7
Australian magpie	0.64	7	25.9	5=
Mallard	0.62	8	14.8	15
Common redpoll	0.60	9	26.9	3=
Eurasian skylark	0.57	10=	26.9	3=
Chaffinch	0.57	10=	25.9	5=
Dunnock	0.40	13	38.0	2
European greenfinch	0.34	14	20.4	8=
New Zealand pipit	0.26	18	19.4	10

Supplementary materials

An Excel spreadsheet of all birds encountered on Te Araroa Trail is available at https://www.birdsnz.org.nz/wp-content/uploads/2025/02/Te-Araroa-supplementary-materials.xlsx

Table 2.17. Twizel to Wānaka (151.1 km, 79 transects).

Species	Birds/ km	Rank	%	% rank
Silvereye	1.87	1=	45.6	2
Black-billed gull	1.87	1=	5.1	32
European greenfinch	1.83	3	32.9	4=
House sparrow	1.58	4	24.1	10
Chaffinch	1.53	5	54.4	1
Mallard	1.47	6	19.0	14
Common starling	1.11	7	17.7	16=
European goldfinch	1.07	8	32.9	4=
New Zealand scaup	0.85	9	17.7	16=
Eurasian blackbird	0.72	10	31.6	6
Common redpoll	0.69	11	25.3	8=
Dunnock	0.66	12	41.8	3
Southern black-backed gull	0.59	13	27.8	7
Yellowhammer	0.46	14	25.3	8=

Table 2.18. Wānaka to Te Anau highway (200.9 km, 105 transects).

Species	Birds/ km	Rank	%	% rank
New Zealand scaup	1.31	1	15.2	16
Silvereye	1.26	2	52.4	2
House sparrow	1.13	3	19.0	14
Chaffinch	0.85	4	54.3	1
Common starling	0.83	5	12.4	22
Paradise shelduck	0.82	6	24.8	10
European goldfinch	0.77	7	22.9	11
Black-billed gull	0.57	8	3.8	33
Tomtit	0.56	9	32.4	7
Dunnock	0.50	10	34.3	3=
Bellbird	0.47	11	33.3	5=
Eurasian blackbird	0.43	12	34.3	3=
Grey warbler	0.39	14	33.3	5=
New Zealand fantail	0.36	15	30.5	8
Yellowhammer	0.32	16	25.7	9

Table 2.19. Te Anau highway to Bluff (240.9 km, 129 transects).

Species	Birds/ km	Rank	%	% rank
Grey teal	8.17	1	3.9	43
Canada goose	6.19	2	4.7	37
South Island pied oystercatcher	3.84	3	15.5	19
Black swan	2.19	4	5.4	33
Common redpoll	2.07	5	29.5	8
House sparrow	2.03	6	21.7	13
Red-billed gull	1.98	7	14.0	20
Black-billed gull	1.67	8	10.1	26
Common starling	1.64	9	25.6	10
Mallard	1.22	10	12.4	22
Southern black-backed gull	1.15	11	28.7	9
Bellbird	1.02	12	46.5	1
Chaffinch	0.90	13	31.8	3=
Tomtit	0.87	15	34.1	2
Silvereye	0.41	21	31.0	7
Eurasian blackbird	0.35	23	31.8	3=
Dunnock	0.34	24	31.8	3=
Grey warbler	0.29	28	31.8	3=

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SHORT NOTE

A nomenclatural issue related to Lopdells' penguin *Archaeospheniscus lopdelli*

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Lopdells' penguin *Archaeospheniscus lopdelli* was described by Brian Marples (1952), who dedicated the fossil species' name to two people, "Dr. and Mrs. J.C. Lopdell."[1] This would make *lopdelli* an incorrect latinisation by Marples of the last name Lopdell into a plural genitive Latin noun, a process described in the International Code of Zoological Nomenclature (ICZN 1999) Article 31.1.2.

Tennyson *et al.* (2010) published an emendation for *lopdelli* to *lopdellorum*, noting that Marples (1952) meant to dedicate the penguin to two people, not just Dr. Lopdell. They justified this emendation by citing part of Article 33.2.1 which deals with original spellings, and they wrote that "the specific epithet *lopdelli* is an incorrect original spelling because Marples (1952) intentionally and explicitly dedicated the species to a man and a woman together."

