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Recovery and other observations of sooty shearwaters (*Puffinus griseus*), New Zealand white-faced storm petrels (*Pelagodroma marina maoriana*), and fairy prions (*Pachyptila turtur*) banded at Motunau Island, New Zealand 1960-1999

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Abstract Three hundred and eighty one sooty shearwaters (*Puffinus griseus*), 2209 New Zealand white-faced storm petrels (*Pelagodroma marina maoriana*) and 14546 fairy prions (*Pachyptila turtur*) were banded at Motunau Island, Canterbury, South Island, New Zealand between 1960 and 1999. One sooty shearwater was recovered off the coast of Washington State, USA and 4 others off Motunau Island; the oldest sooty shearwater recovered was found near Taieri airport over 23 years after banding as an adult. Only 1 white-faced storm petrel was recaptured away from Motunau Island and that was found alive on Pitt Island, Chatham Islands. The oldest white-faced storm petrel recovered was found alive on Motunau Island nearly 13 years after banding. Fourteen fairy prions were found on New Zealand's east coast between Brighton Beach, Christchurch, and Hikutaia near Thames. One fairy prion from Stephens Island and 2 from The Brothers were found at Motunau Island; one was the oldest bird recovered at over 21 years since banding as an adult. Estimates of population sizes based on recapture numbers were 300 for sooty shearwater, 1300 for white-faced storm petrel and 50,000-60,000 for fairy prion.

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INTRODUCTION

Sooty shearwaters (*Puffinus griseus*), New Zealand white-faced storm petrels (WFSP; *Pelagodroma marina maoriana*) and fairy prions (*Pachyptila turtur*) breed on Motunau Island, Canterbury (43° 03′S 173° 04′ E), but can be found throughout the southern hemisphere (OSNZ 2010). The sooty shearwater has been given an IUCN ranking of "near threatened" because of a moderately rapid decline in numbers, and WFSP and fairy prion are classed as of "least concern"(Birdlife International 2013). A New Zealand threat classification of "D. At risk, D.1 Declining" has been assigned to the sooty shearwater, and "D. At risk, D.3 Relict" to both fairy prion and WFSP (Miskelly *et al.* 2008).

In New Zealand, sooty shearwater colonies are generally found on offshore islands but a few small populations can still be found on the mainland (Heather & Robertson 1996; Oliver 1955; OSNZ 2010; Warham *et al*. 1982; Warham 1985).

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Table 1. Numbers of birds of each species banded at Motunau Island (rebands of birds are not included) according to bander.

	B. Bell	C. Challies	K & L Rowe	R. Taylor	Others	Total
Sooty shearwater	3	20	187	162	9	381
White-faced storm petrel	85	0	809	1275	40	2209
Fairy prion	0	50	10525	3581	390	14546

Richdale (1963) and Warham *et al*. (1982) have given detailed accounts of the breeding cycle of sooty shearwaters at Whero Island and The Snares Islands, respectively. White-faced storm petrels breed on many islands around New Zealand (Heather & Robertson 1996; Imber 1985; Oliver 1955; OSNZ 2010); the breeding cycle at Whero Island has been described by Richdale (1943a, 1943b, 1944a, 1965a). Islands around the New Zealand coast are home to fairy prions (Harper 1976, 1980, 1985; Heather & Robertson 1996; Oliver 1955; OSNZ 2010); in-depth studies of their breeding biology have been reported by Richdale (1944b, 1944c, 1965b) at Whero Island and Harper (1976) at the Poor Knights Islands.

Motunau Island is a 2.02 ha nature reserve about 1300 m south of Motunau Beach on the north Canterbury coast. The island rises steeply (the north and west faces are sheer) to a plateau at about 30 m a.s.l. The only other flat area is at the south-east shore. Control of rabbits which infested the island since 1893 (Crockett 1954) began with poisoning operations in 1958 and culminated in extermination in 1963 (Taylor 1967). The island geology and soils have been described by Cox (1967a, 1967b, 1967c) while Mason (1967) describes the vegetation cover that had become very poor in places. Crockett (1954) has some early notes on the birds on Motunau Island and Beach *et al.* (1997) report on vegetation and animal changes since the rabbit extermination programme took place. In addition to the 3 bird species discussed here, Motunau Island has breeding colonies of white-flippered penguin (*Eudyptula minor albosignata*), and southern black-backed gull (*Larus d. dominicanus*; Taylor 1967); red-billed gull (*Larus novaehollandiae*) and white-fronted tern (*Sterna striata*) have bred intermittently (Taylor 1967; Beach *et al*. 1997). Rowe (2013) reported on the dispersal of southern black-backed gulls from Motunau Island together with those from the Ashley River and Waimakariri River in Canterbury, and Challies (1998) has reported on the status of the white-flippered penguin.

