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Hutton's shearwater (*Puffinus huttoni*) at Te Rae o Atiu, Kaikōura Peninsula South Island east coast, New Zealand: a colony established by translocations – 16 years progress

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Abstract: A new colony of the endangered Hutton's shearwaters (*Puffinus huttoni*) has been established at Te Rae o Atiu on the Kaikōura Peninsula, South Island east coast, New Zealand to provide insurance against catastrophic events at the high-altitude natural colonies in the Kōwhai River and Shearwater Stream, Seaward Kaikōura Range. The translocation of 495 chicks from the Kōwhai River colony was carried out in six operations from 2005 to 2013. Of the 473 fledglings, 97 have been recorded back at Te Rae o Atiu. Chick selection criteria, fledgling mass, fledgling wing length, days present before fledging, and days of emergence before fledging had no bearing on whether chicks returned from their post-fledging migration to Australian waters or not. One hundred and twelve Te Rae o Atiu bred chicks have fledged up until 2020–21. The Te Rae o Atiu fledglings had similar mass and wing lengths, and days emerged prior to fledging, to the translocated fledglings. There were no differences between the groups of Te Rae o Atiu bred birds that returned or did not. At 2020–21, 21 of the 112 second-generation chicks have returned from their initial migration, and the earliest have bred successfully. The colony has grown to about 75 birds producing about 30 eggs, 24 chicks, and 22 fledglings annually. Future growth of Te Rae o Atiu will be reliant on these home-bred chicks as the oldest translocation birds will soon be approaching the end of their breeding lives. Acoustic attraction of birds flying over Te Rae o Atiu from the sea towards the Kōwhai River natal colony has been mostly unsuccessful with only two birds attracted.

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INTRODUCTION

Hutton's shearwater (*Puffinus huttoni*) is a small black and white shearwater (length 36–38 cm; mass 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). Hutton's shearwater was first described by Mathews (1912), and Brooke (1990) considered it to be one of seven close relatives to Manx shearwater (*P. puffinus*). Before the 1900s, Māori (Ngati Kuri) knew of shearwaters nesting in the mountains, and used them as a food source. In

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1965, following anecdotal reports of "muttonbird" burrows high in the Seaward Kaikōura Range, Geoff Harrow found carcases that were confirmed as Hutton's shearwaters in the headwaters of the Kōwhai River (42.261°S, 173.603°E) at altitudes between 1,200 and 1,800 m a.s.l. (Harrow 1965). At these altitudes, Hutton's shearwater breed at the highest altitudes of the Manx related shearwaters, only the Newell's shearwater (*P. newelli)* breeding close to 1,200 m a.s.l. (BirdLife International 2021).

Extensive searching in the Kaikōura Ranges led to the confirmation of other populations, but only two remain today – in the Kōwhai River and Shearwater Stream (42.167°S, 173.727°E) (Marchant & Higgins 1990; Cuthbert 2001; Sommer *et al.* 2009). The reasons for the decline in population to the current two colonies are not definitive. The effects of trampling by deer (*Cervus elaphus*), goats (*Capra hircus*), and chamois (*Rupicapra rupicapra*) breaking through the shallow friable soils into burrows and nest chambers have been observed (Harrow 1976) and these are regularly controlled by the Department of Conservation (DOC). Stoats (*Mustela erminea*), although present in the colonies, were not considered to be in sufficient numbers to be a threat (Cuthbert 2001; Cuthbert & Davis 2002a). Cuthbert (2002) noted accessibility for, and evidence of, pigs (*Sus scrofa*) in the colonies that had recently become extinct, and the relative inaccessibility to pigs of the Kōwhai River and Shearwater Stream breeding sites. Thus, he concluded predation and habitat destruction by pigs was likely to be the main cause of the population decline. A pig trap built in 2009 at 1,180 m a.s.l. in the Kōwhai River at one of the few points that could provide access to the colony is still operating. This has likely proved beneficial as more than ten pigs were trapped in 2013 (L. Armstrong & M. Morrissey *pers. comm.* April 2013) indicating this colony, at least, is still extremely vulnerable to pig predation. A new, potential threat at the Kōwhai River colony follows the sighting of a cat (*Felis catus*) at 1,200 m a.s.l. in November 2020, and subsequently, evidence of cat predation was seen in March 2021 (TH *pers. obs.*).

Another major threat to the continued existence of the mountain colonies is devastation by natural processes such as debris avalanches/ rock falls resulting from tectonic activity and snow avalanches. Sherley (1992) observed that two sub-colonies had slipped away between 1986 and 1992 and that erosion could cover burrows with alluvium. Magnitude 5.7 (April 2015) and 6.2 (February 2016) earthquakes, about 50 km deep centred near St Arnaud 50 km to the northwest, did not produce any obvious landsliding in the Kōwhai River area (LR *pers. obs.*). However, the 7.8 magnitude Kaikōura earthquake on 14 November 2016 resulted in about 12% of the colony area being lost through landslides, a reduction in burrow density of about 29% in the remaining areas, and a reduction of about 40% of breeding pairs (Cuthbert 2019). As this earthquake struck at the peak of laying and at 0002 h, burrows with breeding birds that collapsed or were buried by landslides would have resulted in the loss of an egg and at least one adult. A minimum of 40,000 breeding Hutton's shearwaters were lost in landslides and potentially another 80,000 from burrow collapse (Cuthbert 2019). Prior to the Kaikōura earthquake, the Hutton's shearwater population had been expanding at about 2%/year (Sommer *et al.* 2009; Rowe *et al.* 2018) despite recorded losses up to 0.3% of fledglings to fallout around Kaikōura (Deppe *et al.* 2017).

Hutton's shearwaters spend the non-breeding season in Australian waters (Imber & Crockett 1970; Halse 1981; Warham 1981; Rowe & Taylor 2020). The adults are absent from New Zealand waters from mid-February/March to late August/ September (Falla 1965; Harrow 1976; Marchant & Higgins 1990). Juvenile specimens are only found on New Zealand beaches during March and April and have been reported from Australia during the breeding season (Halse 1981; Rowe & Taylor 2020).

The Department of Conservation (DOC) identified Hutton's shearwater as a threatened species requiring medium term action for recovery (Molloy & Davis 1992). A departmental meeting in June 1997 recommended the formation of a recovery group and discussed the option that a third colony be established at a lowland site as insurance against unforeseen occurrences in the two mountain colonies. A draft recovery plan (Paton & Davis 1997) further explored the option of a third, lowland colony, and a review of the status of Hutton's shearwater by Cuthbert (2001) also recommended a site be found for a third colony. A number of investigations were undertaken before selecting the site – productivity assessments (DOC *unpubl. data*), a population estimate of birds present in the Kaikōura region by colour marking birds at the Kōwhai River colony and resighting them at sea (Rowe *et al*. 2018), and the determination of flight paths to and from the Kōwhai colony to the sea (G.A. Taylor, DOC, *unpubl. data*). Early in 2005, an agreement was reached 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) (Fig. 1). Vehicle access to the site, the colony being under the Hutton's shearwater flight path to the Kōwhai River colonies and seaward facing, and being able to have a predator-proof fence established around the site were major determinants in the site selection even though it is near sea-level.

