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- To promote the recording and wide circulation of the results of bird studies and observations.
- To produce a journal and any other publication containing matters of ornithological interest.
- To effect co-operation and exchange of information with other organisations having similar aims and objects.
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Nearshore sightings of seabirds off the coast of Otago and Canterbury, New Zealand

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Abstract: Coastal and nearshore habitats are important to all seabird species. Understanding the distribution of seabirds in these environments can aid in their conservation. Despite the importance of coastal habitat, data collection for seabird species at sea is often difficult and resource intensive. Here, we take advantage of an established marine mammal surveying programme to collect distribution data for seabird species encountered in nearshore habitat. We surveyed seabird communities over 76 days in four locations along the southeast coast of New Zealand's South Island; Dunedin, Moeraki, Timaru, and Banks Peninsula. We present observations of seabird species presence in these locations, as well as, a brief assessment of the counting techniques used during the study. In addition, we summarise the seabird numbers in relation to the marine mammal surveys (i.e. the presence and absence of dolphins). We aim to show the value of opportunistic data collection, while contributing to baseline species distribution knowledge.

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INTRODUCTION

All seabird species use coastal and nearshore habitat, whether they are obligate to these areas year-round, or transient, returning to land to breed, socialise, or rear offspring. Understanding the distribution of seabird species within the nearshore environment can aid in their conservation, providing species managers with insight into habitat use (McLeay *et al.* 2010; Montevecchi *et al.* 2012), potential conflicts with anthropogenic interests (Anderson *et al.* 2011; Grémillet *et al.* 2018; Rodríguez *et al.* 2019), and areas of particular importance for each species (Forest & Bird 2014). Despite the importance of these ecosystems there are few data on seabird distribution in these habitats, particularly in Aotearoa New Zealand (but see O'Driscoll *et al.* 1998; Hawke 1998; Richard 1998). The collection of such data is often limited by access, expense, and weather.

Methods for collecting distribution data for seabirds in coastal habitat vary in scale and specificity. Global Position System (GPS) tracking studies are considered "gold standard" as they provide excellent fine scale distribution data. Such

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tracking does not rely on the researcher having access to the study area and allows for data to be collected regardless of sea condition (e.g. overnight or during storms). However, for small or difficult to access species, GPS studies are not always feasible, trackers can be lost, and the cost of such devices often results in low sample sizes (Casper 2009; Recio *et al.* 2011). Simple and inexpensive methods do exist, like shore based/vantage point observations, where researchers count species passing through an area (e.g. Waggitt *et al.* 2014). These surveys are useful in establishing the presence of a species and have been used to understand changes in habitat use prior to and post changes in the environment (e.g. the establishment of offshore wind farms; Rothery *et al.* 2009). Shore based observations, however, are limited to the immediate coastal area, and rely on birds being identifiable and coming within range of the vantage point (Waggitt *et al.* 2014). Surveying from boat-based platforms, provides the ability to move throughout the entire nearshore area, enabling researchers to collect data on all individuals that are encountered. Although boat-based surveys are still resource intensive, opportunities exist to take advantage of pre-established monitoring trips.

We aimed to record seabird species presence in coastal environments along the southeast coast of the South Island of New Zealand. We took advantage of a Hector's dolphin (*Cephalorhynchus hectori*) surveying programme to collect location data for all seabird species encountered. We use this opportunity to provide, 1) a brief assessment of the distribution of observed seabirds in coastal areas, 2) a comparison of seabird abundance in the presence and absence of dolphins, and 3) a comparison of two different bird counting methods feasible in this opportunistic situation; continuous and point counts.

METHODS

Seabird surveys were conducted on 76 days during November 2021 to July 2022, off the southeast coast of the South Island, New Zealand, in four locations: Dunedin, Moeraki, Timaru, and Banks Peninsula (BP; Fig. 1, Table 1). Surveys were conducted on one of three different planing research vessels (RV; 'Nemo','Grampus', and 'Cetos', Fig. 2). Vessels were 5.0–6.5 m in length and powered by single outboard engines (70–110 horsepower), and all observations took place on the decks which were essentially at sea level. Surveys were performed within 3 nm from shore and included both along shore routes (within 0.5 nm) and offshore 'zig-zags' (up to the 3 nm limit). Resampling of areas on the same day was avoided where possible, although in some areas (e.g. harbour entrances, small inlets/bay) repeated effort was inevitable. Surveys were restricted to weather conditions that favoured detection of marine mammals, principally Beaufort <4 and swell height no greater than 2 m. Surveys were not conducted at a regular time of day, instead they were timed to maximise effort when conditions were suitable. No burley or waste that might attract birds was discarded before or during surveys. Two methods were used to quantify birds during the surveys, continuous counts, and five-minute point counts.

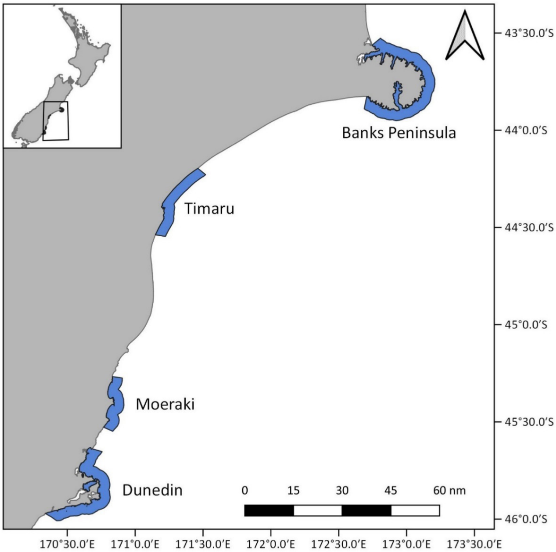

Figure 1. Map of the southeast coast of the South Island, New Zealand. Survey locations (north to south) Banks Peninsula, Timaru, Moeraki, and Dunedin.

For continuous counts, observers collected seabird sightings by facing the bow of the RV and continuously scanning the forward 180° aspect. All birds within an estimated 100 m radius were recorded, whether they were flying, diving, on, or under the water (e.g. diving penguins). The 100 m count radius was calibrated at the beginning of the survey, using static distance markers and GPS positions (e.g. distance to shore) to improve the accuracy of estimates. Count effort was given whilst travelling from 12 to 15 knots. Effort was stopped at low speeds due to the increased likelihood of resighting boat positive individuals. Once an individual was sighted, a GPS point was immediately generated. No attempt was made to assign a position to the bird, instead all individuals were given the location of the RV. Where multiple individuals were seen concurrently, they were recorded as a group and given the same GPS location. Birds flying with the RV were noted and not recounted. When tracking individuals became difficult, i.e. larger groups, a second observer was employed to assist. Continuous counts did not begin until one minute after departing a stop, to reduce any confounding impact of boat positive birds.

Five-minute point counts for seabirds were conducted as part of a distribution survey of Hector's dolphin. The RV stopped to collect environmental data at both dolphin presence and absence locations, it was at these times that five-minute point counts were performed. Presence locations were defined wherever a dolphin sighting was made, with a point count starting immediately upon sighting. While absence locations were taken every 30 minutes when dolphins were not sighted, beginning immediately once the vessel was stopped. At absence locations, counts were performed while the RV was stationary or drifting. Counts at presence locations were taken while stationary or taxiing with a dolphin group (<5 kn). For five-minute counts, one observer would scan a 360° view, and all birds that came within the 100 m perimeter were recorded.

Both continuous and point counts were carried out primarily by a single observer with optional assistance from other crew members. When the number of birds exceeded a reasonable amount to count, the best estimate was made and corroborated. Birds seen outside of the detection zone were not recorded even when identification was possible. Individuals that were within the detection zone but unable to be identified to species level were identified to the nearest taxonomic unit or recorded as unknown. In cases where the bird was totally obscured (usually by the sun), the sighting was given an unknown designation. In the case of fluttering shearwaters (*Puffinus gavia*) and Hutton's shearwaters (*Puffinus huttoni*), we did not attempt to differentiate between the two species given their high degree of similarity. Although we had very few sightings of prions (*Pachyptila* sp.), due to the high degree of similarity between species, we did not attempt to identify to species level. No voucher photographs were taken. The RV did not alter course for distant large aggregations of seabirds, therefore only groupings along the dolphin survey route were recorded. Sighting information and GPS locations were recorded using CyberTracker (CT; www.cybertracker.org) software on handheld mobile devices.

A summary of sightings for each species in each survey area is provided (Appendix 1), but for ease of interpretation we present heat maps and locations of the five primary groups sighted in Dunedin, Timaru, and Banks Peninsula. Moeraki was excluded due to the low number of surveys (n = 2) in this area. Species were grouped as follows: albatross (all family *Diomedeidae*), gulls (red-billed, *Chroicocephalus novaehollandiae scopulinus;* black-billed, *Chroicocephalus bulleri;* and black-backed gulls, *Larus dominicanus*), petrels (all family *Procellariidae*), terns (white-fronted, *Sterna striata;* black-fronted, *Chlidonias albostriatus;* and Caspian terns, *Hydroprogne caspia*) and shags (all family *Phalacrocoracidae*). Heat maps were produced in QGIS (version 3.8.3-Zanzibar, QGIS) using the "heatmap" symbology (radius 5,000 m) which renders all input locations as a raster. We weighted each location by both effort and group size so that sightings within an area of higher surveys, and smaller group size had a lower weight (as in Bennington *et al*. 2021). Effort areas were designated by creating a 3x3 nm grid, then counting the number of surveys (both point and continuous counts) that occurred within each section. The survey effort to each area was calculated as:

Locations were assigned the same survey effort as the area in which they occurred. The seabird count was included in the final weight by multiplying the effort by the proportion of individuals counted divided by the total count of that species:

For the point surveys, we provided a summary of seabird group counts in relation to the presence and absence of dolphins. We compared these counts using a two sample, two-sided t-test with seabird count as the response and presence/absence of dolphins as the grouping variable.

RESULTS

From November 2021 to July 2022, we sighted 10,840 groups of birds comprising 39,018 individuals over 611 five-minute point counts and 2,392.2 km of continuous counts. Most count effort was given at Banks Peninsula (BP) and Dunedin, with 37 and 24 survey days respectively (Table 1). This was reflected in the number of point counts (291 and 195) and the distance surveyed in continuous counts (1,495.6 km & 764.4 km) in both areas. Moeraki and Timaru were given the least effort with two and 13 survey days respectively, noting that no continuous counts were performed in Timaru (Table 1).

The most common species sighted were spotted shags (14,005; *Phalacrocorax punctatus*), black-backed gulls (6,284), red-billed gulls (6,165), sooty shearwaters (5,466; *Ardenna grisea*), and white-fronted terns (2,932). Another 30 species were sighted at least once during the counts. These included seven species of albatross, ten petrels, four shags, two terns, two penguins, arctic skua, black-billed gulls, and Australasian gannets (Table 2). The largest sighting event was a congregation of spotted shag 1.5 nm offshore of Te Kaio Bay (Banks Peninsula, 43º51.42'S 172º46.12'E), where approximately 2,300 individuals were estimated. The next three largest sightings were all

Table 1. Summary of the effort given recording seabird distribution along the southeast coast of the South Island, New Zealand. Displayed are the number of five-minute point counts, the total and average distance of continuous surveys, and the total time spent performing continuous surveys in either Dunedin, Moeraki, Timaru, or Banks Peninsula (BP). The total number of effort days and the summer (2021/22) and winter (2022) effort periods are also provided.

Location	Point counts	Distance surveyed (km)	Avg. survey length (km)	Total survey time (hours)	Survey days	Summer period	Winter period
Dunedin	195	764.4	7.1	31.6	24	Nov/Dec	June
Moeraki	16	132.2	7.8	6.2	2	Nov/Dec	NA
Timaru	109	0	–	0	13	March	June
BP	291	1,495.6	4.9	60.7	37	Jan/Feb	July
Total	611	2,392.2	5.5	98.5	76		

groups of sooty shearwaters directly off Aramoana Beach (Dunedin, 45º46.22′ S 170º42.79′ E) and were estimated at 400–500 individuals in number. Hutton's/fluttering shearwaters, red-billed gulls, black-backed gulls, and white-fronted terns all had single observations over 100 individuals.

Species detection was broadly similar for both continuous and point counts across most species; however, there were a few notable exceptions. Fluttering/Hutton's shearwater, Australasian gannets (*Morrus serrator*), yellow-eyed penguins (*Megadyptes antipodes*), and little penguins (*Eudyptula minor*) all had notable higher detections during continuous counts, with the latter being the most extreme example.