Tennyson *et al.* (2010) are correct that *lopdellorum* would be the correct latinisation of Lopdell for two people. However, their emendation is unjustified under the Code. Article 32.5.1 states:

"If there is in the original publication itself, without recourse to any external source of information, clear evidence of an inadvertent error, such as a lapsus calami or a copyist's or printer's error, it must be corrected. Incorrect transliteration or latinization, or use of an inappropriate connecting vowel, are not to be considered inadvertent errors."

The use of *lopdelli* was an incorrect latinisation, not a *lapsus calami*, and so is not considered inadvertent. Further, Article 33.2 has more context that they do not include in their paper:

"33.2. Emendations
Any demonstrably intentional change in the original spelling of a name other than a mandatory change is an 'emendation', except as provided in Article 33.4.

33.2.1. A change in the original spelling of a name is only to be interpreted as 'demonstrably intentional' when in the work itself, or in an author's (or publisher's) corrigenda, there is an explicit statement of intention, or when both the original and the changed spelling are cited and the latter is adopted in place of the former, or when two or more names in the same work are treated in a similar way."

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The "explicit statement of intention" is meant to refer only to an emendation given in the original text, or in the author's corrigenda - not to the original use of the name. Marples (1952) offered no such emendation of *lopdelli* in his text, and so there is no demonstrably intentional change. Put another way: there can be no change by Marples in the original spelling, if the original spelling is used once only. Article 33.2.1 does not apply here. As noted in 32.2:

> "The original spelling of a name is the 'correct original spelling', unless it is demonstrably incorrect as provided in Article 32.5."

Because Article 32.5.1 is clear that an incorrect latinisation is not to be considered inadvertent, and because there were no other corrections by Marples in his book, *A. lopdellorum* is an unjustified emendation, and the available species name continues to be *Archaeospheniscus lopdelli.*

This latinisation error by Marples is unfortunate, as ideally the species would refer correctly to both Lopdells with a genitive plural. The Code, however, only recommends that authors <u>should</u> use the genitive case, not that they must:

> "Recommendation 31A. Avoidance of personal names as nouns in apposition. An author who establishes a new species-group name based on a personal name should preferably form the name in the genitive case and not as a noun in apposition, in order to avoid the appearance that the species-group name is a citation of the authorship of the generic name."

Further, Article 31.1 notes:

> "A species-group name formed from a personal name may be either a noun in the genitive case, or a noun in apposition (in the nominative case), or an adjective or participle."

Technically, *lopdelli* could be a masculine, singular genitive noun, referring to only one Lopdell. However, if *lopdelli* is considered a well-formed masculine second declension Latin noun in apposition in the nominative plural, it does refer to both Dr John Colin Lopdell OBE and also to Mrs Anne Davidson Lopdell – the Lopdells of Lopdells' penguin.

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Keywords: *Archaeospheniscus*, nomenclature, New Zealand, fossil, ICZN, emendation

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SHORT NOTE

First revision of karoro *Larus dominicanus antipodum* (Bruch, 1853)

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Karoro or kelp gull *Larus dominicanus* Lichtenstein, 1823 is represented in New Zealand by a possibly distinct population, for which the subspecies name *antipodus* was proposed by Jiguet *et al*. (2012). They list the precedent for *antipodus* as *Larus antipodus* G.R. Gray, 1844. The precedence for this binomial is not clear and needs correction.

Pierre Antoine Delalande, who collected in South Africa in 1820, was likely the source of the original specimen for *L. antipodus*. He did not mention gulls in his only presentation to the Museum of Natural History in Paris (Delalande 1822), and he passed away shortly afterwards from diseases caught during his travels (Gunn & Codd 1981).

Bruch (1853) moved *L. antipodus* to *Dominicanus antipodus* in his monograph on the genus *Larus*. Jiguet (2002) correctly noted that the first description of *Dominicanus antipodus* should therefore be attributed as Bruch, 1853, as Gray (1844) included no actual description or figure with this name. When Bruch moved *L. antipodus*, he also added a footnote: "Linguistically speaking, it can only be called with the genitive *Antipodum*: the one who lives near the Antipodes" (Bruch 1853, translation my own, original in German). Bruch did not clarify further in his publication whether *D. antipodus* or *D. antipodum* should be the available species name and his footnote was ignored by some but not all later authors. This confusion has percolated through the taxonomy since.

