

Surveying and monitoring of black petrels on Great Barrier Island, 1997/98

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ABSTRACT

The black petrel (*Procellaria parkinsoni*) is an endemic seabird, which breeds on Little Barrier and Great Barrier Islands, New Zealand. Generally, black petrels are found breeding in burrows, more than 300 metres above sea level. The main breeding area on Great Barrier Island is around the highest point: Mount Hobson (Hirakimata). In the 1997/98 season, as in previous years, the three census grids and 100 study burrows (selected in the 1995/96 and 1996/97 breeding seasons) were intensively monitored during late January and February. Of the 100 study burrows, 73 were being used by breeding pairs, 24 by non-breeding adults and three burrows were empty. A total of 51 burrows were located within the census grids and 33 were being used by breeding pairs. A preliminary population estimate extrapolating from the grid burrows shows that the black petrel population around the peak of Mount Hobson consists of 4125 breeding birds and at least 1125 non-breeding birds. A range of factors affected the breeding success of the black petrels during the 1997/98 season resulting in a breeding success of 82%. Although no direct evidence of long-line fishing impact was found in the Great Barrier Island breeding area, at least three black petrels have been recorded killed on long-lines during this period. By-catch during the breeding season puts increased pressure on the population, and it continues to be important to study the Great Barrier Island black petrel population to determine the dynamics of the population, in particular survivorship, mortality and breeding success.

Keywords: black petrel, *Procellaria parkinsoni*, monitoring, population estimates, breeding success, predation, bycatch, Great Barrier Island, New Zealand

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1. Introduction

The black petrel is a vulnerable, endemic New Zealand seabird, and is the smallest of their genus (Collar et al. 1994; Imber 1987). Previously widespread on North Island and north-western South Island ranges, black petrels now only occur on Little Barrier and Great Barrier Islands (Imber 1987; Scofield 1989; see Bell & Sim 1998a, fig. 1). On Great Barrier Island, black petrels are generally found in forested areas over 300 m, with the main breeding area around the highest point, Hirakimata (Imber 1987). Breeding success is affected by rat and cat predation (Imber 1987; Scofield 1989) with possible impact by the domestic and foreign long-line fishing industry.

Monitoring of the black petrel population during the 1997/98 breeding season is a continuation of a study (Survey and monitoring of black petrels on Great Barrier Island) begun in 1995/96 (Bell & Sim 1998a, 1998b). The data collected throughout this season will assist in determining the population dynamics of the Great Barrier Island black petrel population. Continued monitoring of this population will determine the effects of long-line fishing, predation and habitat disturbance, allow a more accurate population estimate to be made and ensure any population changes will be detected in sufficient time to implement conservation management strategies. In the future, this information can be used to determine any effects the long-line fishing industry might have on the population.

2. Objectives

As a continuation of the previous monitoring, this study aimed to provide more data to establish current population trends of the Great Barrier Island black petrel, and try to determine causes and timing of mortality.

In summary, the objectives were to:

- Monitor the 100 study burrows, banding all adults present in the burrows during January and February and all the remaining fledgling chicks during April.
- Determine breeding success in the long-term study burrows, and causes of breeding failure, such as predation or disappearance of parents were noted.
- Monitor the three census grids established in the 1995/96 season. Band and recapture as many breeding and non-breeding birds present as possible.
- Make a population estimate by extrapolating from the grid areas to the main Mount Hobson breeding area.
- Search other areas thought to be suitable for black petrel breeding.

3. Methods

Three census grids—on the Palmers, Kauri Dam, and South Fork Tracks—were set up around Mount Hobson during the 1995/96 black petrel breeding season (see Bell & Sim 1998a, 1998b, for locality maps fig. 1 and fig. 2). During the period from 21 January to 24 February 1998 these census grids were re-surveyed to locate any new burrows and to determine occupancy. All adults and chicks were banded and weighed (where possible). The information gathered from the census grids was used to make a population estimate for black petrels around the Mount Hobson summit area (30 ha).

The 100 study burrows selected during the 1996/97 season (Fig. 1) were also intensively monitored between 21 January and 24 February 1998. To ensure accurate monitoring of the study burrows, they are either accessible directly through the main entrance or via an artificial opening that has been excavated through the roof of the burrow into the chamber. This opening is covered by a piece of plywood, soil, and debris.