Successful translocations of chicks to establish new colonies of endangered seabirds have been undertaken in New Zealand since the mid-1980s (Miskelly *et al*. 2009). One of the first projects was a transfer of black petrels (*Procellaria parkinsoni*) at Little Barrier Island (Imber *et al*. 2003), and the largest number of birds moved prior this study was 334 fluttering shearwaters (*P. gavia*) from Long Island to Maud Island over six continuous seasons (Bell *et al*. 2005). Thus, there was a wealth of New Zealand expertise available to establish a new colony by translocation at Te Rae o Atiu. In March 2005, an initial trial translocation of Hutton's shearwater to Te Rae o Atiu was undertaken by DOC (Knevel 2005).

At the instigation of Geoff Harrow, the Hutton's Shearwater Charitable Trust (HSCT) was established in October 2008 with the initial task to obtain funds to erect a predator-proof fence around an extended colony site. Funding was obtained by June 2009 and the fence completed in February 2010, five years after the initial translocation. The site is surrounded by a stock fence at least 5 m from the predator-proof fence to protect it from damage by cattle trampling over the buried skirt or rubbing against the mesh (Fig. 1).

This paper summarises aspects of the translocation process, the progress of the Te Rae o Atiu colony development to April 2021, and pitfalls in the process.

Figure 1. Hutton's shearwater (*Puffinus huttoni*) colony (Te Rae o Atiu) on the Kaikōura Peninsula, South Island east coast, New Zealand (42.429°S, 173.703°E). The predator-proof fence completed in February 2010 is protected from stock damage by a deer fence at least 5 m away. The original colony is the outlined area in the lower centre of the colony and the original nestboxes were the six rows delineated by the tussocks below the hut. (Photograph: Andrew Spencer).

METHODS

The area initially selected for Te Rae o Atiu was 0.3 ha of farmland enclosed by a standard farm fence (Fig. 1). The area was extended to 2 ha in 2010 when the predator-proof fence was erected. The altitude range is 55–80 m a.s.l. with the slopes predominantly facing the sea; there is a 35° slope below the colony to the sea. In 2005, 30 artificial burrows (nestboxes) of treated timber and plywood were dug into the soil and connected by a length of 110 mm slotted drainage pipe to the surface (Fig. 2). Access to the nest chamber for helpers was via a removable lid which was insulated to avoid the nestbox overheating. Pea gravel was placed in each nestbox to aid drainage and dry grass was added for nest material. Another 78 nestboxes were installed in summer 2005–06. A few weeks prior to each translocation, a pest control programme was instigated at Te Rae o Atiu to remove as many cats, rats (*Rattus* sp.), mice (*Mus musculus*), stoats (*Mustela* *erminea*), and ferrets (*Mustela furo*) from the area as possible (Knevel 2005); the predator-proof fence was not in place until after the translocations were completed. After a cat killed roaming pre-fledgling chicks in March 2007, fish netting was placed over the fence and pegged down in an attempt to reduce their access to the colony.

The source areas for the chicks were sub-colonies near the research hut in the Kōwhai River at about 1,250 m a.s.l. The main constraint when sourcing chicks was accessibility to the nest chambers in the natural burrows that are up to 2 m in length and twist up, down or sideways, with stones and bedrock present. The nominal criteria for chick selection was mass ≥450 g and wing length 195–215 mm on the day of transfer (Williams 2006). Except for 2005 when unavoidable delays prevented collection until early April, at which time fledging was well underway at Kōwhai River, the collection took place late February to early March before chicks began exiting burrows and receiving visual signs of their home colony (Table 1). Chicks were banded and weighed, wing length measured, and transferred into cardboard "cat boxes" with dry grass on the base; two birds were in each box separated on the diagonal by a cardboard divider. They were flown 20 km by helicopter to Te Rae o Atiu.

At Te Rae o Atiu they were hand-reared and monitored following protocols in Miskelly *et al*. (2009). On arrival, they were checked, given 10 ml of water to reduce dehydration via a syringe fitted with a crop tube, and placed one in each nestbox. Netting gates placed at the tunnel exits prevented chicks from leaving immediately; they were held for at least two, but usually five, days. Every day from the second day until near fledging they were fed sardine "smoothies" (one tin of New Brunswick™ sardines in soya oil blended with 50 ml of water [Miskelly *et al*. 2009]) via crop tubes. Chick mass was measured daily with Pesola™ spring balances or electronic scales, the chicks being in bags or sleeves; wing lengths were measured every second day as flattened chords using stop end rules

Figure 2. Clockwise from top left: View of part of Te Rae o Atiu Hutton's shearwater (*Puffinus huttoni*) colony; a closed nestbox with PIT tag reader; the first egg laid at Te Rae o Atiu; interior of a nestbox with adult and chick. (Photographs: L. Rowe)

(Melville 2011). At Te Rae o Atiu, chicks from the 2012 and 2013 cohorts also had passive integrated transponders (PIT tags) placed in the back of their necks. From 2012–13 onwards, PIT tags were inserted into returned adults from the 2006 to 2008 translocations when they were found in nestboxes, and into Te Rae o Atiu bred chicks.

In 2011–2012, the HSCT made up 100 PIT tag reader systems using DOC made loggers similar to those used by Taylor *et al*. (2012) to study Chatham Island taiko (*Pterodroma magentae*). Each logger was attached to an antenna coil placed around the nestbox tunnel about 20 cm above the exit (Fig. 2; see Rowe [2014] for details). Placing the coil away from the exit reduced the collection of excess records when birds sat at the tunnel exits for extended periods. When a tagged bird passed through the antenna coil, the logger identifier, date, time, and bird transponder number were recorded.

An acoustic sound system was installed at Te Rae o Atiu next to the hut in the middle of the colony (Fig. 1). Hutton's shearwater calls recorded at the Kōwhai River colony were beamed via loudspeakers soon after dark to near dawn between August and March in an attempt to attract additional shearwaters to the colony over and above those translocated.

Apart from PIT tag recordings, Te Rae o Atiu was monitored at about weekly intervals, usually during mornings. Movement of three pins at the tunnel entrance was a guide to which nestboxes may have had birds return since the last inspection and worth inspecting. Movement of three more pins placed in the nestbox at the entrance to the tunnel was considered evidence of the nestbox chamber being visited. No movement of the inside pins was probably an indication of birds searching for food or other shearwaters disturbing the outer pins. HSCT site protocols prevented us undertaking night visits that might disturb any returning birds; it was considered that birds seen and/or handled during the day would have settled by nightfall. Band numbers of the birds found in nestboxes were verified and, up until 2010, white correction fluid (Twink™) was applied to their heads as an identifier to reduce repeat handling.

Reports were produced after each translocation (Knevel 2005; Williams 2006; McGahan 2007, 2008; Williams 2012; WMIL 2013) but the data in them were not always comparable so information reported here has been recalculated from the original datasheets. Calculated averages are given with 95% confidence limits. Other statistics and tests were performed using methods in Freese (1967) or Sokal & Rolfe (1981) and the calculated values for t, F, and χ^2 are given relative to published 95% (P = 0.05) significance levels; calculated test statistics < tabulated values are not significant and *vice versa*.