The purpose of this paper is to present recapture information from 2 long-term banding programmes. I summarise mainly recapture and recovery data for birds banded at Motunau Island but I also present some egg and bird measurements collected during my visits to this island.

METHODS

From 1960 to 1999, over 17000 birds of 3 species were banded (sooty shearwater, white-faced storm petrel, and fairy prion), mainly under permits issued by the Wildlife Branch of Internal Affairs and latterly the Department of Conservation (DoC) to Brian Bell (BB), Chris Challies (CC), the late Ken Rowe (KR), Lindsay Rowe (LR), and Rowley Taylor (RH); small numbers were banded by other operators (Table 1). Bandings undertaken by BB and RT were part of Wildlife Branch research programmes; banding by KR and LR supplemented this earlier work and extended it for a few more years. Chris Challies' main interest was the white-flippered penguin but banding of sooty shearwater and fairy prion was undertaken as KR and LR reduced their visits to the island.

Banding of birds on Motunau Island generally took place between late October and early February and visits were usually between 2 and 7 days duration. Most banding took place at night when birds could be picked up while they were sitting on the ground out of burrows, although some, mainly nestlings, were extracted from burrows during daytime.

Initially, aluminium bands were used on sooty shearwaters and white-faced storm petrels. The first 46 bands used by KR on sooty shearwaters were aluminium and 17 of these were replaced by monel Z-prefix bands when recaptured. Monel bands were used after October 1961 except for 14 stainless steel bands used in summer 1983-84. Aluminium bands were used on the first 59 WFSPs banded by KR and about half were rebanded with monel bands which were the main bands used; 11 stainless steels bands were used in 1993. Aluminium bands were not used on fairy prions. Instead, monel bands were used until replaced by stainless steel bands from October 1970 and put on over 8500 birds.

The recovery data reported here has been extracted from forms sent to KR & LR by the DoC Banding Office or forms submitted to the banding office by them after the visits to the island; most of the data comes from files supplied by the Banding Office. The term "recoveries" includes birds found 1 or more days after banding, either dead birds or recaptured and released alive and healthy. Distances from the banding sites were those given in the DoC supplied records.

Table 2. Numbers of recoveries of each species banded at Motunau Island.

	Birds banded	Birds recovered	All recoveries	Birds dead	Recovered off Motunau Island
Sooty shearwater	381	110	158	3	4
White-faced storm petrel	2209	582	776	4	1
Fairy prion	14546	926	1010	47	12

Table 3. Sooty shearwater recoveries on or off Motunau Island.

Bird number	Where recovered	How recovered	Month recovered	Elapsed time (days-months-years)	Distance from site of banding (km)
Z257	Quinault River mouth, Washington, USA	In fishing net (alive?)	Early September	16-10-2	11750
Z291	Motunau Island	Dead	December	3-0-0	0
Z489	Coordinates incorrect as near Balmoral Forest	In fishing net (alive?)	January	15-1-5	32
Z1197	At sea or coastal? SW of Greymouth	No details	November	13-0-21	210
Z4831	Bay of Plenty	Shot by hunter	January	2-0-0	660
Z4841	Near Taieri Aerodrome	Found freshly dead	May	17-6-23	370
Z1153	Motunau Island	Alive	December	10-0-20	0

Population estimates were made using a simple proportionality relationship. The population estimate is given by:

$$P = n_1 \times n_2/R$$

where P is the estimated population size, n_1 is the number of birds caught in the first capture session, n_2 is the number of birds caught in the second capture session, and R is the number of recaptures of session 1 birds during session 2. The sessions in this instance were up to 7 days long – the length of the banding visits. The time between sessions was kept to less than 14 months. Assumptions of this model are: (1) there were no deaths or recruitment between the sessions, (2) all birds present for a session had the same probability of being caught, and (3) no bands were lost. The model cannot account for changes in the numbers of unemployed birds but repeat sampling within a few months or at similar times about 1 year apart may minimise the effects.