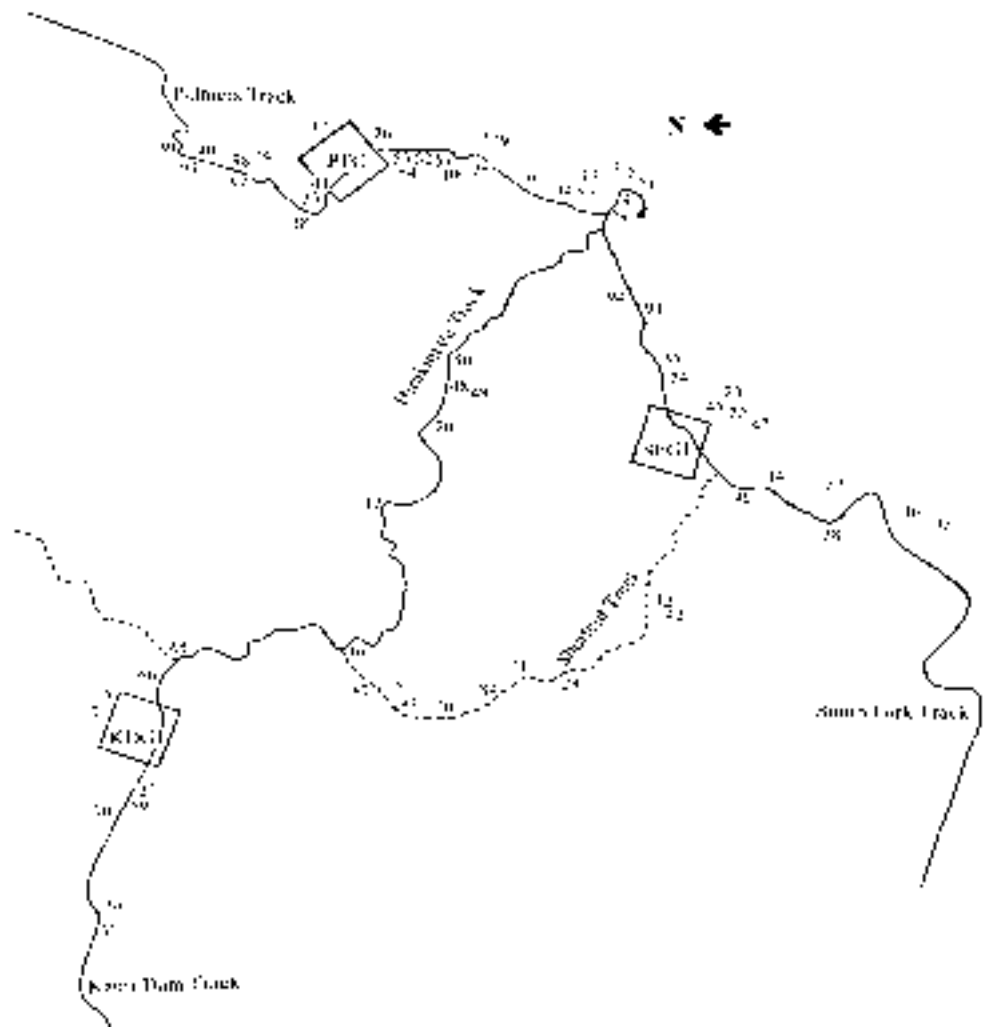


Figure 1. Location of the census grids and 100 study burrows. Note: Palmers Track grid one (PTG1) contains study burrows 32, 55-64 and 96; Kauri Dam grid one (KDG1) contains study burrows 67, 68 and 71-81 and South Fork grid one (SFG1) contains study burrows 85-92.

During the first monitoring session any adult present was removed from the burrow, banded, weighed, and returned. Any eggs or chicks in the burrows were noted. The lack of eggs or chicks identified non-breeding birds. Weighing the adult birds can help identify the sex, as males are usually heavier than the females. The study burrows were also monitored between 14–20 April, and all remaining fledglings were banded and returned. This information was used to determine breeding success and to begin collecting long-term population dynamics data to determine survivorship, mortality, and productivity.

During February, rat index lines were set up as directed by Cunningham & Moors (1993). A peanut butter and rolled-oat mixture was used as bait. Index lines were set up along the track system connecting the census grids. Rats were also trapped around the hut. Observations were also made on feral cat predation and pig rooting.

4. Results

A total of 51 burrows were found in the three census grids: 15 in Kauri Dam Track grid, 14 in South Fork Track grid, and 22 in Palmers Track grid (Table 1, Fig. 2). There were 33 burrows used by breeding birds and 18 used by non-breeding birds. There were also three potential burrows located within the grids (one in each grid). A potential burrow is one that is not ready to be used for breeding, but has been investigated or preliminarily dug out by a black petrel. This figure is not used in the breeding success estimate.