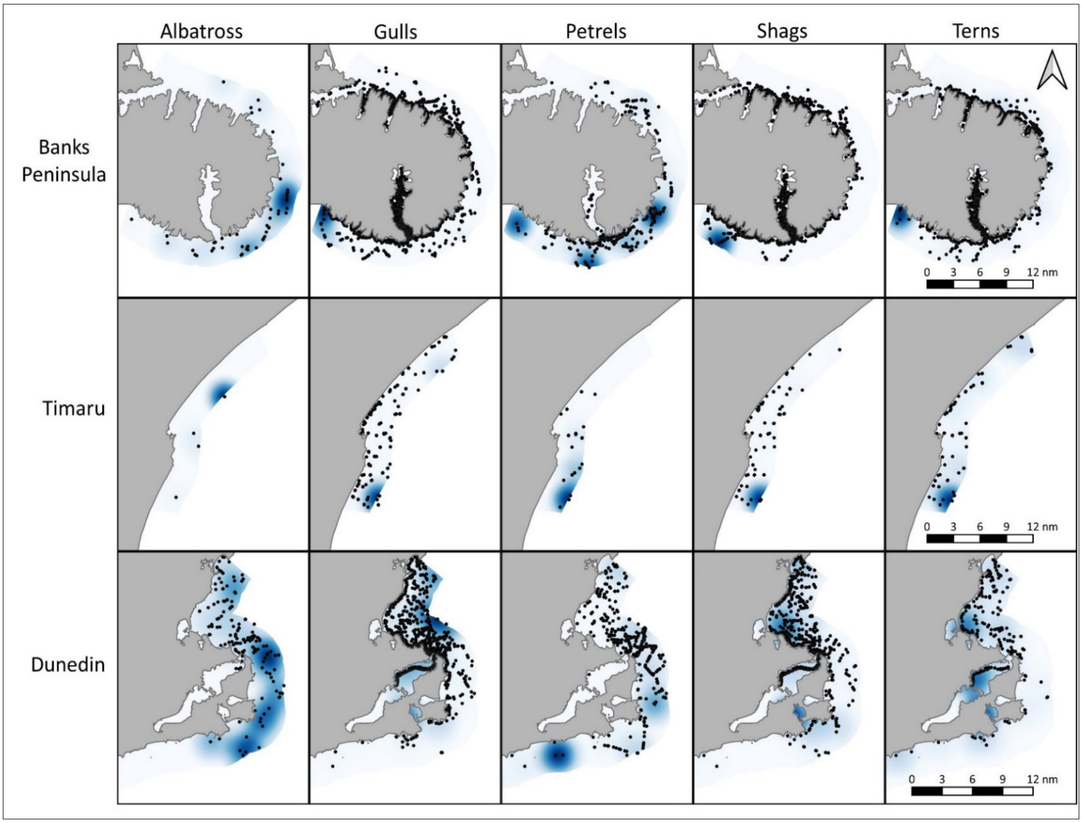

Figure 2. Sighting locations and associated heatmaps of seabird groups found in three sites (Banks Peninsula, Timaru, and Dunedin) along the southeast coast of the South Island, New Zealand. Heatmaps represent sightings weighted by survey effort and group size, with darker areas displaying higher densities. See Figure 1 for location context.

Table 2. Summary of all bird species seen in both five-minute and continuous counts in four locations along the southeast coast of the South Island, New Zealand. Species are grouped by family and identified by both the common and scientific name (as per Checklist Committee (OSNZ) 2022). Displayed are the number of groups, number of birds, average group size, and percentage of surveys were that species was sighted. Proportion (%) of surveys sighted is conditionally formatted to highlight values 0–25% (lightest grey), 25–50% (light grey), 50–75% (medium grey) and 75–100% (dark grey). Sighting records are also categorised by location, either Dunedin, Moeraki, Timaru, or Banks Peninsula (BP).

					Proportion of surveys sighted (%)		Total sighted			
Family	**Species name (Scientific name)**	**No. of groups**	**No. of birds**	**Avg. size**	**Cont. surveys**	**Point counts**	**Dunedin**	**Moeraki**	**Timaru**	**BP**
Albatross	Black-browed albatross (*Thalassarche melanophris*)	1	1	1.0	2.3	0	0	0	0	1
	Buller's albatross (*Thalassarche bulleri*)	103	117	1.1	20.5	14.5	109	0	3	5
	Chatham Island albatross (*Thalassarche eremita*)	2	2	1.0	4.5	0	2	0	0	0
	Northern royal albatross (*Diomedea sanfordi*)	35	36	1.0	20.5	3.9	6	0	0	30
	Salvin's albatross (*Thalassarche salvini*)	44	53	1.2	20.5	17.1	30	12	0	11
	Southern royal albatross (*Diomedea epomophora*)	20	23	1.2	15.9	10.5	13	0	0	10
	White-capped albatross (*Thalassarche cauta*)	92	112	1.2	29.5	21.1	87	18	1	6
Gulls and terns	Black-billed gull (*Chroicocephalus bulleri*)	6	7	1.2	4.5	3.9	1	0	1	5
	Black-fronted tern (*Chlidonias albostriatus*)	3	4	1.3	4.5	0	2	0	0	2
	Caspian tern (*Hydroprogne caspia*)	2	3	1,5	2.3	1.3	0	0	0	3
	Red-billed gull (*Chroicocephalus novaehollandiae scopulinus*)	2,202	6,165	2.8	100	89.5	3,872	246	60	1,987
	Southern black-backed gull (*Larus dominicanus*)	2,612	6,284	2.4	100	98.7	2,532	378	520	2,854
	White-fronted tern (*Sterna striata*)	1,598	2,932	1.8	97.7	88.2	580	45	132	2,175
Shags	Little shag (*Microcarbo melanoleucos brevirostris*)	82	141	1.7	31.8	5.3	133	1	0	7
	Otago shag (*Leucocarbo chalconotus*)	587	986	1.7	36.4	31.6	867	117	0	2
	Pied shag (*Phalacrocorax varius varius*)	71	75	1.1	45.5	18.4	1	0	8	66
	Spotted shag (*Phalacrocorax punctatus*)	2,086	14,005	6.7	100	97.4	2,754	190	107	10,954

Table 2. *Continued*

Family	Species name (Scientific name)	No. of groups	No. of birds	Avg. size	Proportion of surveys sighted (%)		Total sighted			
					Cont. surveys	Point counts	Dunedin	Moeraki	Timaru	BP
Petrels	Buller's shearwater (*Ardenna bulleri*)	24	87	3.6	15.9	6.6	11	0	0	76
	Cape petrel (*Daption capense*)	109	204	1.9	18.2	34.2	104	0	79	21
	Fluttering/Hutton's shearwater (*Puffinus gavia/huttoni*)	479	1,858	3.9	70.5	39.5	395	32	244	1,187
	Northern giant petrel (*Macronectes halli*)	84	98	1.2	47.7	21.1	25	0	7	66
	Prion sp. (*Pachyptila* sp.)	7	13	1.9	2.3	1.3	13	0	0	0
	Sooty shearwater (*Ardenna grisea*)	370	5,466	14.8	47.7	27.6	5,376	30	0	60
	Southern giant petrel (*Macronectes giganteus*)	2	2	1.0	2.3	1.3	1	0	0	1
	Westland petrel (*Procellaria westlandica*)	2	2	1.0	2.3	1.3	0	0	0	2
	White-chinned petrel (*Procellaria aequinoctialis*)	29	32	1.1	25	7.9	16	1	0	15
	White-faced storm petrel (*Pelagodroma marina*)	1	1	1.0	2.3	0	0	0	0	1
Other	Little penguin (*Eudyptula minor*)	116	171	1.5	68.2	14.5	75	0	0	96
	Yellow-eyed penguin (*Megadyptes antipodes*)	4	4	1.0	6.8	0	3	1	0	0
	Arctic skua (*Stercorarius parasiticus*)	3	3	1.0	2.3	0	0	0	0	3
	Australasian gannet (*Morus serrator*)	67	131	2.0	40.9	14.5	34	0	0	97
	Unknown	86	177	2.1	56.8	9.2	74	2	6	96
Total		**10,929**	**39,195**	**3.6**	-	-	**17,116**	**1,073**	**1,168**	**19,839**

One hundred and seventy-four little penguins were seen in total, sighted on 68.2% of continuous survey days and only 15.5% of point survey days (Table 2). Yellow-eyed penguins were not seen at all during point counts. The only species identified more from point counts were Cape petrels (*Daption capense*). Nine species were sighted only during continuous counts, while all species identified in point counts were also identified during continuous counts (Table 2).

Of the three areas with high survey effort (BP, Timaru, and Dunedin), hotspots in distribution of the five primary groups were observed (Fig. 2). At BP, Birdlings Flat (the southwest corner, 43º49.90'S, 172º42.54' E) was an area with high density sightings for all groups except albatross, which were mostly found off the east coast and further away from shore. Terns, shags, and gulls were found consistently along the coastal survey route while albatross and petrels were most often encountered during zig-zags. In Timaru no continuous surveys were completed and albatross and petrels were encountered less. Shags, terns, and gulls were encountered more evenly throughout both the coastal and zig-zag surveys and a hotspot of distribution was towards the southmost limit of the survey area. In Dunedin all groups were encountered regularly, with similar patterns to BP; shags, terns, and gulls were regularly encountered along the coastal surveys, though in comparison to BP, they were spread more evenly throughout the zig-zag surveys out to 3 nm. Hotspots for these groups occurred in Otago harbour and near Warrington beach (45º43.02'S, 170º36.19'E). Albatross and petrels were mostly encountered during zig-zag surveys with hotspots forming from Taiaroa Head (45º46.43'S, 170º44.45'E) and along the east coast of Otago Peninsula.

Some clear patterns in seabird distribution were noted along the latitudinal gradient of the surveyed sites. White-capped albatross (*Thalassarche cauta*), for example, were only sighted south of BP, with increasing frequency the further south the site (Table 2; Appendix SI. 2). Otago shag (*Leucocarbo chalconotus*) and yellow-eyed penguin follow the same pattern. No species displayed the inverse of this pattern, although many species were found only in BP, including black-fronted terns (*Chlidonias albostriatus*), black-browed albatross (*Thalassarche melanophris*), Arctic skua, and white-faced storm petrel (*Pelagodroma marina maoriana*). No species was only seen at either the Moeraki or Timaru sites. Instead, these sites showed intermediary seabird assemblages in comparison to both Dunedin and Banks Peninsula.

Changes in distributions over the study period were primarily noted for two species; sooty shearwaters and Buller's albatross (*Thalassarche bulleri*, Table 3). Sooty shearwaters were sighted almost exclusively in Dunedin during early summer (November/December), with large congregations present on the water (*c.* 500 individuals). Surveys conducted later in summer (and in different survey locations), sighted far fewer individuals, usually in groups less than 10 individuals. Buller's albatrosses were sighted infrequently during summer surveys, usually *c.* 1 nm from shore. During winter surveys, individuals were often sighted much closer to shore, with many sightings within Dunedin harbour and other sheltered waters (data not shown). Sightings of fluttering/Hutton's shearwater, red-billed gulls, southern black-backed gulls, white-fronted terns, and spotted shags were made in every season, but were much higher during early and mid-summer (Table 3).

During the five-minute point counts, there was a statistically significant (T-Test, p-value < 0.05) difference in the number of seabirds that were counted when dolphins were present for two groups: albatross and terns. Albatross were sighted less often when dolphins were present, while terns were more likely to be seen (Table 4).

DISCUSSION

During this investigation we took advantage of established monitoring trips for marine mammals to survey the coastal bird diversity at four sites on the southeast coast of the South Island, New Zealand. We were able to tailor our data collection to be flexible with other research priorities whist still giving *c.* 150 hours of dedicated seabird survey effort. While the distribution data presented here were not collected to answer a particular research question; it contributes to baseline knowledge of seabird species in the nearshore environment.

The range and relative abundance of seabirds sighted across the survey locations fell within reasonable expectation for all species. Four of the five most sighted species (spotted shags, black-backed gulls, red-billed gulls, and white-fronted terns) are common in the coastal environment, while sooty shearwaters are typically a pelagic species. Most sooty shearwaters sightings were large aggregations during November, immediately off the Otago Peninsula. High densities of red-billed gulls, black-backed gulls, and white-fronted terns were noted at feeding aggregations, often associated with pelagic clusters of squat lobster larvae (*Munida gregaria*). Stationary aquacultural equipment (mussel buoys, salmon pens; Banks Peninsula) and commercial processing outfalls (Fish and meat works, Timaru) were also noted as aggregation sites for these species, as well as Cape petrels and northern giant petrels for the latter. Inshore trawlers and aquaculture vessels were also

Table 3. Seabird counts by period for all species sighted across the southeast coast of the South Island of New Zealand. Species are grouped by family and identified by common names. Counts are combined totals of continuous and point counts from November 2021 to July 2022. Early summer includes sightings in November 2021, mid-summer includes December 2021 and January 2022, late summer includes February and March 2022, and winter includes June and July 2022.

		Seabird counts by period			
Family	**Species name**	**Early Summer**	**Mid-Summer**	**Late Summer**	**Winter**
Albatross	Black-browed albatross	0	1	0	0
	Buller's albatross	5	5	0	107
	Chatham's albatross	0	0	0	2
	Northern royal albatross	4	31	0	1
	Salvin's albatross	31	22	0	0
	Southern royal albatross	6	13	0	4
	White-capped albatross	46	41	0	25
Gulls and terns	Southern black-backed gull	1,756	3,537	460	531
	Black-billed gull	1	1	1	4
	Black-fronted tern	2	2	0	0
	Caspian tern	0	3	0	0
	Red-billed gull	2,425	2,985	55	700
	White-fronted tern	462	2,277	97	96
Shags	Little shag	28	63	0	50
	Otago shag	591	249	0	146
	Pied shag	0	46	8	21
	Spotted shag	2,132	11,472	84	317
Petrels	Buller's shearwater	9	76	0	2
	Cape petrel	81	22	11	90
	Fairy prion	13	0	0	0
	Fluttering/Hutton's shearwater	234	1,356	244	24
	Northern giant petrel	20	67	6	5
	Sooty shearwater	5,361	105	0	0
	Southern giant petrel	1	0	0	1
	Westland petrel	0	2	0	0
	White-chinned petrel	12	19	0	1
	White-faced storm petrel	0	1	0	0
Other	Blue penguin	47	98	0	26
	Yellow-eyed penguin	3	1	0	0
	Arctic skua	0	3	0	0
	Australasian gannet	1	92	0	38
Total		13,271	22,590	966	2,191

observed to attract a high number of petrel species, in addition to common species (such as the gulls, terns, and albatross species groups). Species that were rarely sighted in this study, were likely so for several reasons, including actual rarity/conservation status (e.g. yellow-eyed penguin; Robertson 2021), sighting outside of normal range (e.g. southern giant petrel), or are migrant (e.g. Arctic skua, black-

Table 4. Seabird sightings recorded during five-minute point counts in relation to the presence or absence of Hector's dolphin (*Cephalorhynchus hectori*). Displayed are the number of birds sighted and the results of a two sample, two-sided T-test, comparing the means of seabird counts in either group.