Birds translocated in any cohort are referred to by the year of transfer; i.e. 2006 for March 2006. The breeding season in New Zealand is from August through to the following March and, for example, August 2005–March 2006 is denoted 2005–06. A bird arriving back in its n^{th} year after hatching is deemed to be n-years-old as it will pass by its n^{th} birthday in late December/early January (Brooke 1990). With the exception of some late fledging birds, laying through to fledging occurs within New Zealand Daylight Saving Time (NZDST). The PIT tag readers are programmed in NZDST to reduce the possibility of errors in setup, so all times given here are in NZDST. The sexes of many returned birds were determined by outsourcing analysis of feather samples. Where feathers were not available, the sex has been inferred from that of their mates.

RESULTS

Translocation

In total, 495 chicks were translocated from Kōwhai River to Te Rae o Atiu (Table 1). The first ten birds were transferred as a trial in early April 2005. That transfer was atypical as it was delayed by inclement weather (Knevel 2005). Those chicks were at a much later stage of development than the other years and many birds had already fledged. These pre-fledglings may have already imprinted on the Kōwhai River site; none returned to Te Rae o Atiu and have, therefore, been excluded from further analysis although Table 1 includes this information for completeness. The 2006–2013 translocations all took place during 27 February – 9 March.

On arrival at Te Rae o Atiu, the 2006–2013 chicks had an average mass of 485 g (range 205–650 g, SD = 67 g, CL = ± 6 g, n = 485) and an average wing length of 212 mm (range 175–231 mm, SD = 11 mm, CL = ± 1 mm, n = 485) (Table 1). The mass selection criterion was met for 73% (355) of the chicks, 50% (243) met the wing length criterion, and only 36% (175) both met criteria.

ANOVA tests showed there were significant differences between translocations for arrival mass ($F = 33.1 > F_{P=0.05} = 2.39$, df = 4,480); annual average mass varied by ± 8% about the overall average. There was no significant difference between translocations for wing lengths ($F = 2.24 < F_{P=0.05} = 2.39$, df = 4,480). The significant relationship between wing length and mass at transfer, wing length = 199 + 0.0262 x mass (Fig. 3; $F = 12.7 > F_{P=0.05} = 3.86$, df = 1,461; COD = 0.0268), showed a wide scatter of points and only explained 2.7% of the variance in the data; other unknown variables, therefore, contribute to the variance.

Table 1. Summary of Hutton's shearwater (*Puffinus huttoni*) translocations from Kōwhai River to Te Rae o Atiu, 2005–2013. The 2005 data are not included in the final column. Averages are presented with 95% CLs.

	2005	**2006**	**2007**	**2008**	**2012**	**2013**	**2006–13**
Arrival date	2 Apr	8 & 9 Mar	7 & 9 Mar	5 & 6 Mar	7 & 8 Mar	27 & 28 Feb, 8 Mar	
Number of chicks transferred	10	86	95	100	101	103	485
Average mass at transfer (g)	435 ± 20	495 ± 13	525 ± 11	460 ± 12	445 ± 12	510 ± 11	485 ± 6
Mass range (g)	375–480	275–595	385–640	275–610	205–620	385–650	205–650
Standard deviation	31	63	54	61	62	56	67
Average wing length at transfer (mm)	222 ± 2	215 ± 2	211 ± 2	211 ± 2	212 ± 2	211 ± 1	212 ± 1
Wing length range (mm)	217–229	183–231	187–230	175–229	178–229	187–227	175–231
Standard deviation	3	10	11	12	11	11	11
Chicks fledged and left	10	79	83	98	100	103	463
Probable losses by cats	0	2	11	1	0	0	14
Probable losses by swamp harrier	0	5	0	0	0	0	5
Losses from natural causes	0	0	1	1	1	0	3
Nights stayed after arrival	5 ± 2	15 ± 1	21 ± 1	22 ± 1	19 ± 1	18 ± 1	19 ± 1
Nights stayed range	2–8	3–26	8–30	3–38	1–35	7–32	1–38
Standard deviation	3	6	5	7	8	4	6
Date first chick fledged	4 Apr	11 Mar	15 Mar	8 Mar	8 Mar	6 Mar	6 Mar
Date last chick fledged	10 Apr	4 Apr	6 Apr	13 Apr	11 Apr	31 Mar	13 Apr
Average mass at fledging (g)	410 ± 17	425 ± 7	435 ± 7	415 ± 8	400 ± 7	400 ± 7	415 ± 3
Mass range (g)	375–445	350–515	380–550	315–500	295–485	300–550	295–550
Standard deviation	28	34	35	34	34	36	36
Average wing length at fledging (mm)	224 ± 2	226 ± 1	228 ± 1	227 ± 1	225 ± 1	226 ±1	226 ± 1
Wing length range (mm)	221–229	214–237	217–238	200–238	214–237	212–237	200–238
Standard deviation	3	5	4	6	4	5	5
Wing growth rate (mm/day)	0.37 ± 0.25	0.85 ± 0.11	0.79 ± 0.09	0.66 ± 0.08	0.58 ± 0.08	0.80 ± 0.08	0.73 ± 0.04

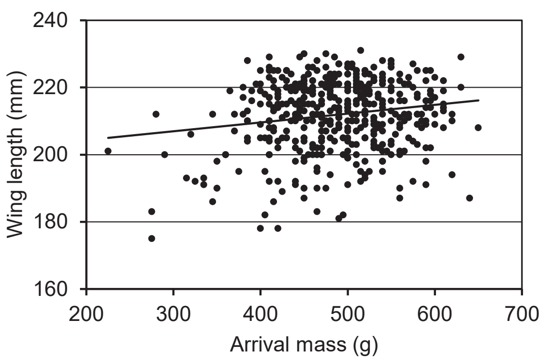

Figure 3. Relationship between wing length and mass of translocated Hutton's shearwater (*Puffinus huttoni*) chicks on arrival at Te Rae o Atiu.

Fledging

Of the 495 chicks brought down from the Kōwhai River, we believe 473 fledged on the basis that we know 22 birds were lost: 14 to cats, five to swamp harrier (*Circus approximans*) or cats, and three from undefined natural causes (Table 1).

Chicks were at Te Rae o Atiu 19 days on average (SD = 6 days, CL = ± 1, n = 463) (Table 1) and stayed between 1 and 38 days; 74% of chicks were present between 11 and 25 days (Fig. 4a). The number of days chicks were present varied significantly between translocations (ANOVA, $F = 20.4 > F_{P=0.05} = 2.39$, df = 4,458). The earliest date translocated chicks fledged was 6 March (2013) and the last chicks left each season between 4 (2006) and 13 (2008) April.

There was a significant relationship between the number of days translocated chicks spent at Te Rae o Atiu before fledging and their arrival mass (Fig. 4b), days = 13 + 0.014 x mass ($F = 9.6 > F_{P=0.05} = 3.9$, df = 4,461, COD = 0.02), but this only explained 2% of the variance in the data. Wing length at arrival was a better predictor of the number of days birds would stay. The relationship, days = 91 – 0.337 x wing length ($F = 201 > F_{P=0.05} = 3.9$, df = 4,461, COD = 0.30) (Fig. 4c) was highly significant and explained 30% of the variance in the data. It is, however, of limited value for estimating how long individual birds will stay until fledging as Fig. 4c shows there is a scatter of about ± 12 days birds could stay for any given arrival wing length.