Antipodus is a Latin adjective in several dictionaries which include mediaeval Latin (Georges 1913; Gaffiot 2016; Du Cange 1883). It is a latinisation of the Greek ἀντίποδες, which was already borrowed into Latin as far back as Seneca (*c*. 64) as *antipodes*, a third declension plural-only masculine noun. *Antipodus* was unlikely to be known as a Latin word by Gray, as most classical Latin dictionaries do not include it, and it is more likely that he made a novel transliteration and latinisation of the Greek word. He also could have used *antipodes* (nominative, plural only), or *antipodum* (genitive pl.), or possibly a form of *antipous* (directly transliterating from Greek, here nom. sg.) or *antepedes* (an extant Latin calque, here nom. pl.).

According to Article 31.2 of the Code (ICZN 1999), the species name *antipodus* does not need to agree in number or gender with the masculine genus name *Larus* if it is a noun. If *antipodus* is considered an adjective, no change is needed as it already is in the masculine, nominative form. If it is considered a noun, it would be considered a noun in apposition and needs no adjustment. Bruch assumed it was only a Latin noun and attempted to change the case. This was not necessary according to the Code. The issue at hand is not that he attempted to correct it, however, rather that he spelled the species name in two different ways in his publication, and it is unclear which he preferred.

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In cases when two names are used in the same publication, Article 24.2.1 of the Code states "the precedence is fixed by the action of the first author citing in a published work those names or acts and selecting from them; this author is termed the "First Reviser"." It goes on in 24.2.4: "Original authors may be deemed to be First Revisers of spellings. When the author, or one of joint authors, of two different original spellings of the same name subsequently uses one of them as valid in a work (including the author's or publisher's corrigenda), and neither had previously been selected as the correct spelling by a First Reviser, the author is deemed to be the First Reviser, whether or not the author cites both spellings together (that used as valid becomes the correct original spelling)." In short: the First Reviser to note both names and to choose one of them clarifies the precedence of the name going forward; or the first author can use the name in a subsequent publication and clearly favor one over the other to set precedence.

Bruch used the name *D. antipodum* shortly after his original publication (Bruch 1855): "*Antipodum* Cab., *antipodus* Gray". Bruch was citing his own work in the journal two years prior, by noting that Cabanis was the publisher of the *Journal für Ornithologie*. He didn't specify directly and clearly which name to use – the first *antipodum* or the following *antipodus.* Relative location in a published text does not determine precedence. As Bruch (1855) did not choose explicitly between the names, this publication did not fix the precedence of the species and Bruch is not his own First Reviser.

While Bruch could have published an unambiguous *D. antipodum* or *D. antipodus* subsequently and fixed the precedence, he did not do so that I can tell. I could find no later publication by Bruch, who passed away in 1857 (Carus 1876).

The first author to use, but not explicitly choose, only one of the names from Bruch was Gray (1862), listing "*Dominicanus antipodum* Bruch, Cab. *Journ. für Ornith*. 1853, p. 100". Gray listed this under the heading "*LARUS ANTIPODUM* [sic], G. R. Gr. *List of Anseres B.M.* p. 169.", showing that he had read Bruch's footnote and that he preferred Bruch's correction. However, he did not explicitly cite both names in the text, and so this is not the action of a First Reviser. Neither Gray nor Bruch noted Gray's (1844) listing as a *nomen nudum*. Bonaparte (1854, 1856) also used *antipodum*, but he referenced it to Gray instead of Bruch, and he did not note the name *antipodus,* in either publication.

None of the subsequent authors have taken on the role of First Reviser by citing both names and choosing between them. Jiguet is closest, with his statement that "*D. antipodum*, Bruch, 1855, is the same name, differently accorded." This is almost accurate, although what "accorded" means is vague, and could perhaps refer to the generic change. However, in a later paper, Jiguet *et al.* (2012) proposed two subspecies, one of which is "*L. d. antipodus* G.R. Gray, 1844 (New Zealand)." This is confusing, as Jiguet (2002) himself was the first to note that *antipodus* was a *nomen nudum*.

A First Reviser is necessary "when the precedence between names or nomenclatural acts cannot be objectively determined." That this is happening here can be seen from the comical difference in citations from following authors. These refer to either Gray's (1844) *nomen nudum antipodus* (which, for instance, Jiguet *et al.* 2012 does); to Gray (1844) for *antipodum* (Bonaparte 1854 & 1856, and Gray 1862 himself, without comment); to Bruch (1853) for *antipodus* (Mathew & Iredale 1913; Jiguet 2002; Checklist Committee 2022); or to Bruch (1855) for *antipodum* (Gray 1862; Jiguet 2002; Checklist Committee 2022). Again, this needs clarification.