Group	Dolphin Absence	Dolphin Presence	p-value
Albatross	120	40	**<0.001**
Gulls	2,319	1,840	0.174
Terns	678	1,055	**<0.001**
Shags	1,051	4,160	0.178
Petrels	1,176	1,021	0.723

fronted terns).

Gulls, terns, and shags were commonly encountered close to shore at BP, and although this was true for both Otago and Timaru, there was a more even distribution of sightings throughout the survey area to 3 nm. This trend could be due to differences in the environment between study areas and could be worth exploring in future studies, though is beyond the scope of our analysis. Seasonal patterns in distribution were strongest for sooty shearwater and Buller's albatross. The higher presence of sooty shearwater in the nearshore environment around Dunedin could be the result of the use of this area (or nearby offshore islands, such as Rakiura) as a breeding ground, or as a productive area for foraging trips during this time of year, resulting in higher encounter rates (Jones 2000). Buller's albatross are endemic to New Zealand but breed on offshore islands (e.g. the Snare's, Solander, Chatham, and Three Kings Island groups; Turbott 1990). Although some individuals make foraging trips passing through our study sites during the breeding season (e.g. Sagar & Weimerskirch 1996), Buller's albatross have been observed in larger, more concentrated aggregations from April to July (Stahl *et al.* 1998), a pattern that agrees with our observations.

The point counts used in this study were performed to compare bird presence in areas with and without Hector's dolphin. Although most groups were not affected by the presence or absence of dolphins, both terns and albatross had strong, and opposing, relationships with dolphin presence. Seabirds and marine mammals are both indicator species, and it is likely that, for terns, they are congregating in areas where there is an abundance of a shared food source. This is not the first study to show a link between dolphins and terns, Bräger (1998) reported a link between white-fronted terns and Hector's dolphins at Banks Peninsula during feeding aggregations. In this study, 15.7% of dolphin groups were accompanied by terns. In contrast, albatross were rarely seen with dolphin groups. In summer, Hector's dolphins congregate in the nearshore environment (Rayment 2010), whereas albatross were much more commonly sighted further offshore. These contrasting ecologies may result in little overlap between these groups and hence, the trends presented here. In contradiction, however, is the hotspot around Taiaroa Head, a location that Hector's dolphins frequent (Williams et al. 2024), and is where the majority of albatross were sighted in the presence of dolphins.

When considering species detection alone, continuous counts performed better than point counts. Continuous counts were able to detect more species, over fewer survey days. This is unsurprising, given continuous counts had nearly double the time of active survey. Despite better species detection, continuous counts can be more difficult to perform during opportunistic surveys. They require personnel skilled enough to sight, identify, and record bird species while travelling *c.* 15 kn. Sea state and wind chill while underway can make it difficult to record data, even in conditions well within survey limits. These factors did not hinder point counts to the same degree and this survey type was easier to perform with sub-optimal identification skills (larger sighting window, opportunity to take photographs if required).

Seabird surveys are used to quantify the density and abundance of seabirds at sea. Although relative density measurements could be extrapolated from our data, variability in the length and direction of transects mean our surveys do not follow traditional methods (e.g. Tasker *et al.* 1984; Spear *et al.* 2004). We believe that strong biases would exist and quantifying data further holds little value. Instead, we provide an observational assessment of the seabird species along the southeast coast of New Zealand South Island and provide an example of the quantity and quality of data that can be collected opportunistically. We believe the description of seabird distribution and the quantity of seabird data collected, is of value as seabird distribution data around Aotearoa New Zealand remain scarce. We highlight the use of existing monitoring trips as opportunities to further gather seabird observations and recommend that future marine mammal surveys consider including seabird observers where possible.

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Appendix 1. Sightings of all seabird species across the southeast coast of the South Island, New Zealand. Locations surveyed include Dunedin, Moeraki, Timaru, and Banks Peninsula. Each map represents a single species, except in the case of fluttering/Hutton's shearwater (F/H) and prion spp. Blue dots represent the location of an individual or group sighting.

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Re-laying by Hutton's shearwaters (*Puffinus huttoni*) at Te Rae o Atiu, Kaikōura Peninsula, New Zealand

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Abstract: Observations were made of the Nationally Vulnerable Hutton's shearwater (*Puffinus huttoni*) breeding at Te Rae o Atiu, Kaikōura Peninsula (42.429°S, 173.703°E), New Zealand, a new colony established by translocations where birds breed in nestboxes. Over 12 seasons there were 245 eggs laid, including seven instances of two eggs laid as separate clutches in one nestbox during the same season. Nestbox inspections, usually undertaken weekly, provided evidence of egg laying date. Bird attendance at the nestboxes was also obtained from implanted passive integrated transponders that triggered a reader and datalogger. There is evidence for birds re-laying an egg after the first egg failed for three separate events, and a fourth was a possibility. In three other events, it appears more likely that two different birds laid the eggs, two as female-female pairings or simply egg dumping by an unpaired female; the third event was inconclusive. Only one of the 14 eggs from two-egg nests hatched, and the chick fledged successfully, about 10 days later than any other chick recorded at this colony. This fledging date was similar to the last date for fallout birds from the natural, mountain colonies, and suggests that re-laying may be a natural consequence of early egg failures in this species.

Rowe, L.K.; Taylor, G.; Howard, T. 2024. Re-laying by Hutton's shearwaters (*Puffinus huttoni*) at Te Rae o Atiu, Kaikōura Peninsula, New Zealand. *Notornis 71(1)*: 12–22.

Keywords: *Puffinus huttoni*, Hutton's shearwater, Te Rae o Atiu, Kaikōura Peninsula, New Zealand, breeding, re-laying, female-female pairs

INTRODUCTION

Hutton's shearwater (*Puffinus huttoni*) is a small black and white shearwater (length 36–38 cm; weight 365 g; Marchant & Higgins 1990) currently classified by BirdLife International (2021) as "Endangered", and as "Threatened – Nationally Vulnerable" under the New Zealand Threat Classification system (Robertson *et al.* 2021). The two known remaining natural colonies are found in the upper Kōwhai River catchment (42.261°S, 173.603°E) and at Shearwater Stream (42.167°S, 173.727°E) in the Seaward Kaikōura Ranges, where they are vulnerable to destruction by pigs (*Sus scrofa*) (Cuthbert 2002) and tectonic activity (Cuthbert 2019). On 14 November 2016, for example,

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the 7.8 magnitude Kaikōura earthquake resulted in approximately 12% colony area loss through landslides and a reduction in burrow density of about 29% in the surviving colonies (Cuthbert 2019).

The Department of Conservation (DOC) identified Hutton's shearwater as a species requiring medium-term action for its recovery (Molloy & Davis 1992). An agreement was reached in 2005 between DOC and Whale Watch Kaikōura for a new colony (now called Te Rae o Atiu) to be established on Whale Watch land on the Kaikōura Peninsula (42.429°S, 173.703°E). Chicks were translocated from 2005 to 2013, and there is now (2022–2023 season) a population of 86 birds returning to the site to breed in nestboxes (TH *unpubl. data*). Intensive monitoring at this new, readily accessible colony has provided the opportunity for more in-depth studies.

Shearwaters generally lay one egg without replacement (Marchant & Higgins 1990; Warham 1990), and this is the norm for small shearwaters, e.g. Manx shearwater (*Puffinus puffinus*; Harris 1966; Brooke 1990), Balearic shearwater (*P. mauretanicus*; ACAP 2021), Yelkouan shearwater (*P. yelkouan*; Anon 2020), black-vented shearwaters (*P. opisthomelas*; Keitt *et al*. 2000) and Newell's shearwater (*P. newelli*; FWS 2021; KESRP 2021). This was the case for 231 of 245 Hutton's shearwater eggs laid at Te Rae o Atiu from 2011 to 2022, where re-laying did not occur if an egg failed (LKR, TH *unpubl. data*). However, over 12 seasons, there were seven instances where we found two eggs in a given nestbox at Te Rae o Atiu in the same season. This paper presents information on re-laying and potential female-female pairings by breeding Hutton's shearwaters at Te Rae o Atiu and makes comparisons with observations from other petrel and shearwater species.

METHODS

During the breeding season (late August to April) (Marchant & Higgins 1990), daytime visits were made to monitor activity at the Te Rae o Atiu Hutton's shearwater colony, usually at about weekly intervals. The occasional night-time visit was made as part of other studies. Each bird was banded with a unique-numbered flattened stainless-steel X-band (8.0x3.5 mm) on the tarsometatarsus (tarsus). Passive integrated transponders (PIT-tags) were inserted under the skin at the base of the neck of the 2012 and 2013 translocation chicks, and from summer 2011–12, into returning birds from the 2006 to 2011 translocations, pre-fledging chicks, and any unmarked immigrant adults visiting the new site. Some of the earlier birds were not PIT-tagged until 2015 or later. Readers and dataloggers located on visited nestboxes enabled records to be obtained when birds entered or left nestboxes (for details, see Taylor *et al.* 2012; Rowe 2014, 2018). Readers were not always available on nestboxes to help determine which adults were attending eggs. In the early years, captured adults had Twink™ markings painted either along (|) or across (–) the crowns of their heads to identify birds in a nestbox without having to disturb them repeatedly (Rowe & Howard 2023).

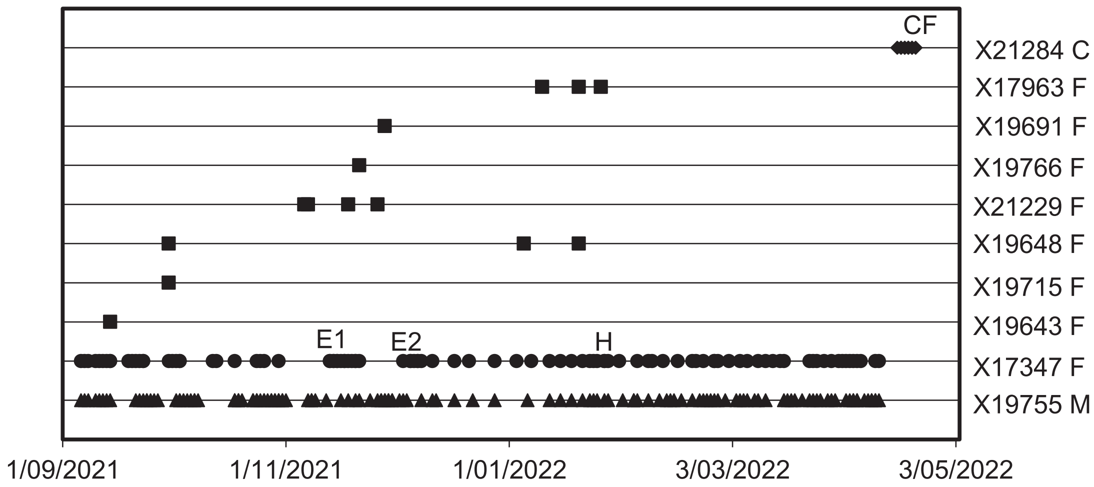

Figure 1. Timelines for Hutton's shearwaters entering and leaving nestbox 97 in 2021–22 (Event A) as recorded by the PIT readers: ▲ = X19755 male; ● = X17347 female; ♦= X21284 fledging chick; ■ = other females. E1 = egg 97/1 first seen and present through January; E2 = egg 97/2 laid about 4 December; H = egg 97/2 hatched about 24 January; CF = date X21284 fledged.

Figure 2. Nestbox 97, 25 December 2021. The egg, probably 97/1, is in the nestbox and an adult bird (X17347 from PIT records) in the rear chamber is incubating egg 97/2. (Photograph: Ted Howard).

Monitoring visits defined the time interval during which eggs were laid. From available PIT records we determined the laying dates as the first night after the cessation of a short pre-laying exodus (PLE). Birds were sexed from DNA analysis of feather samples (Griffiths *et al*. 1998), and where these were not available, they were sexed as breeding partners of known-sex birds.

RESULTS

Event A: Nestbox 97 2021–22

During the 2021–2022 breeding season, birds in nestbox 97 excavated a tunnel about 50 cm deep beyond the incomplete back wall of the nestbox. Egg 97/1 was laid between monitoring visits on 10 and 13 November in the nestbox chamber. Of the eight females known to visit nestbox 97 that season only X17347 was recorded present at the time the egg was laid. PIT records show X17347 followed the general pattern for pre-laying exodus (PLE) and egg laying for Hutton's shearwaters (LKR *unpubl. data*). She left at 0418 h on 30 October and returned 14 days later (13 November at 0041 h) to lay (Fig. 1). This egg was seen in the nestbox chamber later that day, and another seven times when the egg was moved by TH to the bird in the rear chamber (Table 1; Fig. 2). Under normal conditions at Te Rae o Atiu (52 days incubation period, LKR *unpubl. data*), the egg should have hatched about 4 January but was seen in the nestbox chamber until at least 29 January (Table 1), although never incubated.