Birds fledged at an average mass of 415 g (range 295–550 g, SD = 36 g, CL = ± 3 g, n = 463) and wing length of 226 mm (range 200–238 mm, SD = 5 mm, CL = ± 1 mm, df = 463) (Table 1). A regression analysis indicated there was a significant relationship between chick mass and wing length immediately prior to fledging, wing length = 214

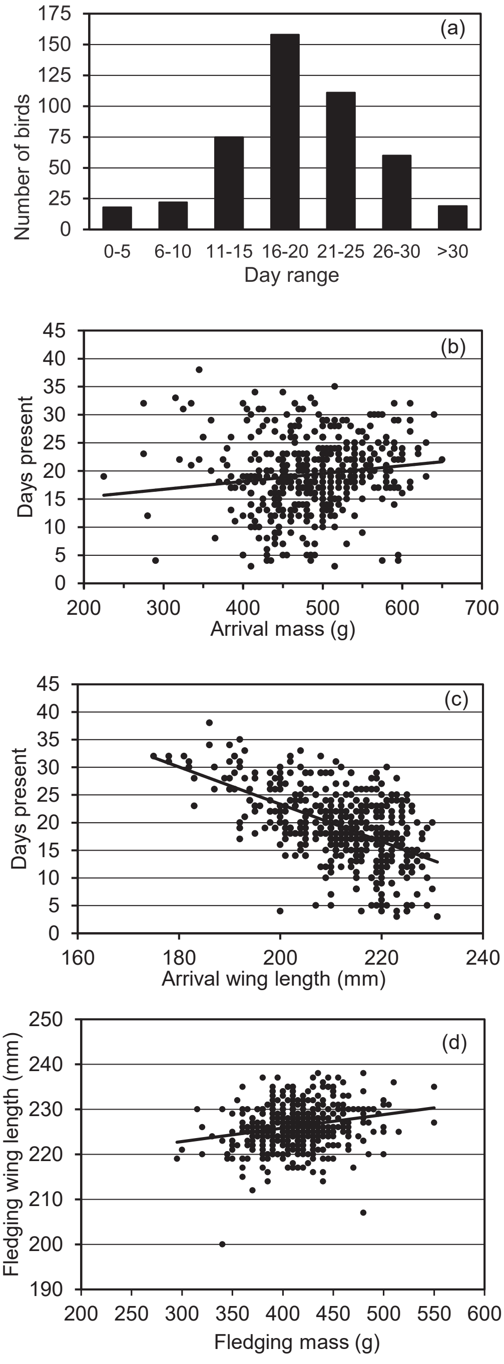

Figure 4. Translocated Hutton's shearwater (*Puffinus huttoni*) chicks at Te Rae o Atiu near fledging. (a) the number of days chicks were present before fledging; (b) the relationship between arrival mass and days present; (c) the relationship between arrival wing length and days present; (d) the relationship between mass and wing length near fledging.

Table 2. Known returns to Te Rae o Atiu of Hutton's shearwaters (*Puffinus huttoni*) from translocations undertaken in 2006 to 2013.

	2006	2007	2008	2012	2013	Total
Fledged	79	83	98	100	103	463
Birds seen	11	12	23	8	30	84
Birds noted from PIT tags only	–	–	–	5	8	13
Total birds returned	11	12	23	13	38	97
% returned	14	14	23	13	37	21
Birds present in 2020–21	3	8	12	6	25	54
Losses of returned birds	8	4	11	7	13	43

+ 0.030 x mass ($F = 24.7 > F_{P=0.05} = 3.9$, df = 1,461, COD = 0.051) but there was a wide scatter of points (Fig. 4d) and the relationship only explained 5.1% of the variance in the data.

The average rate of wing growth of the translocated chicks was 0.73 mm/day (SD = 0.42, CL = ± 0.04, n = 463), ranged up to 1.78 mm/day, and averaged between 0.58 and 0.85 mm/day on a translocation basis (Table 1); these rates were significantly different (ANOVA $F = 6.3 > F_{tab} = 2.39$, df = 4,458). Using the average growth rate, and arrival and fledging wing length differences, the discrepancies in the calculated and actual number of days to fledging for individual birds averaged 9 days and were in the range 25 days too few to 39 days more than observed.

Returns of translocated birds

The earliest confirmed return of a translocated bird from Australian waters was a 2006 bird in its third year and the only bird identified back in the 2008 season. Unfortunately, it was killed in a DOC250 trap set for predators. A cat, eventually tracked to the scrub below the colony, killed three returned birds in one night in November 2009. Two of these were 3rd and 4th year birds that had not been sighted previously; no band could be found to identify the third bird. Indirectly, cats were also responsible for the deaths of another two 4th year birds early in the 2009–10 season when they were caught in the fishing net draped over the stock fence in an attempt to keep cats out. After the predator-proof fence was erected, there have only been two more

Table 3. Numbers of translocated Hutton's shearwater (*Puffinus huttoni*) chicks that met or did not meet the selection criteria, and that returned to Te Rae o Atiu or did not return after fledging. Percentages are in parentheses.

	Mass criterion ≥450 g		Wing length criterion 195≤215 mm		Both criteria	
	Did not return	Returned	Did not return	Returned	Did not return	Returned
Not met	98 (27)	26 (27)	186 (51)	41 (42)	236 (70)	55 (57)
Met	268 (73)	71 (73)	180 (49)	56 (58)	130 (30)	42 (43)
χ^2	0.00		2.24		1.99	
$\chi^2_{P=0.05}$, df=1	3.84		3.84		3.84	

Table 4. Hutton's shearwater (*Puffinus huttoni*) fledging mass and wing lengths, days present until fledging, and days of emergence for those Hutton's shearwater chicks translocated to Te Rae o Atiu that returned from Australian waters or did not return.

	Mass (g)		Wing length (mm)		Days present		Days of emergence	
	Returned	Did not return	Returned	Did not return	Returned	Did not return	Returned	Did not return
Number	97	366	97	366	97	366	25	39
Average	410	415	227	226	20	19	8.8	7.2
Std dev	34	37	4	5	5	7	3.6	3.4
CL	7	4	1	1	1	1	1.4	1.1
t	0.70		1.49		0.98		0.08	
t, P= 0.05	1.97 (df = 461)		1.97 (df = 461)		1.97 (df = 461)		2.00 (df = 62)	

deaths when birds struck the fence as they were leaving the colony.

Of the 463 fledglings, 21% (97) have now been seen or noted from PIT tag records at Te Rae o Atiu (Table 2). The known returns for the five main translocations were variable ranging between 13% and 37% of birds that fledged. Observations from 2012 and 2013 translocations show that 13 of 51 birds (25%) that returned were only recorded by PIT tag readers. Thus, there was probably a numbers of birds from the early translocations not seen, perhaps as many as 12 birds.