I hold that, out of Bruch's (1853) two published forms, *Dominicanus antipodus* and *Dominicanus antipodum*, *antipodum* should be chosen as the precedence. This means that the precedence is not *Larus antipodus* G.R. Gray, 1844, but *Dominicanus antipodum* Bruch, 1853. Thus, the full available name should be *Larus dominicanus antipodum* (Bruch, 1853).

Choosing *antipodum* has a few advantages. First, it would be irrelevant in practice whether or not Bruch (1855) meant the ordering of "*antipodum* Cab., *antipodus* Gray" to determine the precedence of the genitive over the nominative; it'll be as if he did. And while it doesn't strictly matter where in a published text the name is, *antipodum* did come first in Bruch (1855). Second, Gray (1862) also reverted to *antipodum*, and as the first person to publish the name at all, this recognises his contribution and correction. Third, while it could be a noun in apposition in either event, *antipodum* is a Latin word in a case that would fit Latin grammar as the appositional genitive (Ayer 2014). And finally, it clears up the function of the footnote in Bruch (1853), and seems to me to be probably what he would have wanted.

Choosing *antipodum* has one disadvantage: many subsequent works use *antipodus*. Even though there was no choice by a First Reviser, these could be considered misspellings. Under ICZN Article 33.2.3.1. "when an unjustified emendation is in prevailing usage and is attributed to the original author and date it is deemed to be a justified emendation." This would apply here, if Gray, 1844 was the original author of the available name – but he was not. As there is confusion about the author of the original description, only works which cite Bruch (1853) directly should be used to determined prevailing usage under Article 33.2.3.1. Other uses could point to the *nomen nudum antipodus* Gray, 1844 and would not be considered emendations of the available name *Larus dominicanus antipodum* (Bruch, 1853).

In works that clearly refer directly to Bruch (1853), five use *antipodus* (Saunders 1878, 1896; Mathews & Iredale 1913; Mathews 1927; Jiguet 2002), while three use *antipodum* (Gray 1862; Gray 1871; Kidder 1875). I could find no references to Bruch (1853) that include both *antipodus* and *antipodum*.

Article 33.5 of the Code states: "In any case of doubt whether a different subsequent spelling is an emendation or an incorrect subsequent spelling, it is to be treated as an incorrect subsequent spelling (and therefore unavailable), and not as an emendation." The sample size is so small that I am unsure if it is correct to consider *antipodus* as the prevailing usage, and so Article 33.2.3.1 does not apply. For comparison, Article 23.9.1.2 stipulates that precedence can be reverted when "the junior synonym or homonym has been used for a particular taxon, as its presumed valid name, in at least 25 works, published by at least 10 authors in the immediately preceding 50 years and encompassing a span of not less than 10 years." This is certainly not the case here. So: *Larus dominicanus antipodum* (Bruch, 1853) is the correct spelling.

Larus dominicanus antipodum is not recognised universally as a valid subspecies. At the time of writing, *L. d. antipodus* G.R. Gray, 1844 is only accepted by HBW and BirdLife International (2023) and Lepage *et al.* (2014). Some authorities are waiting on better genetic studies, following Jiguet *et al.* (2012)'s advice (Checklist Committee 2022). Linhares *et al.* (2024) could not find any supported clades through a study of mtDNA, although they did find some population structure by looking at haplotype frequency. Their sample size, particularly for birds from Aotearoa New Zealand, could have been larger. Morphometric studies like Jiguet *et al.* (2012) did not cover bare parts, which may show more phenotypic variation. More studies of *L. dominicanus* are warranted.

A note on the Checklist

The Checklist Committee (2022) has a short section listing references for *Larus dominicanus*. I suggest that the following relevant lines be amended or added:

Larus antipodus? [sic] G.R. Gray, 1844: *List Birds Brit. Mus. 3*: 169 – New Zealand. *Nomen nudum.*
Dominicanus antipodum Bruch 1853, *Journ. für Ornith. 1*: 100. Cf. First Reviser Littauer, R. (2025).
Dominicanus Antipodum Cab. [sic], *antipodus* (Gray); Bruch 1855, *Journ. für Ornith. 3*: 281.
Larus antipodum; F.W. Hutton 1870, *Ibis* 2(8): 396.
– ? *antipodum* G.R. Gr.; Cab. Journ. 1853 [sic, Bruch]; G.R. Gray 1871, *Hand-list Birds 3*: 112.
Dominicanus antipodus, Bruch, 1853; Jiguet 2002, *Bull. B.O.C.* 122(1), 71.
Larus dominicanus antipodus G.R. Gray, 1844; Jiguet et al. 2012, *Zoological Studies* 51(6): 891 – New Zealand.