On 29 January, a 90 g chick was heard then found in the rear chamber. During earlier visits, shearwaters were observed sitting in the back chamber but were not handled. These were either X19755 (male) or X17347 from the associated PIT-tag records (Fig. 1). They were presumably incubating egg 97/2 while the first egg, assumed to be 97/1, was in the nestbox chamber (Fig. 2).

The chick fledged on 22 April, suggesting it would have hatched from egg 97/2 about 25 January when applying the average 87-day fledgling period for Hutton's shearwaters at Te Rae o Atiu (LKR *unpubl. data*). Mass/age plots in Cuthbert (2002) suggest that the 90 g chick would have been about four days old when first seen, again indicating 25 January as the hatching date. The average incubation time of 52 days indicates that the egg would have been laid about 4 December. X17347 arrived back from an extended period away from the nestbox between 0405 h on 21 November and 2224 h on 3

Table 1. Timeline of Hutton's shearwaters observations at Te Rae o Atiu, Kaikōura Peninsula, New Zealand; nestbox 97, 2021–22.

Date	Observation
10 November	No birds or egg
13 November	Egg 97/1 first seen
20 November	Bird in rear chamber; TH moved egg from nestbox chamber to rear chamber
27 November	Bird in rear chamber; TH moved egg from nestbox chamber to rear chamber
11 December	Bird in rear chamber; TH moved egg from nestbox chamber to rear chamber
18 December	Bird in rear chamber; TH moved egg from nestbox chamber to rear chamber
25 December	Bird in rear chamber; TH moved egg from nestbox chamber to rear chamber (Fig. 2)
1 January	Bird in rear chamber; TH moved egg from nestbox chamber to rear chamber
5 January	Bird in rear chamber; TH moved egg from nestbox chamber to rear chamber
15 January	No bird present, one egg in nestbox chamber – not touched; floor of rear chamber not visible
29 January	Chick (90 g) in rear chamber; egg in nestbox chamber
19 April	Chick present; 345 g
22 April	Chick gone = fledged

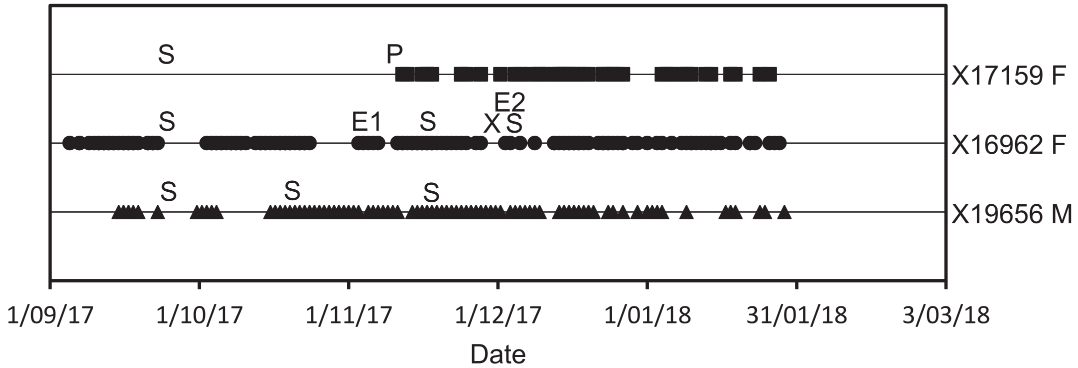

Figure 3. Timelines for Hutton's shearwaters entering and leaving nestbox 21 in 2017–18 (Event B) as recorded by the PIT readers: ▲ = X19656 male; ● = X16962 female; ■ = X17159 female. P = bird PIT-tagged; S = bird seen in nestbox; E1 = egg 21/1 first seen; E2 = egg 21/2 first seen; X = egg 21/1 ejected from nestbox.

December, a total of 13 days. If the return was the end of a PLE, the egg would have been laid before X17347 left the nestbox at 0008 h on 5 December, which corresponds to the time of laying calculated from hatching and fledging dates. There were no other females present on the laying date.

Event B: 2017–18 Nestbox 21

On 24 September three birds, X16962 (female), X19656 (male) and X17159 (female), were seen in nestbox 21 at night. In that same nestbox, egg 21/1 was laid between visits on 1 and 5 November 2017 when a bird was seen sitting on it. X16962 had left on a 10-day PLE at 0511 h on 24 October and arrived back at 2106 h on 3 November. She then laid egg 21/1 before leaving at 0403 h on 4 November (Fig. 3). X16962 was seen sitting on a cracked egg on 18 November, which further suggests she was the female parent. Egg 21/2 was laid between visits on 1 and 5 December when X16962 was seen incubating the egg. Having returned from a six-day PLE starting 0443 h on 28 November to 2210 h on 3 December (or nine days starting 0450 h on 25 November if a short visit on the night of 27 November is ignored), X16962 would have laid egg 21/2 before leaving at 0305 h on 4 December, 31 days after 21/1 was laid. Egg 21/1 was ejected from the nestbox between visits on 30 November and 5 December by X19656(?) before egg 21/2 was laid.

There are no PIT records for X17159 which was seen with X16962 and X16956 in September until she was PIT-tagged on 12 November. Therefore, we do not know what her status was when 21/1 was laid. During the interval egg 21/2 was laid X17159 was only present at 0211 h to 0220 h on 2 December, a 9-minute visit. It seems implausible that she could have laid an egg and departed in this very short interval. The available PIT records did not show she had any extended absences greater than three days prior to 2 December that could be construed as a PLE. X19656 was the only male frequenting nestbox 21 on a regular basis.

There were no PIT records for any other females at this nestbox when egg 21/2 was laid and we believe all birds were PIT-tagged at that time.

Event C: 2012–13 Nestbox 99

Egg 99/1 was laid between visits on 28 October and 1 November 2012 when X16995 was seen sitting on it; this was the first observation of a bird in the nestbox although it had been visited most weeks from 3 September. On 1 November a PIT-tag reader was installed on nestbox 99 and X16995 was PIT-tagged. It is assumed X16995 laid egg 99/1 as she continued to incubate it (Fig. 4). X16912 (male, PIT-tagged 7 November) was seen sitting on the egg on 7 November and is, therefore, likely to be the second parent. No other PIT-tagged females were recorded, although it is likely untagged birds were present at Te Rae o Atiu. On 7 November, egg 99/1 was found stuck to the brood patch of X16912, was detached by LKR and left in the nestbox. When nestbox 99 was visited on the morning of 10 November, no birds nor egg were found. The egg may have cracked, leaking its contents and, presumably, removed from the nestbox by one of the partners.

Monitoring visits to nestbox 99 found egg 99/2 was laid between visits on 23 and 29 November. PIT records show X16955 was absent from 0350 h on 10 November to 2208 h on 24 November, a possible 15-day PLE, and probably laid the egg before leaving again at 0403 h on 25 November. No other PIT-tagged females were recorded at that time. Thus, X16995 could have laid egg 99/1 before 1 November and egg 99/2 on 24 November, about 26 days apart. The female had a continued presence until 24

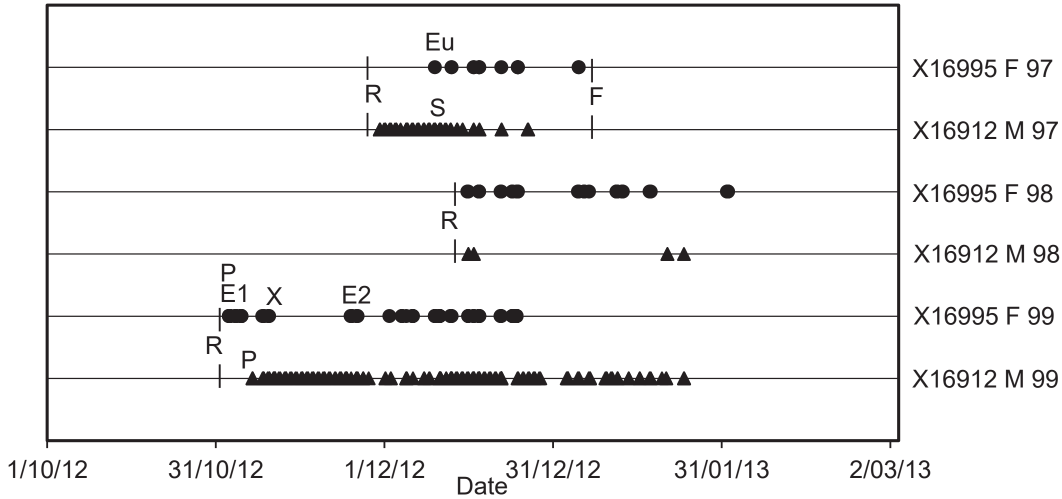

Figure 4. Timelines for Hutton's shearwaters entering and leaving nestboxes 97, 98 and 99 in 2012–13 (Event C) as recorded by the PIT readers: ▲ = X16912 male; ● = X16995 female. R = start of PIT-tag record; F = finish of PIT record; P = bird PIT-tagged; S = bird seen in nestbox; E1 = egg 99/1 first seen; E2 = egg 99/2 first seen; Eu = egg 97/1 first seen; X = egg 99/1 ejected from nestbox.

December and the male until 24 January; the egg was noted as broken on 28 December.

In addition to these activities in nestbox 99, X16955 and X16912 were recorded by PIT-tag readers, but not seen, at nestboxes 97 and 98 later in the season.

Event D: 2012–13 Nestbox 38

The timeline for events at nestbox 38 in which two eggs were laid is shown in Fig. 5. On 11 October, X15960 (male, Twink™ |) and X17152 (female Twink™ –) were seen together in nestbox 38 in the daytime, inferring they may have been a pair; they were then PIT-tagged. The same pair also spent considerable time in nestbox 37, where another egg was laid (Fig. 5); the female that laid that egg is unknown.

Egg 38/1 was laid between monitoring visits on 7 and 10 November. From PIT records, we infer X17152 left on a seven-day PLE at 0423 h

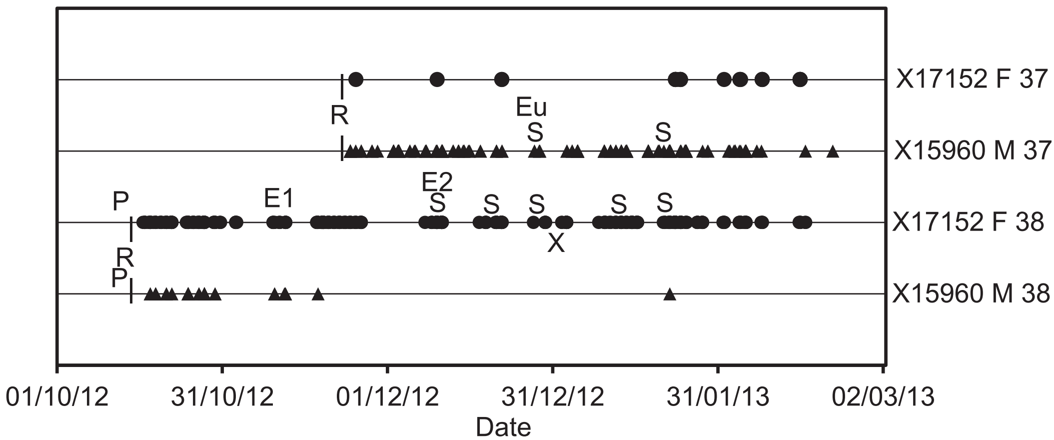

Figure 5. Timelines for Hutton's shearwaters entering and leaving nestboxes 37 and 38 in 2012–13 (Event D) as recorded by the PIT readers: ▲ = X15960 male; ● = X17152 female. R = start of PIT-tag record; P = bird PIT-tagged; S = bird seen in nestbox; E1 = egg 38/1 first seen; E2 = egg 38/2 first seen; Eu = egg 37/1 first seen; X = egg 38/1 ejected from nestbox 38.

on 3 November and arrived back at 2129 h on 9 November. Egg 38/1 would have been laid before she left the nestbox at 0459 h on 10 November. At the time of egg laying, there were no indications of other PIT-tagged females having visited the nestbox, but it is likely there were untagged birds present at Te Rae o Atiu. The egg was unattended during all monitoring visits until 10 December when, based on Twink™ marks on its head, X17152 was in the nestbox at 1140 h sitting next to the egg.

At the next check on 15 December, two eggs were in the nestbox. No females apart from X17152 were seen or recorded in nestbox 38 from 10 to 15 December. It is probable that X17152 was sitting on the second egg, 38/2, on 10 December (she was not picked up to check her band number), with 38/1 seen in the open. In that case, egg 38/2 would have been laid between visits on 1 and 10 December. PIT records show X17152 would have been on a PLE from 0412 h on 26 November and arrived back at 2206 h on 7 December (12 days). She would have laid the egg before leaving at 0337 h on 9 December. She then returned at 0016 h on 10 December to be seen incubating 38/2 during a morning nestbox check while sitting next to egg 38/1. Egg 38/2 was laid 29 days after egg 38/1.