TABLE 1. TYPE AND NUMBER OF BURROWS WITHIN THE CENSUS GRIDS.

AREA	BURROW TYPE	NO. OF BURROWS		
		1995/96	1996/97	1997/98
Kauri Dam grid one	Empty*	3	0	0
	Breeding	8	10	9
	Non-breeding	2	6	6
	Total	13	16	15
Palmers Track grid one	Empty*	2	0	0
	Breeding	8	14	13
	Non-breeding	3	4	9
	Total	13	18	22
South fork grid one	Empty*	1	1	0
	Breeding	5	12	11
	Non-breeding	3	1	3
	Total	9	14	14
Annual totals		35	48	51

* These burrows have been used in previous seasons for breeding, but have no activity this year. This data is included in breeding success estimates if the burrow corresponds to one of the 100 study burrows.

A. Kauri Dam grid one (KDG1)

↓ N	81	67	KT9 68
		80	71
	79		KT1 72
	77	76	75 78 74 73

B. Palmers Track grid one (PTG1)

63 ↗ N			PT19 32
PT29 62	96 PT25	61 PT22	PT17 PT26 PT27
	PT2	60	55
PT24 59	58	57	
64	PT11	56	

C. South Fork Track grid one (SFG1)

↓ N			SF23
			88
	86		87
	SF22	SF6	
SF9 85			
SF21		SF16/17 SF18	89 91
	92		90

During January and February, 73 of the 100 study burrows contained breeding black petrels and 24 were used by non-breeding birds. Three burrows were empty. After the final monitoring check (25 February), there were 60 chicks and one egg remaining. In April this egg was found to be infertile. There had been 13 failures (Table 2). In April, 60 chicks were present. This corresponds to a breeding success of 82% (Table 2).

There were 169 adults present in the study burrows with 147 already banded and 22 banded this season. Thirty-seven other adults were caught, with 13 in the census grids (one of those already banded) and 24 in new (non-study) burrows around the summit area (Appendix 1, 2, and 3). The average weight of all adults combined was 734 g; of all breeding adults was 753 g; and of non-breeding adults was 677 g (Table 3). From 1–4 April, 60 chicks present in the study burrows were also banded. Twenty-four other chicks present in non-study burrows around the summit area were also banded.

TABLE 2. BREEDING SUCCESS AND CAUSES OF MORTALITY.

	1996/97	1997/98
Number of burrows	100	100
Eggs—laid	84	73
—rat predation	7	1
—crushed/pushed out (fight)	5	0
—abandoned	2	1
—infertile	6	3
—dead embryo (various stages)	0	7
Chick—hatched	64	61
—died from disease (suspected avian pox)	1	0
—died from starvation	0	1
—fledged*	63	60
Overall breeding success (%)	75%	82%

* All chicks still present at the end April trip. It is assumed all will fledge safely.

Figure 2. Location of burrows found in each of the three grid sites.

TABLE 3. AVERAGE WEIGHT (g) OF BREEDING AND NON-BREEDING ADULTS.

	1995/96	1996/97	1997/98
Breeding adult	762.7	775.1	752.5
Non-breeding adult	688.0	683.5	676.7
All adults combined	728.3	755.8	734.1

Extrapolating from the three census grids, to the 30-hectare area around the summit area of Mount Hobson, the black petrel population is estimated at 5250 birds (Table 4). This is made up of 2062.5 breeding pairs (i.e. 4125 birds) and 1125 non-breeding birds.

Extrapolating from the census grids (using the data in Table 1), the 'useable' burrow density was 110 burrows/ha. Of these, 68.75 burrows/ha were used for breeding, 37.5 burrows/ha by non-breeding birds and 4.2 burrows/ha were empty or potential burrows. This relates to a ratio of 1:1.8 for non-breeding to breeding burrows and 1:25 ratio of empty/potential to occupied burrows.

Three rat index lines were completed in February. The rat index figures are shown in Table 5. The rat index figures were calculated using the equations in Cunningham and Moors (1993). In total 28 rats (both *Rattus rattus* (all colour morphs) and *R. exulans*) were caught (Appendix 4 and Table 5). In addition to the index line captures, 20 rats (15 *R. rattus* and five *R. exulans*) were caught around the hut over seven nights (Appendix 5).

TABLE 4. POPULATION ESTIMATE OF BLACK PETRELS AROUND THE HIRAKIMATA AREA.