Measurements of eggs and birds reported here were made by LR or KR. Vernier callipers were used to measure eggs (to 0.1 mm), and wing length measurements were made using a ruler to 1 mm. Statistical tests follow Conover (1980). Confidence limits of means are at the 95% significance level.

RESULTS

Sooty shearwater

Of the 3 species reported here, the least number banded was sooty shearwater. A total of 381 sooty shearwaters were banded between 1960 and 1984 and during 1992 (Table 1); 3 nestlings are included in this total. Over half of the birds (193) were banded in December but the dates for banding ranged from 20 October to 7 March; the most birds banded in any breeding season was 48 in 1977-78.

One hundred and ten adult sooty shearwaters were recovered for a total of 158 recoveries (Table 2); this included 19 birds that were rebanded. Only 5 recoveries were made away from Motunau Island (Table 3) with the furthest (bird Z257) found in a fishing net (but not recorded as dead) off the mouth of the Quinault River, Washington, USA, 11750 km in a direct line. All other recoveries were found within 660 km of Motunau Island (Table 3). Three birds were confirmed as being recovered dead; the fate of 3 more is unknown although 2 were reported as being caught in fishing nets. The DoC records show that Z4831 was shot in the Bay of Plenty the day after banding. It had travelled 660 km.

The oldest recovery was 23 years, 6 months and 17 days when Z4841 was found dead near Taieri airport; 2 more sooty shearwaters were recaptured at over 20 years of age (Table 3). Note that these are minimum ages as all these birds were banded as at least 1 year-olds. The average recovery was 4.6 years after banding. None of the 3 banded nestlings was recaptured.

To estimate the population size of sooty shearwater on Motunau Island, I set a minimum threshold of 15 new birds and recaptures for

Table 4. Motunau Island sooty shearwater population estimates. *n1* is the number of birds caught in session 1, *n2* is the number caught in session 2, *R* is the number of session 1 birds caught in session 2, *P* is the population estimate, *m* is the number of months between sessions.

Session 1	Session 2	*n1*	*n2*	*R*	*P*	*m*
October 1960	October 1961	32	15	1	480	12
October 1960	December 1961	32	15	2	240	14
October 1961	December 1961	15	15	1	225	2
December 1961	December 1962	15	18	1	270	12
December 1962	December 1963	18	33	2	300	12
December 1967	December 1968	15	16	2	120	12
October 1970	December 1970	21	30	2	315	2
November 1975	January 1976	23	17	4	100	2
November 1975	October 1976	23	19	3	145	11
January 1976	October 1976	17	19	1	325	9
October 1976	December 1977	19	42	1	800	14
December 1977	January 1978	42	18	4	190	1

both the capture and capture/recovery sessions (up to 7 days long field trips). Even so, the number of recaptures was small (only 1 to 4). As population estimates are sensitive to the numbers of recaptures, my calculations can only give a rough estimate of population size. Table 4 lists the estimates obtained between October-November and December-January sessions within 1 season (*i.e.*, up to 4 months apart) or sessions after 4 months apart. The estimates ranged between about 100 and 800 birds with an average of 290 ± 110 sooty shearwaters on Motunau Island. The one egg found measured 72.6 x 48.4 mm.

White-faced storm petrel

Between 1960 and 1979 and during January 1993, 2209 white-faced storm petrels were banded (Table 1) including 109 nestlings. Almost 1000 of the birds were banded in December with most of the rest in October and November. Adults were banded between 27 September and 27 February, and nestlings between 19 December and 16 February.

Five hundred and eighty two WFSPs were recovered at least the day after banding (Table 2); this included 35 birds that were rebanded. The proportion of chicks (24/109) and adults (558/2100) recovered was not significantly different ($\chi^2 = 0.96$ $df = 1$, $P > 0.05$) nor was the proportion of total recoveries (736 for adults and 30 for nestlings; $\chi^2 = 2.07$ $df = 1$, $P > 0.05$). Some birds were caught up to 4 nights/field trip and others on up to 4 separate field trips. Only one bird (C10699) banded on 11 February 1972 was found off Motunau Island (Table 5); it was caught alive and released with bands intact on the Chatham Islands on 20 January 1979, a distance of 880 km. Only 4 birds were found dead and all were on Motunau Island (Table 5).