No other PIT-tagged females were recorded at nestbox 38 between visits on 1 and 10 December except for one record of X15943 from nestbox 39 at 2326 h on 2 December. She probably entered the lower end of the tunnel, moved up far enough to get recorded by the logger and backed out immediately. Apart from X17152 present on the night of 11 December, no PIT-tagged females were recorded present between visits on 10 and 15 December. X17152 was seen with two eggs several times until 28 December and then with one egg, 38/2, until 21 January when that egg was noted as not viable. The egg ejected from nestbox 38 between visits on 28 December and 5 January was 38/1 based on size measurements.

Events at adjacent nestbox 37 introduced some complications to events at nestbox 38. X15960 seems to have divorced X17152 in mid-November when he became a regular visitor at nestbox 37, perhaps with an untagged female. An egg, 37/1, was laid there between visits on 23 and 28 December (the latest lay date by 13 days at Te Rae o Atiu [LKR *unpubl. data*]), but apart from three sporadic visits by X17152 up to 22 December, there is no evidence of females being present at the time of laying. Therefore, it must have been a female without a PIT-tag. X15960 was seen on egg 37/1 on two occasions (Fig. 5).

Event E: 2014–15 Nestbox 76

PIT-tag records show two females, X17347 and X16995, frequenting nestbox 76 from mid-September (Fig. 6). Nestbox observations indicated egg 76/1 was laid between visits on 28 October and 4 November. X16995 was absent from nestbox 76 from 0440 h on 24 October to 2135 h on 3 November (11 days) and left again at 0425 h on 5 November. X16995 was sitting on the egg when checks were made on 4 November and is considered the likely female parent of egg 76/1, although X17347 had been present much of the week before 4 November.

The nestbox check on 13 November found two eggs in the nestbox. Therefore, 76/2 was laid between visits on 4 and 13 November. X16995 had been present most days since 4 November. Meanwhile X17347 had been away from 0453 h 2 November for seven days on what may have been a PLE, returning at 2141 h on 8 November to potentially lay egg 76/2 before leaving at 0419 h on 9 November. This was only five days after 76/1 was laid. No birds were seen on subsequent visits, and there is no PIT-tag evidence of these birds frequenting the nestbox after 15 December, an exception being a 1-night visit by X16995 in early February. The eggs were present until late January, at least, and did not hatch. No other PIT-tagged females were recorded

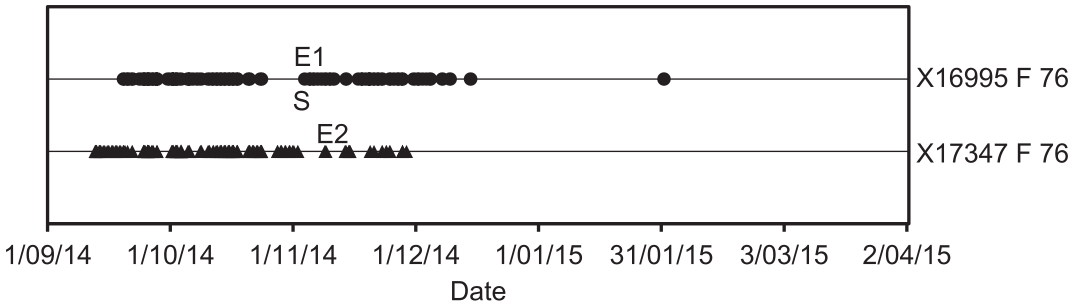

Figure 6. Timelines for Hutton's shearwaters entering and leaving nestbox 76 in 2014–15 (Event E) as recorded by the PIT readers: ▲ = X17347 female; ● = X16995 female. S = X19665 seen in the nestbox; E1 = egg 76/1 first seen; E2 = egg 76/2 first seen.

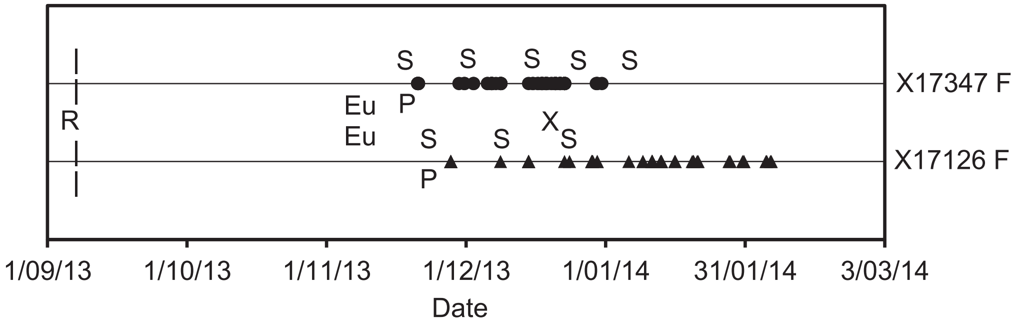

Figure 7. Timelines for Hutton's shearwaters entering and leaving nestbox 11 in 2013–14 (Event F) as recorded by the PIT readers: ▲ = X17126 female; ● = X17347 female. R = start of PIT-tag record; P = bird seen and PIT implanted; S = sightings based on head markings; Eu = egg first seen but unattributable to a given female; X = an egg ejected from the nestbox.

at nestbox 76 about the times the eggs were laid. No PIT-tagged males had a significant presence recorded at this nestbox.

Event F: 2013–14 Nestbox 11

A PIT-tag reader was installed at nestbox 11 on 13 September as there was evidence of birds visiting there. Before 11 November, no birds were seen, nor were there any PIT-tag records of females in this nestbox. However, females X17347 and X17126 may have been frequenting this nestbox prior to this date as they were not PIT-tagged until 20 and 25 November, respectively. Two eggs were seen in this nestbox on 11 November (Fig. 7), there being none on 5 November. Both females were seen sitting on two eggs initially, then one after an egg was ejected between visits on 16 and 20 December; X17347 was on a cracked egg on 6 January. Once females X17347 and X17126 had PIT-tags implanted, they were recorded sporadically at nestbox 11 until February. X17126 was only recorded at nestbox 11, whereas X17347 was recorded occasionally at eight other nestboxes later in the season. Apart from X17124 (male, PIT-tagged 10 November 2012) recorded once only on 22 September, no other birds were seen or recorded from nestbox 11. At the beginning of this season, there were males and females present at Te Rae o Atiu that were not PIT-tagged.

Event G: 2015–16 Nestbox 38

X15990 (male) was seen in nestbox 38 on 16 November. The first of two eggs found in this

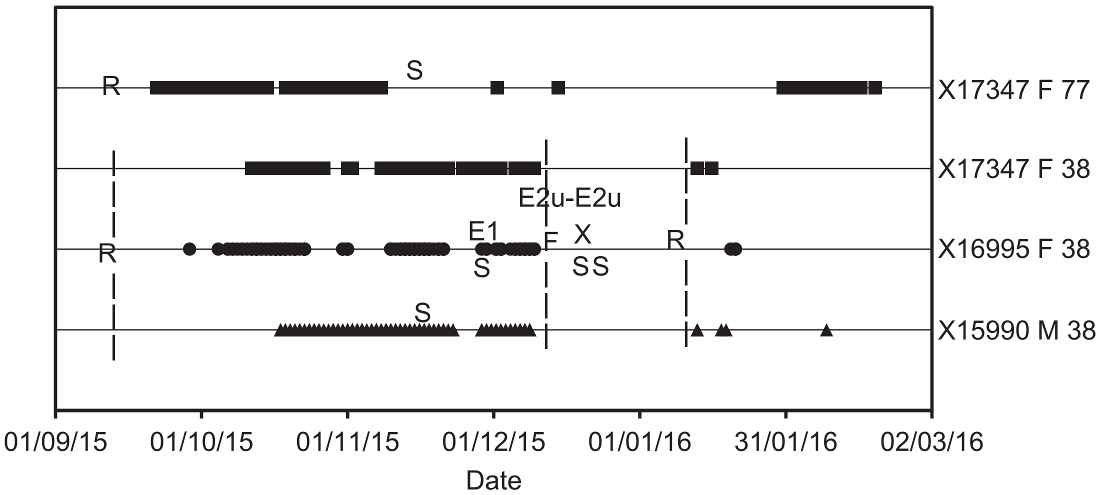

Figure 8. Timelines for Hutton's shearwaters entering and leaving nestboxes 38 and 77 in 2015–16 (Event G) as recorded by the PIT readers: ▲ = X15960 male; ● = X16995 female, ■ = X17347 female. The PIT record at nestbox 38 failed on 10 December through 5 January. R = start of PIT-tag record; F = end of record; S = bird seen in nestbox; E1 = egg 38/1 first seen; E2u–E2u = date range of egg 38/2 laid by unknown female; X = egg 38/1 ejected from nestbox.

nestbox was laid between visits on 23 November and 8 December (Fig. 8). X16995 (female) was seen on egg 38/1 on 8 December and is likely to have laid it after returning at 2158 h on 29 November from a 9-day PLE starting at 0440 h on 21 November. Egg 38/2 was laid between inspections made on 8 and 14 December; no birds were incubating the two eggs on this date. Neither X16995 nor X17347, the other female who had been regularly recorded at nestbox 38, showed the start of an obvious pre-laying exodus before 10 December when the PIT recorder failed. Egg 38/2 would have been laid 10–14 days after egg 38/1 was laid. X16995 was incubating egg 38/2 on 18 December when egg 38/1 was found outside the nestbox, and on 21 December. No birds were seen incubating after 21 December; consequently, neither egg hatched.

DISCUSSION

We are confident that during this study all Hutton's shearwater breeding adults at Te Rae o Atiu were banded. All except two of these breeders were translocated as chicks or were Te Rae o Atiu bred chicks. In the period 2006–2022, only two unbanded immigrant birds have been found at Te Rae o Atiu and both were captured and banded (Rowe & Howard 2023); one of these (X17347) is part of this study – Events A and G. While monitoring undertaken by members of the Hutton's Shearwater Charitable Trust checked birds in nestboxes in daytime, there is a possibility we may have missed birds that were present at night-time. However, several studies from 2014–15 onwards entailing the use of GPS trackers and Time-Depth recorders required night-time visits to capture adult birds provisioning chicks – no unbanded birds were found during that work.

All birds that were not chicks in the 2012 and 2013 translocations or were bred at Te Rae o Atiu have been PIT-tagged as found. Since 2015 we believe all breeding adults have been tagged.

Te Rae o Atiu has 108 nestboxes in place and at 2020–2021 there were 33 breeding pairs present (Rowe & Howard 2023). Thus, there is little competition for nesting sites and no need for multiple pairs to simultaneously use a given nestbox. Up until 2014 there was a sex imbalance with a shortage of males (Rowe & Howard 2023).

Successful relaying Event A

Of the seven events where two eggs were found in a nestbox, Event A has the strongest case for successful re-laying. The only female with a presence throughout the season was X17347. She underwent a PLE leading up to the laying of the first egg and, again, prior to the estimated laying date of the second egg about 22 days later. PIT-tag records did not show any other females present at the time the eggs were laid. PIT-tag records show X19755 was the likely male in attendance and has paired with X17347 for four seasons; single chicks fledged from nestbox 97 in 2019–20 and 2020–2021 but their egg in 2018–19 did not hatch (LKR *unpubl. data*). The egg 97/2 was, therefore, most likely a re-laying after 97/1 was ejected from the rear nest chamber where the adults were incubating 97/2.

Warham (1990) cites studies with circumstantial evidence of re-laying. He also notes many studies have nests with two eggs, but these are likely eggs from two females under the following situations: a) a male with two females forming a trio; b) two pairs trying to use one nest; c) a bird that deserts exposes the egg and allows a second female to lay (dump) hers. There is no evidence to show that situation (a) might have occurred as there is no record of females other than X17347 having a significant presence. Less than 40% of the nestboxes here were occupied in any season, so there was no need for competition for a nestbox and situation (b) does not apply. As X17347 and her mate continued to incubate an egg and fledge a chick then situation (c) is unlikely. Harris (1966) detailed one case of a Manx shearwater repeat-laying after a failure; the second egg also failed. He considered this to be an instance of one female laying eggs by two different mates, but this situation is unlikely in this event. Also, working with Manx shearwaters, Brooke (1990) found re-laying in only one of 77 nestings. Re-laying has been recorded in several species of storm petrels (Morse & Buchheister 1979; Boersma *et al.* 1980) and, more recently, in common diving petrels (*Pelecanoides urinatrix*) (Taylor & Miskelly 2007). Until Event A in this current study, there had been no evidence that re-laying of a second egg has succeeded in producing a fledged chick in larger petrels and shearwaters.

Chick X21284 is the only one from a two-egg nestbox at Te Rae o Atiu to have hatched. It fledged on 22 April (Fig. 1). This fledging date is very late in the season, 12 days later than any others at Te Rae o Atiu (LKR *unpubl. data*). It is also at the later extreme for 682 fallout birds found and banded in Kaikōura; 99% were found by 9 April and the last on 23 April (LKR *unpubl. data)*. Harris (1966) suggested very late fledging Manx shearwater chicks could be due to egg replacements. That is possible here as shown by X21284.

Unsuccessful relaying Events B and C

Nestbox 21 in 2017-18 has a plausible case for re-laying by X16962. She had only three absences greater than nine days which could be construed as PLEs. The first was in September/October which was much earlier than egg laying occurs at Te Rae o Atiu. The timing of the other two absences were immediately prior to an egg being laid and could, therefore, be considered PLEs. All other absences were less than four days, much shorter than average PLEs for Hutton's shearwaters, 12 days (LKR *unpubl. data*). While X17159 was present all season, after PIT tagging it was not absent for an interval that could be considered a PLE prior to egg 21/2 being laid. Warham's (1990) situation (a), one male with two females, could apply but there is no evidence for X17159 undertaking a PLE and egg laying whereas X16962 does twice at the appropriate times. Thus, the second egg is likely to be a re-laying by X16962 after the failure of egg 21/1.