	DENSITY (NUMBER/ha)		TOTAL HABITAT SIZE (ha)	POPULATION ESTIMATE	
	BREEDING PAIRS	NON-BREEDING BIRDS		BREEDING PAIRS	NON-BREEDING BIRDS
1995/96 Total 1995/96 Grand total (Breeders and non-breeders) = 3125 individuals	131.25	50	30	1312.5	500
1996/97 Total 1996/97 Grand total (Breeders and non-breeders) = 5187.5 individuals (5188)	225	68.75	30	2250	687.5
1997/98 Kauri Dam	56.25	37.5	10	562.5	375
1997/98 Palmers Track	81.25	56.25	10	812.5	562.5
1997/98 South Fork	68.75	18.75	10	687.5	187.5
1997/98 Total 1997/98 Grand total (Breeders and non-breeders) = 5250 individuals	206.25	112.5	30	2062.5	1125

In February, a cat-killed corpse of a Cook's petrel (*Pterodroma cookii*) was found near the Lower Kauri Dam. Black petrels are known to breed in burrows around the area where the corpse was found, but in lower numbers than at the summit. No cat sign was found around the summit area. Pig sign was also not seen this year.

The general public visit Mount Hobson regularly over the black petrel breeding season. Unfortunately, at some period in December or January the Department of Conservation (DOC) track counter was stolen from the summit and as a result there has been no data for visitor numbers to the area for this breeding season. However, using personal observation and DOC advice, we estimate similar numbers to previous years—approximately 200 visitors during January and February and at least 500 over March and April. As usual, the petrels did not appear to be disturbed by the high numbers of visitors, even those with burrows directly adjacent to the track.

TABLE 5. RAT INDEX LINE DATA.

SITE (DATES SET)	NO. OF RATS CAUGHT	NO. OF TRAPS SPRUNG	TOTAL TRAP NIGHTS	'LOST' TRAP NIGHTS	CORRECTED TRAP NIGHTS	RAT INDEX
South Fork Track (5-7/2/98)	9	14	150	11.5	138.5	6.5 rats/100 trap nights
Palmer's Track (8-10/2/98)	13	21	150	17	133	9.8 rats/100 trap nights
Kauri Dam Track (16-18/2/98)	6	8	150	7	143	4.2 rats/100 trap nights
February total	28	43	450	35.5	414.5	6.8 rats/100 trap nights

5. Discussion

As in two previous black petrel breeding seasons, the three census areas established in 1996 (Bell & Sim 1998a) were monitored (Table 1). In 1997/98, there were 51 burrows within the grids (33 breeding and 18 non-breeding). This is two more burrows in total than last season with four new burrows being identified in Palmers Track grid, one new burrow (and two burrows with separate entrances connecting into only one breeding chamber) in South Fork grid and one burrow collapsing in Kauri Dam grid. The number of burrows within the various grid sites will only change slightly each year as new birds return to their natal area and start to excavate new burrows, or burrows collapse and become unusable.

In the 1996/97 season, there were six potential burrows. ('Potential' burrows are those that have been investigated, or preliminarily dug out by black petrels, but are not ready to be used for breeding.) During the 1997/98 season, four of these were now being used by breeding or non-breeding birds. There are still three other potential burrows in the census grids (one in each grid). Extrapolating from the census grids to the Mount Hobson summit area (30 ha) gives a population estimate of the Great Barrier Island black petrels of 5250 birds: 2062.5 breeding pairs (4125 birds), and 1125 non-breeding birds.

This season and last season had a higher ratio of burrows that were occupied. Imber (1987) and Scofield (1989) both found ratios of about 1:1 empty to occupied burrows. For the 1997/98 season, the ratio is 1:25. This ratio is much higher than the previous season (1:7); this is due to the fact that there were only three unoccupied potential burrows within the grids this season compared to seven last season. This occupation rate is probably due to a higher number of returning birds in the 1997/98 breeding season. The ratio of non-breeding burrows to breeding burrows was 1:2, which is slightly higher compared to 1:1 from both Imber (1987) and Scofield (1989), but lower than last season (1:3).