There were no significant differences between the proportions of birds that met or did not meet the selection criteria (mass, wing length, or both) and returned or did not (Table 3). Fledging mass, fledging wing length, the number of days chicks stayed until fledging, and the number of days from first emergence to fledging (2013 translocation birds only) were determined for birds that returned to Te Rae o Atiu and the birds that did not (Table 4); unpaired sample t-tests did not indicate any significant differences between the two groups.

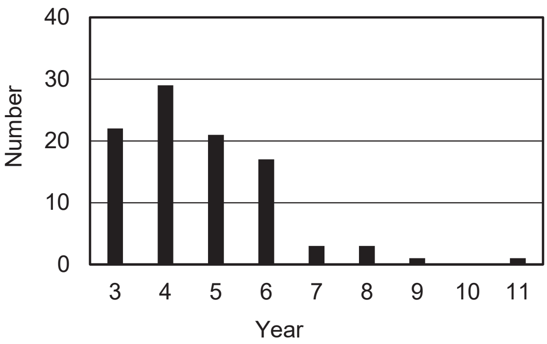

Figure 5. Ages at which translocated Hutton's shearwaters (*Puffinus huttoni*) were first noted returning to Te Rae o Atiu (includes up to 2020–21).

Similarly, χ^2 tests of the frequency distributions of those values for the two groups indicated no significant difference between them: mass $\chi^2 = 4.31 < \chi^2_{P=0.05} = 11.07$, df = 5; wing length $\chi^2 = 3.13 < \chi^2_{P=0.05} = 9.49$, df = 4; days present $\chi^2 = 4.27 < \chi^2_{P=0.05} = 11.07$, df = 5; emerged days $\chi^2 = 3.43 < \chi^2_{P=0.05} = 7.81$, df = 3). Thus, there is no reason to believe that any of these parameters had a significant influence on whether birds returned from their first migration or not.

Birds translocated to Te Rae o Atiu that fledged and returned from their first migration to Australia were seen or recorded from PIT tags the earliest in their 3rd year, at least 23% (22) of the 97 returned birds (Fig. 5); 92% were first noted up to their 6th year and one bird was first seen in its 11th year. It is probable that some birds from earlier translocations may have been back sooner but were not seen in nestboxes nor PIT-tagged. The returned birds comprised 43% males and 56% females; the difference was not significant ($\chi^2 = 1.46 < \chi^2_{P=0.05} = 3.84$, df = 1). From 2012 and 2013 translocations only for which we have better records (all birds were PIT-tagged), the timing of first male and first female returns were not significantly different (unpaired sample t-test: $t = 0.52 < t_{P=0.05} = 2.02$, df = 43).

Acoustic attraction

In 12 years of operation of the sound system, only two unbanded birds were found at the colony (X19101 in 2010; X17347 in 2013). These two birds, both female, may have been attracted to the site by the broadcast sounds, but they did become an integral part of the breeding population.

Losses to the Kōwhai River natal colonies

We know that seven PIT-tagged birds that were brought down to Te Rae o Atiu as part of the translocation programme in 2012 and 2013 returned to the Kōwhai River natal colonies in their 3rd and 4th years (Rowe 2018). Two, as 3rd year birds, had

Table 5. Numbers of Te Rae o Atiu bred Hutton's shearwater (*Puffinus huttoni*) chicks that have returned from Australian waters up to 2020–21.

Cohort	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	Total
Fledged	1	2	8	7	6	12	17	15	21	23	112
Bird returned	0	2	6	3	4	3	2*	1**	–	–	–
% returned	0	100	75	43	68	25	–	–	–	–	–
Present 2020–21	0	1	6	3	4	3	2	1	–	–	–
Losses	1	0	2	4	2	0	–	–	–	–	–

*Chicks returned as 3-year-olds only; **chick returned as a 2-year-old. More birds are expected back from 2016–17 on cohorts.

Table 6. A comparison of near departure mass (g) and wing lengths (mm), and days of emergence for Te Rae o Atiu bred Hutton's shearwater (*Puffinus huttoni*) fledglings that returned or did not return from Australian waters. Data for fledglings from 2011–12 to 2016–17.

	Mass (g)		**Wing length (mm)**		**Days of emergence**	
	Returned	**Did not return**	**Returned**	**Did not return**	**Returned**	**Did not return**
Fledged	18	18	18	18	13	15
Average	385	415	222	223	8.0	9.3
Std dev	49	61	6	8	3.4	5.3
CL	23	28	3	4	1.9	2.7
Maximum	455	525	233	233	15	20
Minimum	265	280	211	203	2	1
t	1.50		0.54		0.78	
$t,_{P=0.05}$	2.03 (df = 34)		2.03 (df = 34)		2.06 (df =26)	

Table 7. A comparison of Hutton's shearwater (*Puffinus huttoni*) near departure mass (g) and wing lengths (mm), and days of emergence of translocated and Te Rae o Atiu bred fledglings.

	Mass (g)		**Wing length (mm)**		**Days of emergence**	
	Translocation	**Te Rae o Atiu**	**Translocation**	**Te Rae of Atiu**	**Translocation***	**Te Rae o Atiu**
Fledged	463	101	463	89	64	100
Average	415	410	226	226	7.8	8.1
Std dev	36	49	5	7	3.5	3.6
CL	3	10	1	1	0.9	0.7
Maximum	550	565	238	237	16	20
Minimum	295	260	200	203	1	1
t	0.54		0.14		0.57	
$t,_{P=0.05}$	1.97 (df = 562)		1.97 (df = 550)		• df = 162)	

* 2012-13 birds only

spent a night at Te Rae o Atiu in early November before being recorded in late December at Kōwhai River. No earlier translocation birds have been physically sighted or recorded in the Kōwhai River by researchers undertaking projects at the natal sub-colonies.

Te Rae o Atiu bred chicks

The first chick bred at Te Rae o Atiu to fledge was in the 2011–12 season; a further 111 fledged up until the 2020–21 season (Table 5). By the end of the 2016–17 season, 18 of the 36 chicks that fledged have come back; this 50% return rate is over twice that of the translocated birds, and there may be more if others return as 5-year-olds or older. Seventeen of the 18 returned birds were still present in 2020–21. On the basis of the 2011–12 to 2016–17 returns, we might expect 38 of the 76 chicks that fledged from 2017–18 to 2020–21 to return and for about 36 to remain medium term.

The mass and wing length near fledging, and the days between first emergence and fledging of the Te Rae o Atiu chicks that returned from their Australian migration were not significantly different from those that did not return, i.e. they were not from different populations (Table 6).

The youngest Te Rae o Atiu bred birds seen back at the colony were in their 2nd year (two) and a further ten birds first returned in their 3rd year. The limited time span since breeding commenced at Te Rae o Atiu means there is little data with which to determine trends or to make comparisons with translocation birds.

Translocation chicks and Te Rae o Atiu chicks

A comparison of the mass and wing lengths at near departure, and the number of days birds emerged before fledging of Te Rae o Atiu bred chicks and translocation chicks showed no significant differences (Table 7). This suggests that the birds

Table 8. Hutton's shearwater (*Puffinus huttoni*) breeding success (fledglings/egg laid) at Te Rae o Atiu. The number of breeding pairs per season is assumed to be equal to the number of eggs laid.