The second instance of failed relaying, nestbox 99 in 2012-13, was also a case of the second egg, 99/2, was being laid after female X16965 returned from a PLE, 26 days after egg 99/1 was laid and then lost. Again, it is unlikely that any of Warham's (1990) situations apply to this nesting.

Potential relaying Event D

Event D presents a good case for re-laying based on PLEs 29 days apart by X17152 and the estimated laying dates falling into the observed periods. Why a bird would re-lay while the first egg is still in the nestbox (it was not ejected until about 13 days after 38/2 was laid) and her partner had moved to an adjacent nestbox about 22 days before 38/2 was laid questions the assumptions made here. Did a female without a PIT-tag lay one egg?

Female-female pairing Events E and F

Event E did not have any records of males at nestbox 76, only two females from mid-September to mid-December. We believe that by this date in the 2014–15 season, all birds would have been PIT-tagged and the likelihood of an un-tagged male being present is small. Therefore, we are likely to have a female-female pairing with both laying in the same box within four or five days. This may have been driven by the sex imbalance; birds seen or recorded by PIT loggers this season were 21 females and 11 males which produced 16 eggs and eight hatched (LKR *unpubl. data*). There is very little evidence from the literature that female-female pairs form in burrowing seabirds (Bried *et al*. 2009). Still, the strong female pair bonds that formed at the Kauwahaia Island flesh-footed shearwater (*Ardenna carneipes*) colony (Taylor 2024) were most likely created by a shortage of male shearwaters (GT *unpubl. data*), as has been observed in other seabirds (Nisbet & Hatch 1999).

Event F also had two eggs laid within a few days in nestbox 11. In the absence of male records at this nestbox, we suspect this could be another female-female pairing or it was simply two females producing an egg each and dumping their eggs in this nestbox. Both females, X17347 and X17126, incubated the eggs over a six-week period which suggests they had formed a pair bond in that season. Of birds known to be at Te Rae o Atiu either from PIT-tag records or seen, there was a sex imbalance favouring 21 females to 11 males for 15 eggs of which eight hatched (LKR *unpubl. data*). In 2014–15 and later years, both birds were with male partners in separate nestboxes.

Possible Trio Event G

Event G had two females frequenting the nest box over several months together with one male. While it is clear that X16995 laid egg 38/1, we have no evidence as to who laid egg 38/2. It seems implausible for X16995 to have laid egg 38/2 given that she had to recognise that there had been a failure, and then progress to laying the second time. She was seen incubating 38/2 after 38/1 was ejected, suggesting she was the parent. We have two females, X16995 and X17347, who could have laid the eggs but X17347 was not seen incubating them. The missing PIT-tag record means re-laying is not conclusive but we could have Warham's (1990) situation (a) with one male and two females forming a trio.

Implications of re-laying and late departures

Some Hutton's shearwater fledglings on their first flight from the inland natal colonies to the sea get attracted to lights in the Kaikōura township (Harrow 1965, 1976; Deppe *et al*. 2017). Dates of fallout events should encompass the range of fledging for chicks from single egg clutches and any re-laying attempts. The last date of 682 fallout birds that have been found and banded in Kaikōura is 23 April (LKR *unpubl. data).* Chick X21284 is the only one from a two-egg nestbox at Te Rae o Atiu to have hatched and it fledged on 22 April (Fig. 1). This late fledging date supports Harris's (1966) suggestion that very late fledging Manx shearwater chicks could be due to egg replacements. Possibly other very late departing chicks found in previous years could be from replacement eggs as the average fledging date at Te Rae o Atiu is 23rd March, and 95% of chicks fledge within the period 14 March to 1 April.

At Te Rae o Atiu, 95% of eggs are laid before 23 November, and only seven eggs have been laid in December (LKR *unpubl. data*). These seven include probable re-layings: Event A, egg laid 4 December, and chick X21284, the only one from a two-egg nestbox at Te Rae o Atiu to hatch, fledged on 22 April (Fig. 1); Event B egg laid 3 December, with a potential fledging date of 21 April; and Event D egg laid 7 December which had a potential fledging date of 25 April.

There were two other eggs laid very late at Te Rae o Atiu that are well outside the normal pattern of laying in this species and they could potentially have fledged chicks much later than known birds. Brooke (1990) suggested that Manx shearwaters would only lay when there was a chance of a successful outcome and that late egg replacements would fledge late with a low probability of survival. Event G with the second egg laid 11 December might have fledged on 29 April, 6 days later that the last recorded fallout bird. The latest known laying date in this species at Te Rae o Atiu was 25 December, with a potential fledging date of 15 May. The question with this laying is why would a bird lay this late in the season when there was a low probability of fledgling survival, and most fledglings would have gone seven weeks earlier and the colony would be largely deserted by the beginning of April?

While no instances of re-laying in Hutton's shearwaters at the two remaining mountain colonies have been reported, this may be a consequence of limited viewing opportunities and difficulties accessing nest chambers in natural burrows, which are up to two metres long and twist in all directions. Artificial burrows with access through removable wooden lids, as we use at Te Rae o Atiu, and equipped with PIT-tag recorders provide greater opportunities for observing these unusual events.

The ability of Hutton's shearwaters to re-lay might be a local adaptation to the extreme environment in which they normally breed. The Seaward Kaikōura Ranges rise to 2,600 m a.s.l. within 25 km of the coast and are covered in snow during most winters. The extant inland colonies of Hutton's shearwaters range from 1,200 to 1,800 m a.s.l. (Marchant & Higgins 1990). The snow cover on south-facing slopes reduces at a variable rate across these colonies in early spring, and access to nests can be delayed by one or more months on the upper slopes by hard-packed snow and ice cover (Harrow 1976). It is possible that birds could mate in a burrow and then be unable to access the nest chamber when they return from the pre-laying exodus because of an unseasonal dump of fresh snow. If the egg is then dropped at sea or on the land, perhaps the female immediately begins to form a second egg to allow another attempt at laying in the same season. This might explain why Hutton's shearwaters at Te Rae o Atiu are showing more evidence of re-laying a second egg than comparable-sized petrels and shearwaters (Warham 1990), but it might simply be a consequence of the detailed monitoring being undertaken.

In summary, we believe we have one excellent case for a Hutton's shearwater re-laying after an egg failure and fledging a chick (Event A), two further cases for re-laying in which the eggs did not hatch (Events B and C), a probable re-laying (Event D), two cases for female-female pairings (Events E and F), and one inconclusive event that may be a trio (Event G).

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SHORT NOTE

A survey of northern New Zealand dotterels (*Charadrius obscurus aquilonius*) undertaken on Waiheke Island, New Zealand, in October 2023

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The New Zealand dotterel (*Charadrius obscurus*, NZD) is a large plover endemic to New Zealand. Two subspecies have been described (Dowding 1994). These were raised to species level by del Hoyo *et al.* (2014), but this change has not been adopted by other authorities, such as the eBird/Clements Checklist (Clements *et al*. 2023), the IOU Checklist (Gill *et al*. 2023), or the latest New Zealand Checklist (Checklist Committee 2022).

The northern New Zealand dotterel (*C. o. aquilonius*, NNZD) now breeds around much of the coastline of the North Island, but the bulk of the population is found in Northland, Auckland, Coromandel Peninsula, and Bay of Plenty. The entire population was censused four times between 1989 and 2011. Those counts were all undertaken in October, when nesting is under way and most birds are sedentary, and revealed a steady overall increase in numbers (Dowding 2020). There has not been a census since 2011, and it is not known whether the increase in numbers has continued. In the absence of a complete North Island census, it may be possible to gather some information on trends by undertaking similar but smaller-scale breeding-season counts, or by examining changes in autumn counts of post-breeding flocks.

We report here the results of a breeding-season count of NNZD on Waiheke Island, undertaken in October 2023. Waiheke (*c*. 9200 ha) lies in the inner Hauraki Gulf, about 20 km east-northeast of Auckland city. The western half of the island has a dense human population, while the eastern half is mainly farmland. In the 2011 national census, 40 dotterels were counted on Waiheke, about 1.9% of the national NNZD population. We also include observations made outside the 2023 census period, including counts of post-breeding flocks on Waiheke, cases of inland breeding on the island, and comments on adult mortality in 2022/23 and 2023/24. In addition, we consider some of the potential threats that dotterels face on the island.

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The count was conducted in the same way as the four national censuses undertaken between 1989 and 2011 (Dowding 2020). The core period for the census was 17–20 October 2023. NNZD numbers are at an annual minimum in October (normally, no chicks will have fledged by then), and breeding adults are sedentary. Consequently, movement between sites is minimal, and so the number of birds missed or double-counted is likely to be negligible. Counts were carried out within 2 hrs of high water to ensure that birds foraging in inter-tidal areas over low water were not missed. We could not obtain land access to three sites on Man o' War Station during the core census period, and so these were checked by boat on 28 October. Principal sites used by NNZD are shown in Figure 1.

The totals for each of the censuses undertaken between 1989 and 2023 are minimum estimates of the population size at those times, but rates of change between them will not be comparable because the number of sites checked differed in each census. Rates of change between consecutive pairs of censuses are therefore presented as percentage changes in gross totals and in 'comparison' totals, i.e. totals from only the sites counted in both censuses of a consecutive pair. The actual rates of change will lie somewhere between the gross changes and the comparison changes (see Dowding 2020). Of the four North Island censuses, those undertaken in 2004 and 2011 were believed to be the most complete (Dowding 2020). We therefore calculated rates of increase on Waiheke between 2004 and 2011, and between 2011 and 2023.

Annual post-breeding flock counts on Waiheke were undertaken by members of the Ornithological Society of New Zealand's Auckland region and others between 1996 and 2007. We have found no counts between 2008 and 2018, but they resumed in 2019 and have been undertaken by the authors since then. Flocks were counted between early March and early April, when numbers are normally at their peak (Dowding & Chamberlin 1991), and were conducted within one hour of high water (HW). Nomenclature of birds follows Checklist Committee (2022).

The counts obtained around Waiheke Island in 2004, 2011, and 2023 are shown in Table 1.

The number of NNZD counted on Waiheke in October 2023 was 77, a gross increase of 92.5% on the 40 counted in 2011. Rates of increase between 2011 and 2023 were much greater than those seen between 2004 and 2011 (Table 2). The population

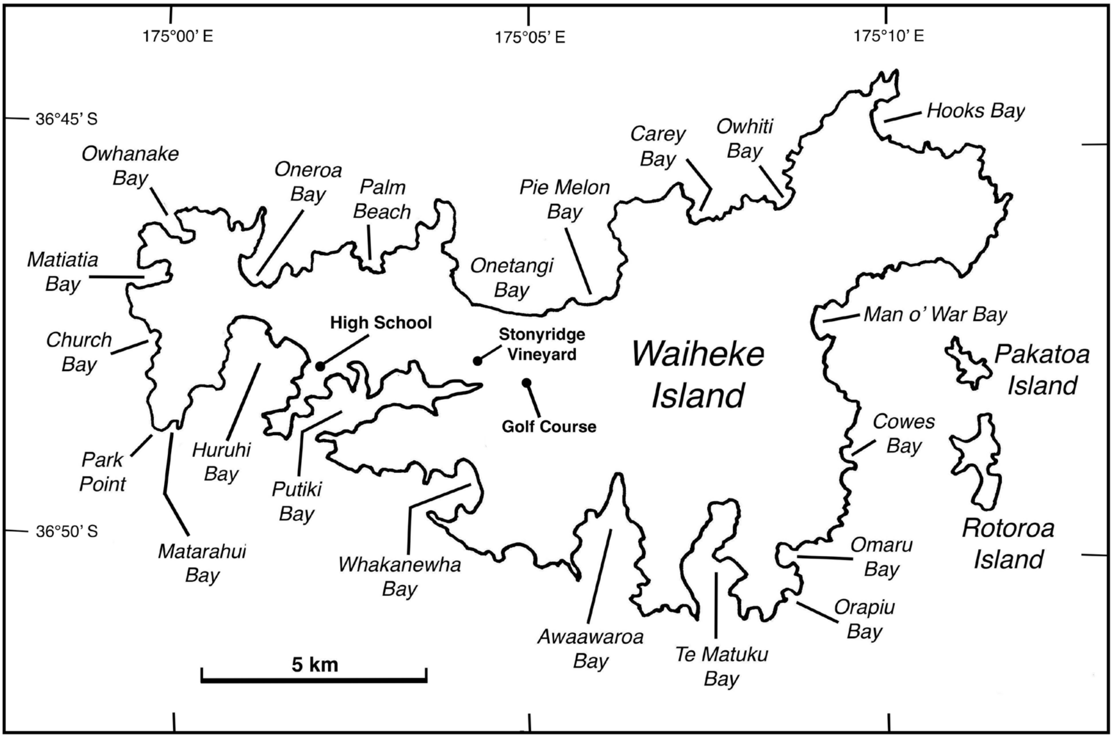

Figure 1. Map of Waiheke Island, Hauraki Gulf, showing principal sites used by northern New Zealand dotterels and other locations mentioned in the text

in 2023 appeared to consist of 33–36 definite or probable pairs, and 5–11 non-breeding birds. Some sites surveyed are known to have had birds in the past, but were not occupied in 2023 (Table 1).