The 100 study burrows selected for long-term study during the 1996/97 breeding season (Bell & Sim 1998b) were intensively monitored this season. Seventy-three of these burrows were used for breeding, 24 used by non-breeding birds and 3 were empty. One egg was predated by rats (1.3%), one egg was abandoned (1.3%), three eggs were infertile (4.1%), seven embryos died at various stages within the egg (9.6%) and one chick died of starvation (1.3%). This means an overall breeding success of 82% compared to 50% in 1977, 60% in 1978 (Imber 1987) or 62% in 1988/89 (Scofield 1989). This breeding success rate is also slightly higher than the previous season (75%). Each breeding season has had very different mortality factors. The 1996/97 season was predominately affected by rat predation whilst this season it was death of embryos within the egg. Five of these embryos were at the pipping stage and the deaths may have been caused by the high temperatures during February and March. The weather during this 1997/98 season was very hot and dry for most of March when chicks are beginning to pip. Chicks are very vulnerable to changes in humidity and temperature, and are affected by loss of water at the pipping stage (Warham 1990). Several adults were noted panting in the burrows and later in the season

this behaviour was also noted with some chicks (pers. obs.). Despite the range of mortality factors, the 1997/98 season appears to have been a good breeding season.

Observation and irregular trapping during the two earlier breeding seasons identified high numbers of rats around the summit area. Although rat predation this season was low (1.3%), it was 8% in the 1996/97 season and 3% in the 1995/96 season. Imber (1987) and Scofield (1989) also recorded rat predation during their studies. As rat predation can be an important mortality factor, we estimated the density of rats around the summit area. The 1997/98 season was the first time rat index lines were run around the summit since Scofield (1989) completed them. The average density was 6.8 rats/100 trap nights, which was higher than Scofield's (1989) rat index of 1 rat/98 trap nights. Most of the rat predation recorded during all three seasons was generally in the Palmers Track census grid or in those study burrows along Palmers Track, or around the summit (pers. obs.; Bell & Sim 1998a, 1998b).

In total, 206 adult black petrels were found around the summit area this season. Of these, 169 were found in the study burrows, with 147 birds already banded. Another 13 adults were found in the census grids (one already banded) and 23 adults (three already banded) were located in new non-study burrows around the summit area. Most adults were weighed. The average adult weight (of all adults combined) was 734 g (compared to 770 g from Scofield 1989). The average weight for a breeding adult was 753 g compared to 677 g for a non-breeding bird and this difference is due to physical requirements for incubation, and chick feeding. Sixty chicks from the study burrows, 3 from within the census grids and 21 from non-study burrows around the summit area were banded.

Neither feral cats nor cat sign was seen around the summit area this season. In February a Cook's petrel corpse, which had been predated by a feral cat, was found near the Lower Kauri Dam. Black petrels nest in the area and are at risk from any feral cat. Juvenile black petrels are most vulnerable when they leave the burrows to strengthen wings. No cat trapping was done this season by DOC or the local branch of the Royal Forest and Bird Society.

As in both the previous breeding seasons, many people visited the Mount Hobson black petrel breeding area. This had little, to no, impact on the breeding success. The construction of raised walkways around the summit has decreased damage to the environment and to the burrows. Extra walkway construction is recommended, particularly on Palmers (Windy Canyon) and Kauri Dam Tracks where erosion has increased along the tracks. Another important development for Great Barrier Island would be if more interpretative material could be placed around the summit area (perhaps sited on the summit platform). This would educate the visitors about the unique habitat of the black petrels, and discourage the littering or fouling of the area.

During this season, in study burrow 15, only one parent was identified (out of a known pair, both were identified in the 1996/97 season). This parent incubated the egg, hatched the chick, and guarded it for 18 continuous days before having to leave it alone to go feeding. Its partner never returned, and the chick died of starvation after the original parent did not return in time to feed it. A few days later, a bird did return to the burrow, but did not stay overnight and so could

not be identified (it was assumed to be the original parent returning too late to feed the chick). The missing parent could have died at sea, been caught by a fishing vessel, or been away for much longer than normal while hunting for food. It is very important to monitor this burrow during the next breeding season to determine whether the remaining parent has a new partner, or whether the old partner returns.

The domestic long-line industry operates during the black petrel breeding season and despite observer data being limited, three unbanded black petrel have been caught in this season's domestic long-line fishing season (Ian West DOC, pers. comm.). In previous incidents over the last several years at least 15 black petrels have been killed by the long-line fishing industry (Ian West pers. comm.; Sandy Bartle pers. comm.). Any adult black petrels caught on long lines from February to June could be foraging food for chicks. The loss of an adult would result in the starvation of the chick. Overall this could affect the entire population greatly by reducing recruitment and productivity. Like most procellariiforms, black petrels have delayed maturity, low reproduction rates and high adult survivorship, and any change, however small, in adult survivorship is likely to affect the population (Murray et al. 1993). If large numbers of breeding adults continue to get caught on long-lines, this species could be drastically affected. It is important to continue the study of the black petrel population, especially in relation to adult survivorship, mortality, productivity, and breeding success. These factors will help to determine the overall effects of by-catch in the long-line fishing industry.