The oldest WFSP recapture was nearly 13 years after banding and 4 additional birds were recaptured after 10 years; these are minimum time spans as all these birds were banded as adults (Table 6). The first time nestlings were recaptured on Motunau Island was 2 years after banding; the oldest nestling recovered was nearly 8 years old. Seven nestlings and 78 adults were recovered more than 5 years after banding. The average time since banding for the last recovery of any particular bird was 2.5 years.

The DoC files list one bird having been caught on Motunau Island that was not banded there. Bird number C16483 was banded at Pitt Island, Chatham Islands on 2 November 1970 and was caught at Motunau Island on 22 November 1971, 880 km from it banding location (M. Nesaratnam, DoC; *pers. comm.*).

As for sooty shearwaters, estimates were made of the population size. Because the population of storm petrels was larger, I set the threshold of numbers caught at each session to over 40 to reduce the effects of small recapture numbers. Fourteen estimates could be made over 15 summers with the periods between sessions ranging from 2 weeks to 12 months. The population estimates varied between 400 and 2370 (Table 7) with an average of 1320 ± 300 birds. A Cox & Stuart test did not indicate a linear trend over the 14 periods. Again, it should be noted these estimates are sensitive to the number of recaptures, especially at the lower level of recaptures (*i.e.*, a change of one recapture from $R = 5$ can lead to a change in the estimate of ~200 birds, while a change of one from $R = 16$ is ~130 birds).

The average size of 18 eggs measured was 35.7 ± 0.7 x 25.1 ± 0.7 mm. Wing length measurements obtained for 3 WFSP adults on 28 December 1971 were 147, 155 and 159 mm.

Fairy Prion

A total of 14,546 fairy prions were banded at Motunau Island (Table 1) of which 347 were nestlings banded between 19 December and 7 February. Most birds were banded prior to 1980 with 60 banded in 1986 and 21 banded in 1998-99. Labour weekend 1970 was exceptional for banding with 4869 birds being caught over 3 nights, including 4721 new birds banded and 148 recaptured.

There have been 926 (6.4%) Motunau Island birds recovered, for a total of 1010 recoveries (Table 2); only 18 birds were rebanded which reflects the use of the harder wearing monel metal bands from the start of the programme. Band wear, and therefore loss, does not seem to have been a problem when monel bands were used on fairy prion at Motunau Island. While 2 bands had to be replaced after 2

Table 5. White-faced storm petrel recoveries found on or off Motunau Island.

Number	Where	How recovered	Month recovered	Elapsed time (days-months-years)	Distance (km)
C10699	Pitt Island, Chatham Islands	Alive & released	January	8-11-6	880
C4100	Motunau Island	Dead	February	21-03-0	0
C4796	Motunau Island	Dead	December	9-0-1	0
C10964	Motunau Island	Dead	December	26-0-8	0
C18964	Motunau Island	Dead	December	29-0-2	0

Table 6. White-faced storm petrel recoveries – length of time since banding. All were on Motunau Island and were released alive with bands.

Band	Age at banding	Month recovered	Elapsed time (days-months-years)
C4731	Adult	October	15-10-12
C4043	Adult	October	9-0-11
C19008	Adult	December	21-11-10
C14680	Adult	January	18-0-10
C4094	Adult	October	6-0-10
C3443	Pullus	February	28-11-7
C3451	Pullus	November	7-9-7
C14509	Pullus	November	30-10-6
C3413	Pullus	December	14-10-6

years, 5 more were not replaced for 10-13 years, and another 80 bands, all > 10 years old were not considered needing replacing when recaptured. A comparison of the time distribution of recoveries from all monel and stainless-steel banded birds showed no significant difference ($\chi^2 = 36.3$, $df = 25$, $P > 0.05$) despite the different sample period lengths, nor did a subsample of 1721 monel-banded birds and 3000 stainless-steel banded birds from October 1970 ($\chi^2 = 10.1$, $df = 15$, $P > 0.05$).