In spite of the large increase, there is some evidence that turnover of adults has been relatively high on Waiheke Island recently. Adult NNZD normally show very high annual survival (Dowding 2020). They also show high breeding-site fidelity, and the failure of a pair to return to their territory often means that one of them has died (Dowding & Chamberlin 1991). There were obvious losses of adults during the 2022/23 and 2023/24 seasons. The number of pairs at Church Bay fell from eight in

Table 1. October counts of northern New Zealand dotterels (NNZD) on Waiheke Island in 2004, 2011, and 2023. Sites are listed clockwise around the island from Park Point in the southwest. – indicates that a site was not checked, 0 that a site was checked and no birds were seen.

Site	2004 count	2011 count	2023 count	Notes
Cable Bay	0	2	2	
Church Bay	0	2	6	8 pairs in 2022/23, 3 in 2023/24
Matiatia Bay	0	0	0	No previous records
Owhanake Bay	–	0	0	
Oneroa/Little Oneroa	0	0	0	No previous records
Sandy Bay	–	–	0	Small, very limited habitat
Enclosure Bay	–	–	0	Small, unsuitable habitat
Palm Beach	0	0	0	No previous records
Opopoto Bay	–	0	0	
Onetangi Beach	0	0	1	1 pair 2022/23, male lost Oct 23
Pie Melon Bay	4	4	5	Usually 2 pairs present
Woodlands Bay	–	–	0	Unsuitable, narrow and stony
Honeymoon Bay	–	–	0	Unsuitable, steep and stony
Carey Bay	–	–	0	Probably suitable for 1 pair
Cactus Bay	0	0	2	
Garden Cove	–	–	0	Very small beach
Owhiti Bay	5	2	4	
Hooks Bay	2	4	2	
Man o’ War Bay	–	0	2	Possibly 1st record in 2023
Waikopou Bay	–	–	0	Beach narrow at HW
Days Bay	–	0	0	
Cowes Bay	–	0	0	
Arran Bay	–	–	0	
Waikorariki Bay	–	–	0	Beach narrow at HW
Patio Bay	–	–	0	
Omaru Bay	–	–	0	Little nesting habitat above HW
Orapiu Bay	0	0	0	
Otakawhe Bay	–	–	0	
Te Matuku Bay	3	4	14	Breeding site, autumn flock site
Awaawaroa Bay	9	6	10	2 on spit, 6 Waimanga, 2 Simoni
Woodside Bay	0	0	0	
Kauaroa Bay	–	–	0	Pair attempted to breed 2022/23
Whakanewha Bay	8	10	18	4 Poukaraka, 14 on main beach

Table 1. *continued*

Site	2004 count	2011 count	2023 count	Notes
Kuakarau Bay	–	0	0	Narrow, unsuitable
Oakura Bay	–	0	2	
Wharetana Bay	–	–	2	
Okoka Bay	–	–	0	Previous record of breeding
Putiki Bay shell bank	–	–	0	
Rangihoua/Golf Course	–	–	0	1 pair on Golf Course 2022/23
Anzac Bay	–	–	0	No records of breeding here
Ostend causeway	–	–	2	Not previously recorded here
Shelley Beach	–	0	1	No evidence of breeding here
High School fields	–	2	2	2 pairs in 2022/23
Bays on Kennedy Point	–	–	0	Habitat unsuitable
Huruhi Bay (Surfdale)	0	0	0	
Huruhi Bay (Blackpool)	0	2	2	No evidence of breeding here
Te Wharau Bay	–	0	0	Habitat marginal
Matarahui Bay	–	2	0	1 pair in 2022/23
Number of sites	**17**	**28**	**48**	
Total NNZD counted	**31**	**40**	**77**	

Table 2. Percentage changes in the numbers of northern New Zealand dotterels counted between consecutive censuses on Waiheke Island, 2004–2023. Comparison totals are from sites counted in both censuses of each consecutive pair (see Methods). Mid-point changes are the average of gross and comparison changes.

	2004–2011	2011–2023
Changes in gross totals	+ 29.0%	+ 92.5%
Changes in comparison totals	+ 16.0%	+ 82.5%
Mid-point changes	+ 22.5%	+ 87.5%

2022 to three in 2023, one bird in a pair at Matarahui Bay was lost in 2022/23, and one bird of a pair on the Golf Course in 2022/23 was found dead. One pair disappeared from the High School playing fields between 2022/23 and 2023/24, and on the night of 17–18 October 2023, the male of a pair nesting on Onetangi Beach disappeared, with cat (*Felis catus*) tracks leading to and from the nest. Remains of another adult were found on the Awaawaroa shell spit in 2022/23, and a trail camera recorded a cat at the site.

Inland (or non-beach) breeding by NNZD, defined as breeding more than 100 m from the nearest beach or HW mark (Dowding 2020), is now not uncommon in the Auckland region, with about 11% of the birds recorded in the region during the 2011 census showing this behaviour; in other regions it is rare (see Discussion in Dowding 2020). We are aware of instances of inland breeding on Waiheke, including a nest on a mulch pile near the entrance to Stonyridge Vineyard in 2019/20 (1.1 km inland), a pair attempting to breed in grass on the Golf Course in 2022/23 (1.3 km inland), and nests in grass on the Waiheke High School playing fields in 2022/23 and 2023/24 (230 m and 270 m inland). These sites are shown in Figure 1.

Annual autumn counts of the post-breeding flock at Te Matuku Bay have also increased markedly. Numbers have increased roughly three-fold from an average of 20.7 (*sd* = 5.91, range = 16–37, n = 12) during the period 1996–2007 to an average of 64.6 (*sd* = 13.9, range = 49–84, n = 5) during the period 2019–2023. In March 2022, our count at Te Matuku Bay recorded 84 birds, while in 2023 we recorded 49 birds at Te Matuku and 24 at Blackpool Beach (*c*. 12.5 km to the northwest) on the same high tide. Previously, Te Matuku was the only known NNZD flock site on the island, but it is possible that the flock split in 2023, either permanently or temporarily.

If the rate of increase recorded nationally between 2004 and 2011 (*c.* 20%) has continued, there would be roughly 2,700 birds in the NNZD population in 2023. The Waiheke count of 77 birds would constitute about 2.9% of that total, an increase from 1.9% of the national total in 2011. We note that Waiheke is located within the Auckland East count region, which had one of the highest rates of increase between 1989 and 2011 (see Dowding 2020). Even taking into account the longer interval between counts, the rate of increase in the Waiheke population between 2011 and 2023 was much higher than the 2004–2011 increase, and may not be typical of the North Island-wide population trend over the same period.

Survey coverage in the 2023 Waiheke count was by far the most extensive to date (Table 1), but many of the additional sites checked were small, contained marginal or unsuitable habitat (e.g. narrow, stony beaches), and most had no dotterels. Almost all of the growth in the Waiheke population therefore occurred at sites counted in earlier censuses, and was not the result of better coverage. This was reflected in the gross and comparison rates of increase that were similar for the period 2011–2023. However, the improved coverage does provide a much more detailed baseline for future counts, and a more complete view of current NNZD breeding distribution on the island. Further surveys are required to determine when the island's carrying capacity has been reached.

There are a number of likely reasons for the population increase. The long-running and intensive management programme at Auckland Council's Whakanewha Regional Park has included control of introduced mammalian predators (particularly cats, stoats *Mustela erminea*, and hedgehogs *Erinaceus europaeus*), re-location of nests at risk of flooding, and measures to reduce human disturbance to breeding birds. That programme has increasingly been supplemented by similar projects undertaken by community groups and concerned individuals at other sites on the island. NNZD show low natal-site fidelity (Dowding & Moore 2006), so there will probably also be immigration of young birds produced on the mainland and on nearby islands, such as Browns, Rangitoto/Motutapu, and Motuihe, all of which have been cleared of mammalian predators. Stoats are known predators of adult NNZD (Dowding & Murphy 1996), and the current programme to eradicate stoats from Waiheke (https://tekorowaiowaiheke.org/eradication-project-progress), will have helped, although the increase in dotterel numbers appears (from flock counts) to have been under way before widespread stoat control began in February 2020. While the increase is positive, the NNZD remains Conservation Dependent, and management needs to be maintained if the taxon is not to decline again.

The three wide, sandy beaches on the north coast of Waiheke (Oneroa/Little Oneroa, Palm Beach, and Onetangi) now have no breeding pairs of NNZD. Physically, these beaches appear to provide good nesting habitat, but all three sites are used by many people and dogs (*Canis familiaris*), and are backed by dense housing and populations of domestic cats. In contrast, the sites that have shown the largest increases in numbers (Awaawaroa, Te Matuku, and Whakanewha Bays) are all relatively distant from human population centres.

The apparently high rate of loss of adults on Waiheke in the past two years is of concern, but further data are required to determine whether this level of mortality was unusual. Nationally, the main predators of adult NZD are stoats and cats (Dowding & Murphy 1996, 2001). Stoat numbers on Waiheke are currently believed to be very low (Frank Lepera, Te Korowai o Waiheke, *pers. comm*. October 2023), suggesting that cats may be largely responsible for recent adult NNZD losses on the island, as they are for losses of adult southern New Zealand dotterels (*C. o. obscurus*) on Stewart Island (Dowding & Murphy 1993).

Common native avian predators on Waiheke include swamp harrier (*Circus approximans*), southern black-backed gull (*Larus dominicanus*), pukeko (*Porphyrio melanotus*), red-billed gull (*Chroicocephalus novaehollandiae scopulinus*), and spur-winged plover (*Vanellus miles*), all of which are known predators of NNZD eggs and/or chicks (Marchant & Higgins 1993, JED *pers. obs*.). The North Island weka (*Gallirallus australis greyi*) is a recent addition to the suite of potential avian predators. Weka were introduced to Pakatoa Island, close to the eastern end of Waiheke, in 1996 (Beauchamp *et al.* 2009), and were subsequently transferred to nearby Rotoroa Island in 2002 (https://www.facebook.com/RotoroaIslandNZ/posts/2260708340653207/). They colonised the eastern end of Waiheke (either by swimming or by deliberate introduction) by 2011 at the latest (Rhys Burns, Department of Conservation, *pers. comm*.), and have been spreading westwards. They are now common at least as far west as Onetangi Bay (JED, *pers. obs.*). Weka are known to take the eggs and young of a wide range of bird species, and have been removed from a number of islands to protect other native fauna (Marchant & Higgins 1993). Little appears to be known about the potential impact of weka on NNZD; there are currently few places where their ranges overlap, and we are not aware of any research on the subject.

Potential threats other than predation include disturbance to nesting birds, primarily by people, dogs, and vehicles, and losses of nests to spring tides and storm surges (Dowding & Davis 2007). Birds nesting on grassed areas are also at risk of losing eggs and small chicks to mowing (Dowding 2020).

Our census demonstrates that Waiheke Island is a discrete area that can easily be surveyed by about 10 people within 3–4 days. It thus provides a limited but rapid snapshot of a small part of the NNZD population, and one that could be undertaken regularly. We acknowledge that the NNZD population on Waiheke represents only a small fraction of the national population, but we have recorded our results here because we are unaware of any other published NNZD trend data collected since 2011. The large increases we have recorded on the island in both breeding season numbers and in post-breeding flock counts are at least consistent with the hypothesis that the national population has continued to grow since 2011. As many Waiheke residents own boats, it should be possible in future to expand our survey area (and hence the proportion of the population covered) to include nearby islands, particularly Pakatoa, Rotoroa, Ponui, Browns, and Motuihe. We also encourage others to undertake similar local or regional censuses elsewhere to provide further data on overall trends in the NNZD population.

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Keywords: *Charadrius obscurus aquilonius*, northern New Zealand dotterel, census, population trend, Waiheke Island

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SHORT NOTE

Fernbird (mātātā, *Poodytes punctatus*) preying on a lizard

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Fernbirds (mātātā, *Poodytes punctatus*) are abundant on the summit plateau of Mana Island, off the Wellington west coast, following a successful translocation from Taranaki in 2019 (Miskelly 2023). At 1100 h on 18 October 2023, I observed a fernbird calling from the top of a *Coprosma propinqua* bush at the south end of the summit plateau, about 80 m above sea level. The bird was about 10 m from me, and appeared to be holding a large prey item. I used 8x30 binoculars to identify the prey as a dead adult copper skink (*Oligosoma aeneum*), identifiable by its size, rich yellow belly, and the absence of a dorsolateral stripe. The tail-less skink was about twice the head + bill length of the bird, making it about 70 mm long.

Copper skinks are abundant on the summit plateau of Mana Island, where they comprised 60.5% of 1,711 skinks (of three species) caught in unbaited pitfall traps during 2018–22 (Miskelly 2023). It was very rare to catch a copper skink that had recently lost its tail (*pers. obs.*), and so it is likely that the skink being held by the fernbird had shed its tail during the predation event, indicating that it was probably alive before capture, rather than having been scavenged.

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Fernbirds are almost entirely insectivorous (Barlow & Moeed 1980; Ball & Parrish 2005; Higgins *et al*. 2006). The only known previous report of a fernbird preying on a lizard was a photograph of one holding a copper skink, taken on Matakohe (Limestone Island) in Whangarei Harbour (Ball & Parrish 2005; Hare *et al*. 2016). This observation was the basis of Higgins *et al*. (2006) giving "*Cyclodina aenea*" *fide* "R. Parrish" as a food item for fernbird (Richard Parrish, *pers. comm*.).