6. Recommendations

The authors recommend:

- Continued monitoring of the black petrel population (using the long-term study burrows) on Great Barrier Island for at least five further breeding seasons.

This will ensure sufficient data will be collected for determining the population dynamics of black petrels, in particular survivorship, mortality and breeding success, and for determining the effects of predation, long-line fishing and other environmental factors.

- Visiting the Great Barrier Island breeding population for two weeks during October/November to monitor pair bonding and pre-breeding behaviour.

This would allow a large number of adults to be banded as the birds are generally outside burrows at this time. This could be established as a mark-recapture programme to determine a better population estimate.

- The January/February study session to remain five weeks, as this gives a clearer picture of breeding behaviour and results; the April period to remain one week.
- Continuing to run rat index lines. This will ensure total rat densities will be collected and can be related to effects on petrel mortality.

- Continuation of the walkway system down Palmers (Windy Canyon) and Kauri Dam Track. Construction should be completed between July and October when the chicks have fledged and before the adults return. Known petrel burrows could be identified for the construction team to avoid.

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Appendix 1

RESULTS FROM THE 100 STUDY BURROWS

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
1	H31176 —	680g —	Non-breeder
2	H27516 —	690g —	Non-breeder
3	H31267 H31109	640g 840g	Chick, 680g H31370
4	H27542 H31234	760g 850g	Infertile egg
5	H31020 H31161	730g 640g	Non-breeder
6	H31269 H31216	860g 710g	Infertile egg
7	H31272 H30854	765g 850g	Chick, 1100g H31070
8	H31103 H31273	710g 850g	Chick, 1040g H31071
9	H31275 H31145	710g 760g	Chick, 1080g H31076
10	— —	— —	Empty
11	H31277 H31294	690g 800g	Chick, 1180g H31079
12	H31171 H31279	660g 915g	Chick, 670g H31082
13	H31281 —	670g —	Non-breeder
14	H31284 —	720g —	Chick, 1210g H31092
15	H31287 —	780g —	Starvation of chick
16	H31004 H31296	710g 715g	Chick, 950g H31358
17	H31297 H31108	765g 835g	Dead Embryo
18	H31204 —	620g —	Chick, 700g H31094
19	H31162 H31208	900g 790g	Chick, 520g H31353

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
20	— —	— —	Non-breeder
21	H31235 H31019	690g 630	Chick, 1140g H31357
22	— —	— —	Non-breeder
23	H31232 H23024	830g 770g	Chick, 600g H31388
24	H31242 H31215	— 760g	Dead embryo
25	H31166 H31217	810g 770g	Chick, 1110g H31351
26	H23014 H31218	880g 660	Chick, 1110g H31099
27	H31146 H31222	760g 870g	Chick, 760g H31064
28	H31231 H31114	760g 870g	Chick, 840g H31080
29	H30859 H28204	600g 890g	Chick, 1280g H31371
30	H31236 H31149	790g 730g	Chick, 650g H31399
31	H31101 H31237	780g 820g	Infertile
32	H31011 —	700g —	Non-breeder
33	H31123 H31244	620g 660g	Chick, 1000g H31354
34	H31248 H31121	780g 730g	Chick, 670g H31354
35	H31249 H13641	760g 760g	Chick, 1060g H31374
36	H31129 H31106	880g 680g	Chick, 1010g H31395
37	H31017 H31107	710g 690g	Non-breeder
38	H31024 —	670g —	Non-breeder

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
39	H31039 —	640g —	Non-breeder
40	H31111 H31122	— —	Chick, 1040g H31088
41	H31029 —	660g —	Chick, 1120g H31097
42	H31115 H31140	870g 655g	Chick, 1060g H31081
43	H31016 —	710g —	Non-breeder
44	H31130 H31139	680g 610g	Chick, 1200g H31396
45	H31117 H31157	710g 780g	Dead embryo
46	H28813 H31002	650g 680g	Non-breeder
47	H31005 H31018	640g 655g	Non-breeder
48	H31003 H26991	630g 710g	Chick, 960g H31359
49	H31243 H31010	640g 705g	Non-breeder
50	H31256 H31282	705g 940g	Chick, 1000g H31360
51	H31290 H31291	800g 860g	Rat predation
52	H31289 H31255	850g 670g	Chick, 1280g H31100
53	H31021 H31022	595g 700g	Non-breeder
54	— —	— —	Empty
55	H31041 —	660g —	Chick, 1160g H31361
56	H31151 H31152	650g 680g	Chick, 1080g H31363
57	H31136 H31153	795 690	Chick, 1030g H31364
58	H31205 —	605g —	Non-breeder
59	H31125 H31220	720g 840g	Chick, 1080g H31365
60	H28584 H31246	810g 640g	Chick, 1020g H31367