Season	Breeding pairs	Chicks hatched	Fledged	Breeding success (%)
2009–10	0	-	-	-
2010–11	2	0	0	0
2011–12	4	1	1	25
2012–13	16	3	2	13
2013–14	15	8	8	53
2014–15	16	8	7	44
2015–16	16	8	6	38
2016–17	23	14	12	52
2017–18	25	20	17	68
2018–19	31	15	15	48
2019–20	29	24	21	72
2020–21	33	26	23	70
Total	210	127	112	53

could be from the same populations despite the different feeding regimes – translocation feeding vs parental feeding.

Te Rae o Atiu colony growth

Colony growth to date has been mostly from returning translocated and Te Rae o Atiu bred chicks. There have only been two unbanded birds brought in by, possibly, acoustic attraction; these two females have had chicks fledge. We can now identify nearly all the birds at the colony as, from 2014–15 on, most birds present have been recorded by PIT tag readers.

At 2020–21, it is probable that all translocated birds that will return have done so. Numbers of each cohort peaked at about age five to six years old and were steady until a slow decline from about age 10 years with the loss of older birds (Fig. 6). Unlike for translocations, the Te Rae o Atiu plot reflects only the younger birds from the first few Te Rae o Atiu breeding seasons; older returning birds and those fledglings yet to return from their first Australian migration will enhance those numbers.

The breeding success (fledged/eggs laid) at Te Rae o Atiu has been about 62% from 2016–17 through 2020–21 (Table 8). There has been an increase in the number of fledglings with bursts in 2013–14 reflecting the increased breeding success with older birds, and 2016–17 with the second batch of translocated birds and Te Rae o Atiu bred birds starting to contribute to the colony.

The growth of the Te Rae o Atiu colony is shown in Fig. 7. At 2020–21 there was about 75 birds present producing about 20–25 fledglings/season.

DISCUSSION

Operational procedures

Before the predator-proof fence was installed at the Te Rae o Atiu colony, it was necessary to undertake

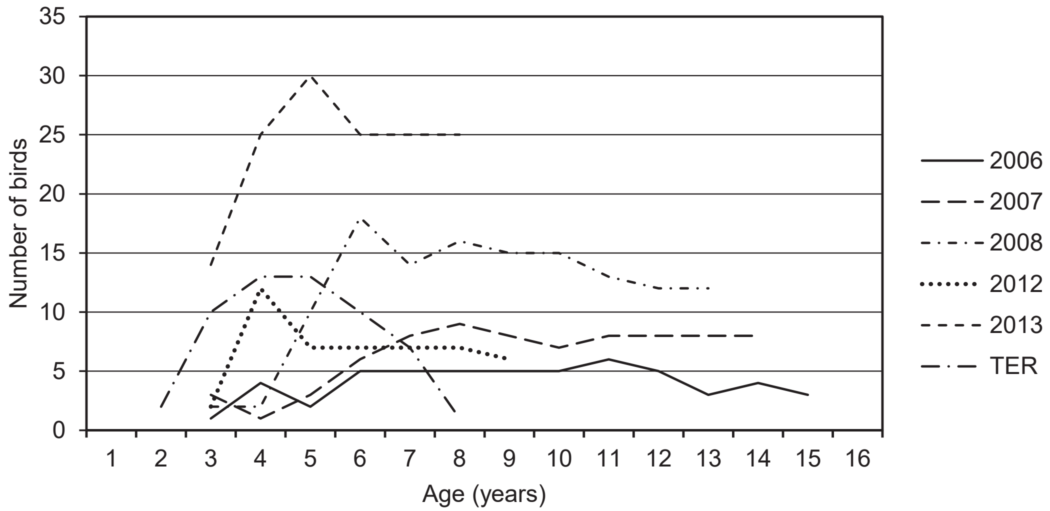

Figure 6. Number of Hutton's shearwaters (*Puffinus huttoni*) by age and cohort noted at Te Rae o Atiu. The Te Rae o Atiu graph will change significantly with time as more chicks fledge and return from their first migrations to Australian waters. Data to 2020–21.

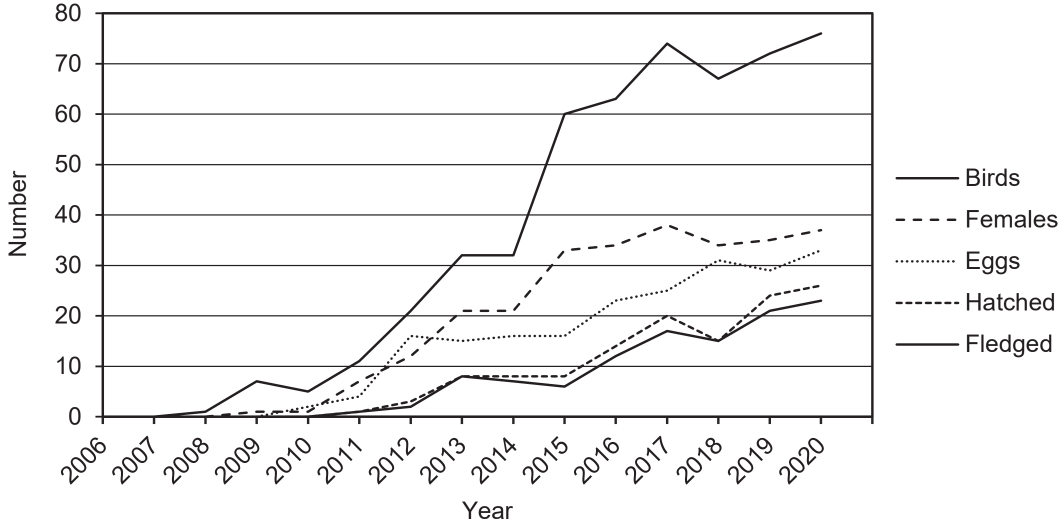

Figure 7. Growth of the Te Rae o Atiu Hutton's shearwater (*Puffinus huttoni*) colony. 2006 represents the 2006–07 season, and so forth.

predator control as the new site was located on farmland which was home to cats, rats, stoats, etc. One control measure was the use of DOC250 predator traps laid out around the new colony site. Unfortunately, the first known translocated Hutton's shearwater to return from its maiden migration was killed in a trap inside the standard farm fence; the bird triggered the trap when it put its head through the opening (M. Morrissey, DOC Kaikōura, *pers. comm*.). The openings of all traps were then made smaller by fitting small battens across the top of the entrance holes but leaving the openings large enough for mustelids to enter; there were no more fatalities associated with the traps, but we do not know if they have been tested.

There were significant losses of pre-fledging chicks at Te Rae o Atiu during 2006–2008 by cats and swamp harriers despite substantial control work of the former in the area surrounding the translocation site. On the worst night seven roaming chicks were taken. Once birds started to return from their first migrations the problem continued with three birds killed in one night and two more dying in the fishing net placed over the farm fence in an attempt to reduce cat access. That was the major drawback of trying to establish a new colony on farmland with the Kaikōura township less than 1 km distant, and it highlighted the need for a predator-proof fence that would exclude cats. Those losses may have been a prime factor that persuaded funders the fence was necessary. Without a predator-proof fence this colony would not have prospered as the relatively small number of returning birds would have been wiped out by cats. Since the fence was erected, there were no further losses to predators.