Forty-seven birds were recovered dead, 11 of which, together with 1 live recovery, were off Motunau Island (Table 8); the majority of recoveries were found on the south Wellington and Wairarapa coasts. Three birds from Stephens Island and The Brothers were recovered alive at Motunau Island (Table 9).

The longest recoveries were just over 21 years after banding birds as adults (Table 10); D13832 was a bird that had been banded at The Brothers. Of the 9 birds recovered aged 16 or over, 3 were found dead; 43 were more than 10 years old when recovered. Five of the banded nestlings were recovered after the initial breeding season, the youngest of these being captured at nearly 3 years old and the oldest being 5 years. On average, birds were recovered 3.8 years after banding. It is possible that more older birds would have been recovered as the frequency of visits by banders to the island declined after 1980.

Table 7. Motunau Island white-faced storm petrel population estimates. *n1* is the number of birds caught in session 1, *n2* is the number caught in session 2, *R* is the number of session 1 birds caught in session 2, *P* is the population estimate, *m* is the number of months between sessions.

Session 1	Session 2	*n1*	*n2*	*R*	*P*	*m*
October 1960	November 1960	59	45	3	890	1
November 1960	December 1961	45	79	4	890	12
December 1961	October 1962	79	82	9	720	11
December 1963	February 1964	96	60	5	1150	2
December 1967	December 1968	223	107	11	2170	12
December 1968	November 1969	107	330	16	2210	12
November 1969	October 1970	330	122	17	2370	11
October 1970	December 1970	122	289	19	1860	2
December 1970	November 1971	289	246	64	1110	11
December 1972	December 1972	48	120	6	960	0.5
December 1972	October 1973	120	162	17	1140	10
December 1974	January 1975	42	57	6	400	1
January 1975	November 1975	57	113	5	1290	10
November 1975	January 1976	113	46	4	1300	2

Estimates for the size of the fairy prion population were based on a threshold of 150 birds caught at each session to reduce the effects of small recapture numbers. Seven estimates could be made with the time between periods ranging from 2 weeks to 13 months (Table 11). The first 2 estimates indicated a population between 9000 and 12000 birds but the overall number of banded birds in the population was very small. Four estimates could be made using the high numbers caught in October 1970 and these varied between 32,000 and 94,000 birds, and averaged 57,000 ± 26,000 birds. It should be noted these estimates are still sensitive to the number of

Table 8. Fairy prion recoveries off Motunau Island.

Number	Where	How recovered	Month recovered	Elapsed time (days-months-years)	Distance (km)
D93912	Hikutaia near Thames	Dead (after storm)	August	22-8-7	687
D29570	South Wairarapa	Alive and released	May	27-6-6	257
D98234	White Rock Beach – Wairarapa	Dead	February	14-3-15	256
D95087	Lake Onoke	Dead	August	23-9-3	250
D99223	Lake Onoke	Dead	August	11-9-8	250
D119676	Lake Onoke	Dead	August	29-8-9	250
D30065	Princess Bay, Wellington	Dead	August	18-9-6	234
D90250	Island Bay, Wellington	Dead	July	17-8-3	234
D99400	South Bay, Kaikoura	Dead	December	2-2-2	87
D96545	South Brighton Beach	Dead	January	3-2-9	60
D97584	Central Brighton Beach	Dead	November	3-11-12	58
D110790	Brighton Beach	Dead	January	26-2-11	58

Table 9. Fairy prion recoveries at Motunau Island of birds banded elsewhere.

Number	Where banded	How recovered	Month recovered	Elapsed time (days-months-years)	Distance (km)
D13823	The Brothers	Alive & released	October	21-5-16	242
D13832	The Brothers	Alive & released	November	2-6-21	242
D81020	Stephens Island	Alive & released	December	12-1-5	272

recaptures with a change of 1 recapture leading to a change to a given estimate of ~500 to 5000 birds. The average size of 26 eggs measured was 43.4 ± 0.6 x 31.5 ± 0.5 mm.