Gray (1871) did not include "*? antipodum*" in a genus, instead leaving the generic name blank, although he did note *Dominicanus* Bruch, 1853 as the source of the tentative genus.

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SHORT NOTE

Further increase of tūī (*Prosthemadera novaeseelandiae*) on Miramar Peninsula, Wellington

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Sustained observations over a 26-year period (1998–2023) at a Seatoun Heights site provided an index of change in tūī (*Prosthemadera novaeseelandiae*) numbers on the Miramar Peninsula, east of Wellington city. Few tūī used to be seen on the peninsula, as in other areas of the city; however, the species is now widespread and common across the area (Bell 2008; Brockie & Duncan 2012; Miskelly 2018; McArthur *et al*. 2023). As noted by Bell (2008), the search effort per day varied, generally continuing for at least 10 min until the first tūī was either seen or heard. If no tūī were encountered, efforts were made to locate them later the same day. The data reported here therefore represent the days on which tūī were searched for and recorded (or not), rather than numbers of tūī *per se*. Over time, the number of 'tūī days' increased dramatically, but with some year–to–year variation (Table 1).

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The percentage of observation days on which tūī were encountered in Seatoun was calculated for each year over 1998–2023, based on monthly totals of days on which tūī were seen or heard (Table 1; Fig. 1). The author's absence in some years accounted for fewer observations in some calendar months, with no records for 3 months over 2009–2015 (Table 1). The number of days on which tūī were noted was low over 1998–2000 (0.3%–0.4%), increased over 2001–2005 (1.2%–9.0%), then rose sharply in 2006 (44.2%) and 2007 (76.4%), with high percentages (>80%) thereafter. Tūī were encountered on every observation day (n=1,378) over the last 4 years of study (Table 1; Fig. 1).

The first breeding of tūī reported on Miramar Peninsula in recent times was at the Massey Memorial area (on the northern end of the peninsula) in 2005, following 2 years of intensive possum control, with at least two juvenile tūī reported there in January 2005 (Atkinson 2005). That date coincides with the data shown in Table 1 showing the start of the population rise over 2004–05, when tūī observation days first reached double figures. The population increase

Table 1. Monthly distribution of days on which tūī were encountered at Seatoun, Wellington (1998–2023).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Days tūī recorded	Total days of obs.
1998	0	0	0	0	0	1	0	0	0	0	0	0	1	277
1999	0	0	0	0	0	0	0	0	0	0	0	1	1	319
2000	0	0	0	0	0	0	1	0	0	0	0	0	1	323
2001	1	0	0	0	0	0	1	2	0	0	0	0	4	347
2002	0	0	0	1	0	0	3	1	0	0	0	0	5	263
2003	0	0	1	1	1	1	0	0	0	0	0	0	4	324
2004	0	0	0	1	1	2	4	3	2	1	2	2	18	335
2005	1	1	0	5	4	0	6	2	1	4	4	2	30	334
2006	2	2	4	9	12	8	14	22	17	12	20	22	144	326
2007	24	3	10	22	21	28	31	19	22	27	21	28	256	335
2008	27	14	23	28	24	22	27	25	26	31	23	13	283	329
2009	24	27	24	20	26	0	25	29	28	26	28	27	284	298
2010	27	19	26	30	23	28	26	31	29	24	28	22	313	332
2011	25	15	30	25	18	0	18	28	16	25	25	28	253	284
2012	26	21	26	29	19	16	24	13	19	24	30	29	276	291
2013	25	27	23	29	27	22	27	27	25	25	25	19	301	319
2014	21	10	14	27	23	15	15	20	20	30	24	22	241	285
2015	21	7	8	21	0	19	27	26	12	25	29	21	216	254
2016	29	26	25	29	26	18	23	25	12	20	23	30	286	292
2017	27	26	29	25	15	28	27	27	24	26	30	29	313	322
2018	28	24	28	26	8	23	25	22	15	27	29	22	277	293
2019	20	21	23	28	30	17	23	29	29	24	30	27	301	318
2020	28	28	31	28	30	30	31	29	25	31	30	30	351	351
2021	30	27	31	29	20	27	31	31	27	23	30	31	337	337
2022	31	28	31	27	27	27	31	31	26	30	22	31	342	342
2023	31	28	31	30	28	22	31	31	27	30	30	29	348	348
Total	**448**	**354**	**418**	**470**	**383**	**354**	**471**	**473**	**402**	**465**	**483**	**465**	**5,186**	**8,178**