Two returned birds are known to have died when they flew into the bottom predator-proof fence when leaving the colony. Shrubs planted a few metres inside the fence may have prevented further fatalities because no more fatalities have been recorded to date.

The simple Twink™ marking system used to identify which bird of a pair was present without extracting it from the nestbox and reading the band, proved not to be foolproof. Birds seen together and marked in a nestbox very early in the season were sometimes found later breeding in other boxes with different partners. In some cases, both birds of the new pairing had the same twink patterns, i.e. both horizontal or both vertical marks. Thus, this simple system was abandoned after two seasons because of the uncertainty created in individually identifying birds. We now know adult shearwaters range widely; for example, one bird triggered 22 PIT tag readers beyond its own nestbox in one season (LR *unpubl. data*).

The movement of three pins placed at the external entrance of each nestbox tunnel to give a record of when chicks emerged from, and adults visited, nestboxes proved to be an unreliable measure for three reasons. Firstly, before the predator proof fence was erected, rabbits (*Oryctolagus cuniculus*) seen in nestboxes (LR *pers. obs.)* had knocked over the pins. Secondly, pins were moved by song thrushes (*Turdus philomelos*) prospecting for snails in the tunnels thus negating the reliable interpretation of the movements.

Thirdly, PIT tag records obtained during the 2013 translocation showed that pre-fledging chicks could move up to 25 m away from their home nestbox visiting up to four nestboxes in one night (Rowe 2014), a phenomenon also observed at the natal Kowhai River colony (Rowe 2018), and in fluttering shearwaters at Mana Island (Gummer & Adams 2010). These roaming chicks knocked over pins outside nestboxes other than their home nestbox up to 13 days before the incumbent chick triggered the logger for the first time (Rowe 2014). As a consequence of the chick and adult movements, the three pins were only useful in indicating which nestboxes may have been visited since the last check, and thus worth inspecting. To solve the problem, an additional three pins were placed at the exit of the nest chamber but the movement of these pins only indicated if a bird entered the nestbox, not which bird nor at what times.

It is highly likely we missed some returning birds each year up until, at least, 2013 because we did not make night visits when birds would be present. The daytime visits at about weekly intervals did not often find birds present unless on eggs or very small chicks. At that time the early birds were not PIT-tagged, and the value of PIT tagging was demonstrated in the 2015–16 season when 61 birds were recorded but only 34 were seen. The other 27, mainly young birds from the 2013 translocation, were known to have been at Te Rae o Atiu only from PIT tag reader records.

Contrary to some other studies, e.g. common diving petrels (*Pelecanoides urinatrix*) at Mana Island (Miskelly & Taylor 2004), the acoustic system calls at night has not been very successful in attracting new birds to the colony. Only two unbanded birds have been caught and banded, and became part of the breeding population. This rate of attraction is similar to that for the closely related fluttering shearwater which also had limited acoustic attraction to new sites. Two unbanded birds were seen prospecting near loudspeakers at Mana Island (Gummer & Adams 2010), and at Maud Island eight unbanded fluttering shearwaters were found at the translocation site, possibly attracted by the sound system (Bell *et al*. 2005). There does, however, seem to be some response by Hutton's shearwaters to the playbacks here because the majority of the nestboxes used are in a vee-formation below the speakers and not at the upper corners of the nestbox array. We know that the site is under the flight path to the Kōwhai River colony (G. Taylor; F. Barber, *unpubl. data* presented to OSNZ Conference 1 June 2003), and complaints from the public 1.5 km from the loudspeakers suggests that there was a lot of noise emitted. Why acoustic attraction has not been very successful here remains to be investigated, but the reason may be as simple as Hutton's shearwaters flying past not being attracted to that particular recording.

Translocation

With 495 Hutton's shearwater chicks translocated from the Kōwhai River, the Te Rae o Atiu experience is possibly the largest seabird translocation carried out since the 1970s—1980s when Atlantic puffin (*Fratercula artica*) chicks were translocated 1,600 km to Eastern Egg Rock (954 chicks, 1973–86) and Seal Island (950 chicks, 1984–89) in the Gulf of Maine, USA (Kress 1997; Jones & Kress 2012). While it may not be the longest continuous translocation project, it may well have been the first to carry out top up transfers a few years after the first set (M. Bell *pers. comm*. 2020), a procedure since followed at Mana Island where 200 fairy prion (*Pachyptila turtur*) chicks were moved in 2015 and 2016 to enhance the colony established from 240 chicks translocated in 2002–04 (Gummer *et al*. 2015, 2016).

Chicks for translocation need to be selected so that they have not emerged from their natal burrows and imprinted on the natal site, and to have sufficient time to imprint on the new site before fledging (Miskelly *et al*. 2009), about 2–5 weeks before fledging. Wing length is usually considered the best predictor of age with heavier birds often preferred to optimise fledging (e.g. Miskelly *et al*. 2009; Gummer & Adams 2010). Bell *et al*. (2005) confined their selections to fluttering shearwater chicks in full down with primaries half grown as more advanced chicks may already have begun imprinting on the natal site, and they noted that returning chicks had mean fledging weights greater that those that did not return. In this project the selection of chicks was based on wing length and mass but difficulties in retrieving the required number of chicks necessitated taking many chicks outside the guidelines. The wing length range, 195–215 mm, corresponded to chicks 23–15 days before fledging (from a wing length growth curve in Cuthbert & Davis [2002b]) which should have provided adequate time to imprint on the Te Rae o Atiu site and are within the time line suggested by Gummer & Adams (2010) and Miskelly *et al*. (2009). From a body mass growth curve (Cuthbert & Davis 2002b), chicks meeting the minimum mass criteria, >450 g, could be aged from about 42 days before fledging, through the peak mass of 530 g at about 18 days to fledging, through to fledging. Thus, mass is not as useful as wing length to estimate the days chicks stayed until fledging. Although potentially the best predictor of how long birds would stay, wing length was also not particularly useful in a practical sense as, for any given value, the translocated chicks showed a range of 24 days about the predicted value of how long a bird would stay.

Of the 495 chicks translocated, only three (0.6%) were recorded as having died of unidentified natural causes before fledging. This high level of survival was similar to that for many other translocations of small petrels: 100% for 240 fairy prions transferred to Mana Island in 2002–2004 (Miskelly & Gummer 2013) and 200 in 2015–2016 (Gummer *et al*. 2015, 2016), Gould's petrel (*Pterodroma leucoptera leucoptera*) 100% (Priddel & Carlile 2001), Chatham petrel (*Pt. axillaris*) 99% (Miskelly *et al*. 2009), Bermuda petrel (*Pt. cahow*) 97% (Carlile *et al*. 2012), and Pycroft's petrel (*Pt. pycrofti*) 98% (Miskelly *et al*. 2009). The survival rate was better than for the closely related fluttering shearwater, 82% at Maud Island (Bell *et al*. 2005) and 83% at Mana Island (Miskelly *et al*. 2009). The high survival rate of translocated Hutton's shearwater chicks at Te Rae o Atiu suggests that the collection procedures, transporting to, and housing at Te Rae o Atiu, and the feeding regimes using sardine smoothies were adequate despite there being four different lead contractors for the six translocations, each following their own, unpublished, guidelines as to a chick's feed requirements prior to fledging.