DISCUSSION

Sooty shearwater

It is well known that sooty shearwaters leave New Zealand and migrate to the northern hemisphere for the winter months (*e.g.*, Marchant & Higgins 1990; Shaffer *et al*. 2006; Spear & Ainley 1999). Robertson (1994) listed a sooty shearwater recovery of a bird banded at the Titi Islands being found near La Jolla in California. Using geolocator archival tags, Shaffer *et al*. (2006) were able to determine that breeding-age sooty shearwaters from New Zealand arrived at a northern hemisphere overwintering ground off California about 4 May where they stayed to feed for about 150 days before returning to the New Zealand breeding grounds arriving in October. Z257, the Motunau Island bird banded as an adult and caught less than 3 years later in a net off the mouth of the Quinault River, Washington, USA fits into this pattern as it was recovered in early September; Quinault River is about 1700 km north of La Jolla.

One sooty shearwater (Z4841) was found "freshly dead" in a woodpile near Taieri aerodrome in mid-May 2000. All breeding sooty shearwaters have typically left their breeding colonies by the start of May and arrive back from mid-September (Richdale 1963; Warham *et al*. 1982; Heather & Robertson 1996). Few birds remain in New Zealand waters over winter (Richdale 1963) and beach patrol records also indicate there are few birds in New Zealand in May (Scofield & Christie 2002). Therefore, this bird should have left New Zealand waters by the time of its recovery, but as it was nearly 24 years since being banded as an adult, it is possible that old age meant it was not fit enough to undertake the migration and was forced to stay in New Zealand waters for the winter and later succumbed.

Bird Z4831 was reportedly shot by a hunter in the Bay of Plenty only 2 days after banding; this was about 660 km in a direct line from the banding site at Motunau Island or close to 1000 km by sea. While this may seem to be a long distance to travel in such a short time it is feasible. Sunrise at Motunau Island is about 0600 and sunset in the Bay of Plenty is about 2045 in early January (RASNZ 2013). If a bird leaves Motunau Island an hour before sunrise there is ~39

Table 10. Fairy prion recoveries over 16 years after banding at Motunau Island.

Number	Age at banding	Where banded	How recovered	Month recovered	Elapsed time (days-months-years)
D13832	Adult	The Brothers	Alive	December 1983	2-6-21
D96980	Adult	Motunau Island	Alive	November 1993	16-2-21
D110308	Adult	Motunau Island	Alive	October 1992	2-0-19
D90870	Adult	Motunau Island	Dead	December 1987	17-1-17
D119658	Adult	Motunau Island	Alive	October 1993	29-11-16
C13823	Adult	The Brothers	Alive	November 1978	21-5-16
D96858	Adult	Motunau Island	Dead	November 1988	15-2-16
D93414	Adult	Motunau Island	Dead	December 1986	24-1-16
D16460	Adult	Motunau Island	Alive	December 1983	0-0-16

Table 11. Motunau Island fairy prion population estimates. *n1* is the number of birds caught in session 1, *n2* is the number caught in session 2, *R* is the number of session 1 birds caught in session 2, *P* is the population estimate, *m* is the number of months between sessions.

Session 1	Session 2	*n1*	*n2*	*R*	*P*	*m*
October 1960	October 1961	300	211	7	9050	12
December 1967	October 1968	241	304	6	12200	11
November 1969	October 1970	354	4869	54	31900	11
October 1970	November 1970	4869	111	10	54050	0.5
October 1970	October 1971	4869	932	93	48800	12
October 1970	November 1971	4869	713	37	94000	13
October 1971	November 1971	932	713	9	74000	0.5

hours until dusk the next day at which time it may have been shot. During the incubation period, sooty shearwaters have been known to travel in excess of 500 km/day, reaching speeds of 81 km/hour, and with a 4-day average over 45 km/hour (Söhle *et al*. 2007; Shaffer *et al*. 2006). Thus, reaching the Bay of Plenty in 2 days is possible.

Both sooty shearwaters banded on Motunau Island and recovered in New Zealand waters (Z489 and Z1197) were found in November or January, which is during the breeding season. Three of the Motunau Island birds lived over 20 years since banding with Z4841 having reached 23.5 years; these estimates are minimum ages as all birds were all banded as adults. The DoC database also has 2 New Zealand records of sooty shearwaters having reached 29.5 and 26 years (G. Taylor, DoC; *pers. comm.*).