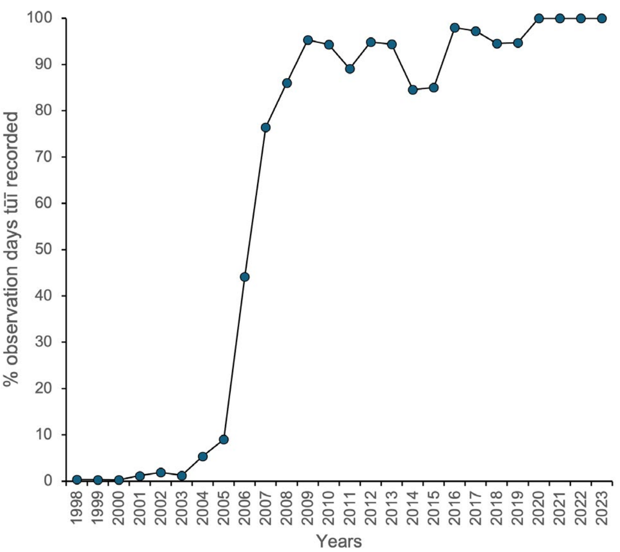

Figure 1. Annual percentages of observation days on which tūī were encountered at Seatoun, Wellington, over 1998–2023. Tūī were seen or heard on every observation day over the last 4 years.

of tūī around Wellington most likely results from two Wellington-based pest control initiatives: invasive mammal control and the establishment of the 252 ha predator-excluded Zealandia eco-sanctuary in Karori (Campbell-Hunt 2002; Atkinson 2005; Miskelly *et al*. 2005; Bell 2008; Brockie & Duncan 2012; Miskelly 2018; McArthur *et al*. 2023). Pest–mammal control was sustained intensively on the Miramar Peninsula over the period of study.

Along a 2.3 km bird count transect through a central Wellington suburb, Brockie & Duncan (2012) counted no tūī during the first three count periods (1969–70; 1970–71; 1981–82). Two tūī were recorded during 1988–89, with numbers then markedly increasing to 89 tūī over 2005–06, broadly consistent with the timing of increases at Seatoun over 1998–2005 (Table 1; Fig. 1). Around Zealandia, a multi–species predator exclusion fence was constructed in 1999 (Campbell–Hunt 2002). Within the ecosanctuary, 5-minute bird counts were compared over three time periods (Miskelly 2018): 1995–98 (pre-fence), 2002–05 (after pest mammal eradication) and 2013–16 (after several reintroduced endemic bird species had become established). Over these three time periods there was a total of 8,933 tūī encounters: 390 (4%) from 1995–98, 2589 (29%) from 2002–05, and 5,954 (67%) from 2013–16 (Miskelly 2018). Relatively few tūī were present in early years before the fence was installed, numbers rose after pest mammal eradication, reaching highest numbers by 2013–16. Again, this is broadly consistent with the trends evident at Seatoun (Table 1; Fig.1).

The changing pattern of tūī records reported here illustrates the value of sustained documentation of even casual observations of birds from a single site, involving a simple presence/absence approach This method is best suited to measuring dramatic changes in numbers, as illustrated here by the tūī population in the Wellington area. Finally, while this increase in tūī numbers in response to pest–mammal control has been dramatic, increases of tūī populations following implementation of pest–mammal control have occurred elsewhere in New Zealand (e.g., Elliott & Kemp 2016; Ruffell & Didham 2017; Fea *et al*. 2020; Fitzgerald *et al.* 2021; Innes *et al*. 2022). Consequently, the tūī has recently become a relatively common species in many areas where formerly it was less often encountered. To maintain this improved situation, pest-mammal control needs to be sustained over the long-term, not only for the tūī but for a suite of other endemic species as well.

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