The criteria used to select chicks for translocation appear not to be definitive but provide a suitable guideline for which birds may survive the translocation process and fledge. Also, they were not factors that determined whether the birds returned to Te Rae o Atiu or not. The same parameters at fledging did not appear to influence returns. While fledging mass has been shown to have an effect for some species, e.g. for diving petrels and fluttering shearwaters where returned birds averaged 7% heavier at fledging than those that did not return (Miskelly & Taylor 2004, Bell *et al*. 2005), it was not a factor determining Hutton's shearwater returns. Unknown environmental factors while on migration, possibly weather, sea conditions, and food supplies, may be the important determinants for Hutton's shearwaters returning or not.

There were marked differences in the returns, 13 to 38%, from each translocation cohort which is not unusual. For example, returns of early translocations of fairy prions ranged between 2–29% (Miskelly & Gummer 2013), 11–23% for diving petrels (Miskelly & Taylor 2004), and fluttering shearwaters 4–32% (Bell *et al*. 2005). The average return to Te Rae o Atiu, 21%, is higher than at other translocation studies: 8% for fairy prions (Miskelly & Gummer 2013), 17% for diving petrels (Miskelly & Taylor 2004), and 12% for fluttering shearwaters (Bell *et al*. 2005). One reason may be that Te Rae o Atiu is a relatively small, defined site within a predator proof fence with the shearwaters only using nestboxes, and does not need the extensive search effort required at some natural release sites which may not find all returns.

Some studies, e.g. fluttering shearwaters moved from Long Island to Maud Island (Bell *et al*. 2005) and fairy prions from Takapourewa to Mana Island (Miskelly & Gummer 2013) have shown a number of birds returned to the natal colonies. There has been no systematic survey of the natal colonies in the Kōwhai River to determine how many Hutton's shearwaters may have returned. Annual limited scale productivity surveys, and captures for banding, determining migration patterns, and food source studies have not found any returns (LR *unpubl. data*) but, incidental to another project, Rowe (2018) found seven PIT-tagged Hutton's shearwater chicks had returned to the Kōwhai River. This was in spite of them being at Te Rae o Atiu for 1–18 days prior to fledging, long enough for other birds to imprint there and return to breed. Two of these birds had previously spent a night at Te Rae o Atiu on their return from Australian waters. Before returning to the colonies at night, Hutton's shearwater raft off the Kaikōura coast and it is possible that the birds that returned to the Kōwhai River were caught up in the movement of these birds which was strong enough to overcome any imprinting on Te Rae o Atiu. This small loss to the Kōwhai River, 1.5% of the translocation birds, is unlikely to have had a significant impact on the new colony.

Te Rae o Atiu colony growth

Breeding success (fledglings/egg laid) at Te Rae o Atiu has increased to about 70% by 2020–21 as the number of experienced breeders present increased. This success rate is encouraging as it is above that reported for the Kōwhai River colonies between 2009 and 2015, 63% calculated from Cuthbert (2019). It is similar to that for fluttering shearwaters at Maud Island which averaged 72% rising to over 80% in the last two years reported (Bell *et al*. 2005), but is lower than at Mana Island where it is now usually above 82% (Gummer 2020). Returns of locally bred birds have contributed to the recent steady growth of the Te Rae o Atiu colony which had previously been boosted greatly in 2015–16 by returns from the second set of translocations. Half of the early Te Rae o Atiu bred chicks have returned and these second-generation birds have bred and contributed to fledgling numbers from 2018–19. We await this third generation to return and contribute to the colony growth as future growth will soon depend on the Te Rae o Atiu bred birds returning from Australia and breeding.

Birds at Te Rae o Atiu are the only known age breeding Hutton's shearwaters and the oldest of these are three 15-year-olds (2 male, 1 female) from the 2006 translocation. Although DOC records have about 775 birds banded as pulli and juveniles at Kōwhai River, only 14 have been recaptured alive, ranging in age from 6.6 to 19.0 years, and their breeding status was not known when recaptured. Eleven birds banded as adults have been recaptured at minimum ages of 19–23 years old and one at 32 years (Rowe & Taylor 2020) but it is not known if these birds were still breeding. Thus, there is insufficient data to produce reliable life tables for Hutton's shearwaters and their potential breeding span. BirdLife International (2021) lists the generation length of Hutton's shearwater at 19.5 years and for the seven other Manx related shearwaters to be between 15 and 18.3 years; individual Manx shearwaters have been recovered at over 50 years old (Robinson 2005) and fluttering shearwaters 27 years (M. Bradshaw, DOC *pers. comm.*). This limited information suggests that Hutton's shearwaters could breed to about 20 years, so the older birds may be nearing the end of their reproductive lives. There are indications here that there is a gradual decline in numbers of a given cohort at Te Rae o Atiu from about age 10. There will soon be a need for replacements for the natural losses of the translocated birds as they cease being part of the breeding stock. Additional birds may be necessary to expand the colony further and to diversify the gene pool which is limited through lack of new birds being attracted to the site. While the current and future breeding stock may provide sufficient replacements, a third set of translocations to Te Rae o Atiu, perhaps 300 chicks over two or three years, is desirable to ensure another boost to the growth of the colony as was seen after the 2012 and 2013 translocations.

There is a lot of space for potential growth at Te Rae o Atiu. During 2020–21, Hutton's shearwaters were found in 49 burrows and eggs in 33, suggesting the present 108 wooden nestboxes will be adequate for a number of years to come. Shearwaters have not dug their own burrows to date but have dug around the back of nestboxes and dug tunnels up to 0.5 m deep out the back of chambers where there were gaps in the woodwork. At the density of the nestboxes already installed, there is a potential for about 4,000 breeding pairs at Te Rae o Atiu. The potential numbers could be as high as 10,000 pairs at the density reported for areas at Kōwhai River by Cuthbert (2019). This does not include any birds that might burrow outside the predator-proof fence. Thus, there is no real limit on the number of birds that can be resident at the Te Rae o Atiu colony. It need not be a token insurance colony in the event of more catastrophic events at the Kōwhai River and Shearwater Stream colonies, nor be of a limited size where it could be vulnerable to avian diseases or other events.

Conclusions

This study has shown that for translocation birds that returned or did not return from their first migration to Australia, the two groups had similar wing lengths and mass at collection, at fledging, and emerged for a similar number of days before fledging. The translocation chicks and locally bred chicks also had similar parameters at fledging. Fledging parameters for Te Rae o Atiu chicks that returned or did not were also similar. This suggests that for birds that are adequately provisioned by the translocation teams or parents, man might have little influence over returns. Weather and sea parameters including food sources whilst the birds are on migration probably control the numbers of birds that return.

The colony numbers have been relatively stable over the last four years of the study at about 75 birds. With the numbers of older breeding birds declining slowly it is hoped that chick production will be adequate to replace those. Warming sea temperatures may be a factor influencing future colony expansion as birds have to travel further than at present, around and south of Banks Peninsula (Bennet *et al.* 2019, 2022) to find food as sources move south to cooler waters. Further translocations may be necessary to boost Te Rae o Atiu colony growth.

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