A previous estimate for the population of sooty shearwaters on Motunau Island was 200 – 240 birds (Taylor 1967) based on recapture data (some of which was used for Table 4). The data presented here (12 estimates in Table 4) for periods in 1960-77 suggests a slightly higher population at nearly 300 birds. However, these estimates are extremely variable due to the low numbers of recaptures. The model used does not account for recruitment or deaths over the short time spans between banding sessions (2-14 months) and there are potentially different populations being compared depending on the number of pre- or non-breeders present. Clucas *et al.* (2008) suggested that a large proportion of sooty shearwaters at 3 colonies they studied were juveniles and pre-breeders so any change in proportions through the October-January period might influence the model estimates. Beach *et al.* (1997) suggested there might have been an increase in sooty shearwater numbers based on an increase shearwater-sized burrows they resurveyed in quadrants set up in 1958-62 but cautioned that comparisons of the 2 data sets was difficult as the shearwater-sized burrows may have been being used by other petrels.

White-faced storm petrels

Aluminium bands were used on the first 59 birds caught at Motunau Island in 1960. Menkhorst *et al*. (1984) stated that aluminium bands on WFSPs banded at Mud Islands, Port Phillip Bay, Victoria, Australia usually only lasted 3 or 4 years but one was found after 6-7 years. Thirty five of the 59 Motunau Island birds were rebanded with monel reducing the degree of bias that the use of aluminium bands might have introduced. The oldest known age bird at Motunau Island (*i.e.*, banded as a nestling), was 8 years old when last released. At Motunau Island the longest period between banding and recovery was nearly 13 years when that bird was released; adding 2 years for the first return makes this bird at least 15 years old. This is only 1 year shorter than the oldest recaptured known age bird at Mud Islands (Menkhorst *et al*. 1984) but considerably shorter than the longest record in the Australian Bird and Bat Banding Scheme of 19 years and 10 months for another bird at Mud Islands (ABBBS 2013).

Table 12. Breeding chronology of fairy prion on various islands around New Zealand.

Island	First egg	Hatching	Last fledging	Source
Poor Knights Island	14 to 24 October	21 November to 4 December	~22 January	Harper (1976)
Stephens Island	19 October	3 December to ~ 17 December	< 10 February	Walls (1978)
Motunau Island	?	>6 December & < 19 December to ?	7 to mid-February	Taylor (1967); this paper
Whero Island	?	18 December to 7 January	28 February	Richdale (1944b)

Imber (1984) noted that little was known about the movements of pre-breeders and age of first breeding in white-faced storm petrels. Birds banded as nestlings were not recovered back at Mud Islands until they were in their third year suggesting that they did not return to the colonies until then (Menkhorst *et al*. 1984). The first time any of the 35 birds banded as nestlings at Motunau Island were recovered was at about 2 years of age, which is about 1 year earlier than at Mud Islands.

While WFSPs are known to spend the winter away from New Zealand in the eastern Pacific (Heather & Robertson 1966; Imber 1984, 1985; Marchant & Higgins 1990), none of the Motunau Island birds were found in that region. Only one WFSP was recovered off Motunau Island, at Pitt Island in the Chatham Islands 7 years after banding; and 1 Pitt Island bird was recaptured at Motunau Island a year after banding. I have not found any published reports of WFSPs moving from one breeding area to another.

Richdale (1943a) gives hatching dates for WFSPs at Whero Island between 25 December and 22 January in 1940-41 and 20 December and 31 January in 1941-42. The first nestlings banded on Motunau Island were on 19 December which extends the period forward as the nestlings needed to be large enough to band. This would fit into the broad pattern given by Imber (1985) whereby WFSPs lay earlier in the north than at the Chatham Islands (latitude about 1.2° S of Motunau Island) and later still in the south.

An earlier population estimate for WFSPs on Motunau Island was 1400 birds with individual estimates between 410 and 2750 birds (Taylor 1967). Over 16 years, my estimates ranged from 400 to 2370 birds, with a possible peak about 1968-1970. However, these estimates are very sensitive to the number of birds caught and the larger totals coincided with the greatest numbers of birds banded in a field trip. There may have been a more recent decline in the population as Beach *et al.* (1997) only identified 134 burrows in 1996 but that is likely to be an underestimate as some of their burrows could have been attributed to fairy prions based on size.