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
61	H31113 H30878	760g 850g	Chick, 1140g H31369
62	H31257 H31288	930g 755g	Dead embryo
63	H31247 H31206	640g 810g	Chick, 650g H31368
64	H31286 H30861	695 690	Chick, 1000g H31366
65	H27535 H27548	680g 890g	Dead embryo
66	H31182 H31250	870g 660g	Dead embryo
67	H31270 —	580g —	Chick, 1020g H31062
68	H31154 H30866	— 870g	Chick, 860g H31063
69	H31240 H27604	770g 880g	Chick, 950g H31065
70	H31292 H27665	815g 880g	Chick, 1180g H31066
71	H31023 —	660g —	Non-breeder
72	H31293 H31155	790g 760g	Chick, 750g H31067
73	H28572 H31300	800g 780g	Chick, 1040 H31069
74	H31102 —	710g —	Chick, 870g H31072
75	H30867 H31147	745g 690g	Non-breeder
76	H31450 H31001	610g 690g	Non-breeder
77	H31274 H30870	560g 670g	Non-breeder
78	H31141 H31163	760g 920g	Chick, 680g H31068
79	H30857 H13618	710g 940g	Chick, 1220g H31073
80	H31104 —	705g —	Abandoned
81	H31030 H27666	640g 730g	Non-breeder
82	H31253 H30889	635g 690g	Chick, 1070g H31075

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
83	H31170	640g	Chick, 1110g H31077
	H31127	690g	
84	H31179	850g	Chick, 730g H31078
	H28551	830g	
85	H31213	780g	Chick, 1130 H31385
	H31118	820g	
86	H27678	785	Chick, 860g H31384
	H31259	—	
87	H31211	720g	Chick, 1180g H31382
	H31158	710g	
88	H31295	780g	Dead embryo
	H31212	840g	
89	H31233	630g	Chick, 1030g H31381
	H30910	690g	
90	H31280	800g	Chick, 940g H31380
	H31260	730g	
91	H31160	710g	Chick, 1180g H31378
	H31159	680g	
92	H31261	685g	Chick, 1120g H31377
	H31119	730g	

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
93	H30856	780g	Chick, 890g H31372
	H27552	780g	
94	H23018	680g	Non-breeder H31028
	H31028	630g	
95	—	—	Non-breeder —
	—	—	
96	H31033	735g	Non-breeder H31034 H31051
	H31034	710g	
	H31051	680g	
97	H30872	570g	Chick, 1260g H31091
	—	—	
98	H31283	790g	Chick, 910g H31376
	H30890	—	
99	H31262	745g	Chick, 1000g H31087
	H31201	680g	
100	—	—	Empty —
	—	—	

Appendix 2

RESULTS FROM THE BURROWS NOT LISTED IN APPENDIX 1

AREA	ADULT		OUTCOME	
	BAND	WEIGHT		
Kauri Dam Grid	KT1	—	Non-breeder	
	KT9	—	Non-breeder	
	KT18	—	Potential	
Palmers Track Grid	PT2	H31053	Chick (out of reach)	
	PT11	H31032	Non-breeder	
	PT17	—	Chick (out of reach)	
	PT19	—	Non breeder (out of reach)	
	PT22	—	Non-breeder (out of reach)	
	PT24	H31050	715g	Non-breeder
		H31056	—	
	PT25	H31057	—	Chick (out of reach)
	PT27	H23635	920g	Chick
		H31042	720g	H31262
PT28	—	—	Non-breeder	
PT29	—	—	Potential	
South Fork Grid	SF6	—	Non-breeder	
	SF9	H31025	930g	Chick
		H31036	700g	H31386
	SF16/17	H31007	660g	Non-breeder
		H31008	700g	
	SF18	—	—	Potential
	SF21	—	—	Chick (out of reach)
	SF22	—	—	Chick (out of reach)
SF23	H31006	770g	Chick	
	H31026	800g	H31383	