Copper skinks are found throughout most of the North Island, and are one of New Zealand's smallest lizards (van Winkel *et al*. 2018). As with many New Zealand lizards they are much more abundant on rodent-free islands near Wellington than they are on the mainland (Towns *et al*. 2016; Nelson *et al*. 2016; *pers. obs*.). The fact that the first two reports of fernbirds eating lizards were from small islands is likely due to the relative abundance of both fernbirds and lizards on some islands compared to the mainland. It is possible that these high densities of insectivorous birds and lizards (which are predominantly insectivorous) creates competition for a limited food resource, and pressure to exploit a wider range of prey items.

The abundance of three small skink species plus Raukawa geckos (*Woodworthia maculata*) on the summit plateau of Mana Island (Miskelly 2023) means that foraging fernbirds are likely to encounter lizards frequently. It would be an ideal site to observe and photograph prey items delivered to nestlings, to determine how often lizards are taken by fernbirds

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SHORT NOTE

Successful breeding by female-female pairs of flesh-footed shearwaters (*Ardenna carneipes*)

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Flesh-footed shearwaters (*Ardenna carneipes*) (length 40–45 cm; weight 650 g; Marchant & Higgins 1990) currently classified by BirdLife International (2021) as "Near Threatened" and as "At Risk - Relict" under the New Zealand Threat Classification system (Robertson *et al.* 2021) breed on 14 islands around northern New Zealand from the Hauraki Gulf to Cook Strait. There is a small colony of these summer nesting shearwaters on Kauwahaia Island, Bethells Beach (0.7 ha; 36°53´S, 174°26´E). Long-term monitoring of the breeding birds at this site revealed the presence of two eggs in nests on multiple occasions since 2005. Closer examination indicated that rather than re-laying or egg dumping, the eggs were laid by two different females, sometimes in long-term stable partnerships. These same female-female pairs moved together between several different burrows during the study as competition for nests is intense at this site due to the large population (>300 pairs) of winter breeding grey-faced petrels (*Pterodroma gouldi*) which are present from April to December. This short note reports on the success or otherwise of these same-sex pair bonds and how two females paired together might produce viable eggs.

The flesh-footed shearwater colony at Kauwahaia Island has been monitored annually since 1989 with several short visits made in the Dec–Jan incubation period and again in March or April during chick rearing. I made fewer colony visits after 2014, which reduced the chances of encountering a partner on the nest. No visits were possible in April 2020 and April 2023 due to Covid-19 restrictions and storm damage to the access road and islands. Each bird encountered was banded with a stainless-steel Z-band and records made of presence of eggs or chicks in nests. All accessible eggs were candled by torchlight to determine the state of fertility and extent of embryo development. In addition, in the past seven years (2016-2022) the nests of two female-female pairs were monitored by a trail camera (night setting and short video clips) to observe bird behaviour outside their burrow entrances.

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Amongst a colony of around 20–25 pairs of flesh-footed shearwaters (maximum of 27 pairs in 2016 season), two female-female pairs formed that have remained together for more than a decade. All four birds have been sexed repeatedly at different times by cloacal examination just after laying, presence of an egg in the abdomen or by DNA sexing. These females have had unpaired males available in the colony but seem content to breed together. In most, but not all seasons, there are two eggs laid in their burrows (Tables 1 & 2). When the nest chamber was accessible by using a study hatch, egg fertility was assessed and developing embryos were observed in most seasons in at least one of these eggs (Tables 1 & 2). Often both eggs were warm as the birds tried to maintain incubation of two eggs under their brood patch. This contrasts with the occasional 2-egg nests found in the grey-faced petrel burrows where usually birds were sitting on one warm egg and the other egg was cold or pushed aside. Both females in the flesh-footed shearwater pairs were captured incubating warm eggs in their nest in the same season on 11 occasions. When both eggs were accessible, I discarded the least developed egg or one infertile egg from the nest so that the birds only needed to incubate a single egg. In ten seasons a fully grown chick was encountered in the nest in April (two other chicks died before April). Trail camera footage in some of these seasons showed the chick was being fed by two different banded flesh-footed shearwaters so both females contributed to rearing the solitary chick. The chicks did not appear to be any different in terms of body mass or wing measurements than other flesh-footed shearwater chicks reared by conventional pairs in the same colony in the same seasons.

The mechanism for successful breeding by two females was finally observed one night on trail camera video footage. A female flesh-footed shearwater emerged from burrow C39 and began calling by her burrow entrance. In the next video clip, a flesh-footed shearwater from a breeding site upslope wandered down, called, and then mounted the female. There was a short act of copulation, then the female returned into her burrow and the helpful male wandered off. No pair bonding or mutual preening behaviour was observed. Extra-pair paternity is seldom recorded in seabirds (Quillfeldt *et al.* 2012) so this is an example where the behaviour is advantageous to both participants.

There is very little evidence from the literature that female-female pairs form in burrowing or cavity-nesting seabirds (Bried *et al.* 2009, Lorentsen *et al.* 2000) and long-term successful relationships

Table 1. Annual activity by a female-female pair of flesh-footed shearwaters (FFS) (*Ardenna carneipes*) at Kauwahaia Island. This pair apparently stayed together from 2007 to 2022. M67 is only 1 m from M54, which had a grey-faced petrel (*Pterodroma gouldi*) chick in 2022.

Year	Burrow	Band A	Band B	Egg status	Chick status
2005	G35	Z-50495	?	1x infertile	No
2006	G35	?	?	Grey-faced petrel chick	-
2007	G35	Z-50495	Z-50496	2x infertile	No
2008	G28	Z-50495	Z-50496	1x infertile, 1x fertile	1x chick
2009	G28	Z-50495	Z-50496	2x fertile	No
2010	G28	Z-50495	Z-50496	1x fertile	No
2011	G28	Z-50495	Z-50496	1x infertile, 1x fertile	1x chick
2012	G28	Z-50495	Z-50496	2x infertile	No
2013	M2	Z-50495	Z-50496	1x infertile, 1x fertile	1x chick
2014	M54	Z-50495	?	1x infertile, 1x fertile	No
2015	M54	Z-50495	?	1 fertile	1x chick
2016	M54	?	Z-50496	1x infertile, 1x fertile	1x chick
2017	M54	?	Z-50496	1x infertile, 1x fertile	1x chick
2018	M54	Z-50495	?	1x infertile, 1x fertile	1x chick
2019	M54	Z-50495	?	1x egg	? (Covid-19)
2020	M54	?	Z-50496	1x infertile, 1x fertile	1x chick
2021	M54	Z-50495	?	1x infertile	No
2022	M67	?	?	FFS x 2 eggs	? (no access - cyclone damage)

Table 2. Annual activity by three different female-female pairs of flesh-footed shearwaters (FFS) (*Ardenna carneipes*) at Kauwahaia Island. The G17 and M7 pairings only lasted one season. The M10/C39 pairing apparently stayed together for 13 years although the nest chamber used was sometimes inaccessible. *cold fertile FFS egg found abandoned in collapsed nest was successfully reared by C39 pair in 2012.

Year	Burrow	Band A	Band B	Egg status	Chick status
2005	G17	Z-35239	Z-35191	2x infertile	No
2006	-				
2007	M7	Z-23893	Z-2827	2x infertile	No
2008	M7	Z-23893	-	1x fertile	No
2009	-				
2010	M10	Z-23893	Z-23404	2x infertile	No
2011	C39	Z-23893	Z-23404	2x infertile	No
2012	C39	Z-23893	Z-23404	2x fresh eggs	1x chick*
2013	C39	?	?	2x eggs	1x chick
2014	C39	Z-23893	?	2x fertile	1x chick
2015	C39	?	?	2x eggs	No
2016	C39	?	?	1x egg	No
2017	C39	?	Z-23404	2x eggs	No
2018	C39	Z-23893	Z-23404	1x egg	1x chick
2019	C39	?	Z-23404	1x infertile, 1x fertile	? (Covid-19)
2020	C39	Z-23893	?	1x fertile	No
2021	C39	Z-23893	?	2x fertile	No
2022	C39	?	?	FFS on 2 eggs	? (no access - cyclone damage)

have not been observed previously. The strong female pair bonds formed at the Kauwahaia Island shearwater colony was most likely created by a shortage of male shearwaters at this site, as has been observed in other seabirds with a skewed sex ratio at the colony (Nisbet & Hatch 1999; Young *et al*. 2008). For example, DNA sexing of a random sample of 98 banded shearwaters caught on the colony across two decades found only 33 males, whereas 65 were females (GT *unpubl. data*).

These two long-term female-female shearwater pairs were successful in staying together across burrow shifts and despite recruiting males observed displaying near their nests. One bird was observed on motion activated trail camera to attract a male to copulate with but then bred with her long-term female partner in their usual burrow. These extra-pair copulations resulted in viable eggs but in most years human intervention was needed to allow a chick to be raised by removal of one of these eggs. On the occasions that both eggs were left in the burrow (due to the eggs being out of reach) the nests were unsuccessful, except in 2013 when a chick was produced in C39 (Table 2). The successful rearing of occasional chicks may have been a factor keeping these female-female pairs together over many years. Whether the pair bonds would have lasted without any chicks being raised is unknown but elsewhere low breeding success in seabirds does often lead to divorce (Bradley *et al.* 1990). Two other female-female pairings lasted only one season after their nests failed (Table 2) and one of those females (Z-35191) paired with a male the following season. Small population sizes can make birds more willing to adopt mate choices that may not occur on large colonies with plenty of pairing opportunities (Bried *et al*. 2021). Interestingly, on Kauwahaia Island, newly recruiting male flesh-footed shearwaters observed calling at night near the burrows of the female pairs had no success in separating these well-established female pair bonds.

Warham (1990) reported that there was no evidence that any Procellariiformes could successfully rear two chicks in the same breeding season and only one natural nest with two young chicks had ever been observed - a pair of southern giant petrels (*Macronectes giganteus*) on Macquarie Island. Most likely both fertile eggs in these flesh-footed shearwater nests would have failed to hatch without intervention although one chick from a 2-egg clutch was reared once without any human intervention. The fate of the second egg was not determined.

Embryo development was observed in both

eggs of these female-female pairs on multiple occasions, which is surprising as the brood patch of shearwaters is shaped to accommodate only a single egg (Warham 1990). Over time it may become harder for the birds to heat both eggs sufficiently to maintain proper incubation temperatures. These partially incubated eggs were viable however as when the second fertile egg was swapped on several occasions with other flesh-footed shearwater pairs sitting on an infertile egg, those pairs went on to rear the adopted egg and fledge a chick.

Breeding by female-female pairs in burrowing seabirds may be more prevalent than previously realised, especially if colony sex ratios are skewed in favour of females. These findings further challenge the assumption that an unsexed partner will aways be part of a male-female pairing in burrowing seabirds.

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Keywords: *Puffinus carneipes,* same-sex pairings, breeding success, extra-pair copulations

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SHORT NOTE

An unusual last meal for a fairy prion (titi wainui, *Pachyptila turtur*)

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On the 28 February 2023 a dead fairy prion (titi wainui, *Pachyptila turtur*) was found washed up on Saint Clair beach, Ōtepoti Dunedin (45.909580°S, 170.502050°E). The bird appeared to have been dead for at least one week and was placed in a covered sand box to continue its decay. When inspected six months later the abdominal cavity was found to contain the elytra of 22 eucalyptus tortoise beetles (*Paropsis charybdis* Stål, 1860).

These chrysomelid beetles are approximately 10 mm long, hemispherical, and a mottled tan/brown/pink colour. They were accidentally introduced to New Zealand in the 1920's, becoming widespread over 50 years ago. As a herbivorous pest of *Eucalyptus* gum trees it has been the focus of biocontrol research (White 1973; Radics *et al*. 2018). The adult beetles are strong and widespread fliers in late summer (McGregor 1989; Selman 1994) and many were observed in late February 2023 at the Hump Ridge, Southland (R. Goldsmith *pers. comm*.). Flying beetles could be blown offshore or swept down rivers and may concentrate along convergent zones of coastal currents. Previously a large number were found washed up on Bay of Plenty (North Island, New Zealand) beaches (White 1973).

Gum trees in coastal Otago are relatively common with over 12,000 hectares of plantation *Eucalyptus* in Otago/Southland in 2014 (SWC 2015). Fairy prions are also relatively common in coastal Otago and breed on the Otago coast including at Saint Clair and Green Island.

Fairy prions usually feed on euphausiids, amphipods, cephalopods, fish, and molluscs but will readily feed on anything resembling food on the water surface (Harper & Fowler 1987), particularly if the bird is starved or a juvenile (Harper & Fowler 1987; Acampora *et al*. 2014). The bird in this observation was a fledgling as indicated by the incomplete fusion of some of the bones (N. Rawlence *pers. comm*.). Terrestrial insects have occasionally been reported in seabird stomach contents (Steele & Klages 1986; Gartshore *et al*. 1988; Petry *et al*. 2008; Acampora *et al*. 2014) but may be considered an irregular and unimportant dietary

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component (Gartshore *et al*. 1988) and therefore omitted from dietary study results.

Although low numbers of the eucalyptus tortoise beetles have been recorded in the stomachs of rooks (*Corvus frugilegus*) (Porter 1979), common starlings (*Sturnus vulgaris*) (Moeed 1980), house sparrows (*Passer domesticus*) and European greenfinches (*Chloris chloris*) (MacMillan 1981), the beetle larvae and adults are considered to be poisonous or at least unpalatable (Moore 1967; Selman 1994). It is not known if eating 22 *Paropsis charybdis* beetles caused the death of this prion.

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