The mean size of the 18 eggs measured here (35.7 x 25.1 mm) was similar to that given in Heather and Robertson (1996; 36 x 26 mm), the range from 3 widely dispersed sites in Oliver (1955; 33.5 x 24.0 mm to 36.2 x 27.4 mm), the mean of 100 eggs from Whero Island by Richdale (1943a; 35.9 x 26.0 mm), and the mean of 4 Motunau Island eggs in Taylor (1967; 35.4 x 24.9 mm). Three wing length measurements of adult WFSPs (147, 155 and 159 mm) were also similar to published information: mean 157 mm, range 145-175 mm (Heather and Robertson 1996), 151-156 mm (Oliver 1955), and mean 159 mm, range 149-170 mm, at Whero Island (Richdale 1944a).

Fairy prion

Most New Zealand breeding fairy prions are believed to winter in the New Zealand region but may visit subtropical waters or the Tasman Sea (Robertson 1968; Harper 1980; Heather & Robertson 1986; Marchant & Higgins 1990). For example, birds banded at Stephens Island have reached eastern Australia (Robertson 1968; Harper 1980; Heather & Robertson 1986). All fairy prions in this study recovered off Motunau Island were found along the New Zealand east coast. Most birds found on the New Zealand coast during beach patrols are picked up in the period from July to September (Powlesland 1989) which is the period when half of all the Motunau Island birds found off the island were recovered.

The longest recoveries were just over 21 years after banding birds as adults which is similar to the longest reported period of just over 22 years (Heather & Robertson 1986) and birds banded as adults breeding 19 years later (Harper 1985). DoC archives have the oldest bird found alive at 36 years and 4 more at 22 years after banding (G Taylor, DoC; *pers. comm.).* It is possible that older breeding birds could have been present at Motunau Island as the frequency of visits, and hence the opportunity for recoveries, declined after 1980. Three birds from Stephens Island and The Brothers were recovered alive at Motunau Island which must be unusual as I have not been able to find any published

information on movements of fairy prions from one colony to another.

Five banded nestlings were recovered first at nearly 3 years. Assuming that this is the norm, this raises the question as to where the birds were for the previous 2 summers and whether fairy prions spend the first 2 winters at sea before coming back to the breeding grounds as seems the case for sooty shearwaters and WFSPs. These returned nestlings were probably pre-breeders as Harper (1980) and Richdale (1965b) had birds breeding first at 4-5 years.

A trend of earlier breeding at northern New Zealand colonies compared to those further south has been reported by Harper (1976) and Walls (1978). The Motunau Island data, although limited because of the timing of the short visits, fits in between the 2 extremes (Table 12).

Estimates for the size of the fairy prion population were based on thresholds of numbers caught at each session set at over 150 to reduce the effects of small recapture numbers. Seven estimates could be made with the time between periods ranging from 2 weeks to 13 months (Table 11). The departures of unemployed birds is a complicating factor as it is not known when they leave Motunau Island; at the Poor Knights they leave by about 8 December (Harper 1976) and at Whero Island they are gone by mid-January. I avoided this problem by making comparisons using mainly October and November data; the number of birds caught or recaptured during visits in December and January were too small. The first 2 estimates indicated a population between 9000 and 12,000 birds but the overall numbers of banded birds in the population was relatively small. Four estimates could be made based around the exceptional numbers caught in October 1970 and these varied between about 32,000 and 94,000 birds, and averaged 57 000 ± 26 000 birds. It should be noted these estimates are sensitive to the number of recaptures with a change of one recapture leading to a change to a given estimate of ~500 to 5000 birds.

Beach *et al*. (1997) reported there were ~14000 fairy prion burrows present in 1996/1997 on Motunau Island, which was similar to that estimated in 1962 by Taylor (1967) but more than estimated in 1958 (9900 burrows). Taylor (1967) also reported a population estimate of 27,000 birds (range 9500 to 55,000 birds), based on small samples of recoveries, often less than 4. The estimate of ~57,000 here may be more reliable as it is based on much larger sample sizes.

Twenty six eggs were measured and the mean size (43.4 x 31.5 mm) was close to that measured at the Poor Knights Islands (Harper 1976; 43.86 x 31.41 mm) but smaller than those at Whero Island (Richdale 1965; 45.1 x 32.6 mm) and another set from Motunau Island (Taylor 1967; 44.7 x 32.4 mm).

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