BURROW NO.	STUDY BURROW*
KT2	68
KT5	79
KT6	80
KT8	67
KT10	76
KT11	77
KT12	72
KT13	74
KT15	75
KT16	78
KT24	81
KT25	71
The following burrow numbers were not used: KT3, 4, 6, 14, 17, 20, 21, 22 and 23	
PT1	61
PT4	62
PT5	63
PT8	55
PT9	56
PT10	64
PT15	59
PT16	60
PT18	32
PT20	58
PT21	57
PT23	96
The following burrow numbers were not used: PT3, 6, 7, 12, 13, 14, and 23	
SF7	85
SF8	86
SF10	92
SF12	91
SF13	90
SF14	89
SF19	88
SF20	87
The following burrow numbers were not used: SF1, 2, 3, 4, 5 and 11	

* See Appendix 1.

Appendix 3

RESULTS FROM THE EXTRA BURROWS AROUND THE MOUNT HOBSON SUMMIT AREA

LOCATION OF BURROW BURROW		ADULT		OUTCOME
		BAND	WEIGHT	
E1	Hirakimata Track (old alphabet burrow F)	H31038	760g	Non-breeder
E2	South Fork Track (old alphabet burrow Z)	H27728	720g	Non-breeder
E3	Shortcut Track (cliff, near Study 84)	H31254	—	Non-breeder
E4	Hirakimata Track (old alphabet burrow E)			Empty
E5	Summit Junction (old alphabet burrow I)			Chick (out of reach)
E6	South Fork Track (old alphabet burrow J)			Chick (out of reach)
E7	Palmers Track (old alphabet burrow N)			Chick, H31352
E8	Summit (old alphabet burrow T)			Contents not visible
E9	Summit Junction (old alphabet burrow Y)			Non-breeder
E10	Palmers Track (near Study 41)	H31055	—	Chick, H31098
E11	Shortcut Track (opposite Study 10)	H30877 H31037	720g 620g	Non-breeder
E12	Summit (near Study 3)	H31009	700g	Non-breeder
E13	Shortcut Track (near Study 9)	H31012 H31013	690g 650g	Non-breeder
E14	Hirakimata Track (near the top junction)	H31014 H31015	700g 650g	Non-breeder
E15	Palmers Track (near Study 6)	H31031	690g	Non-breeder
E16	Summit (opposite E8)	H31035	880g	Chick, H31356
E17	South Fork Track (near Shortcut Junction)	H31040	790g	Chick (out of reach)
E18	Palmers Track (past large rocks)	H31043	660g	Chick, H31083
E19	Palmers Track (past large rocks)	H31044	670g	Chick, H31084
E20	Palmers Track (past large rocks)	H31045	610g	Chick, H31085
E21	Palmers Track (past large rocks)	H31046	640g	Chick, H31086
E22	Palmers Track (past large rocks)	H31047	660g	Non-breeder
E23	Palmers Track (past large rocks)	H31048	715g	Non-breeder
E24	Shortcut Track (next to Study 10)	H31052	690g	Non-breeder
E25	South Fork Track (near Shortcut Junction)	H31054	730g	Chick, H31387
E26	South Fork Track (down past steep section)	H31058	670g	Chick, H31397
E27	South Fork Track (at base of steep section)	H31060	735	Non-breeder
E28	Kauri Dam Track (opposite Study 65)			Chick, H31074
E29	Kauri Dam Track (near Study 7)			Dead embryo
E30	Palmers Track (opposite Study 40)			Chick, H31089
E31	Shortcut Track (above Study 28)			Non-breeder

LOCATION OF BURROW BURROW		ADULT		OUTCOME
		BAND	WEIGHT	
E32	Shortcut Track (in log)			Chick (out of reach)
E33	Palmers Track (on boardwalk, in roots)			Chick (out of reach)
E34	Kauri Dam Track (near Study 68)			Non-breeder
E35	Summit (near Study 2)			Chick (out of reach)
E36	South Fork Track (at launch rock)			Chick, H31373
E37	Palmers Track (past Study 33)			Chick, H31095
E38	Palmers Track (near track, up from 98)			Chick, H31093
E39	Summit (crawling cave, near 13)			Chick, H31355
E40	South Fork Track (at steep bit, next to E26)			Chick, H31398
E41	South Fork Track (beyond steep section)			Chick, H31389
E42	South Fork Track (beyond steep section)	—	—	Chick, H31390
E43	South Fork Track (beyond steep section)	—	—	Chick, H31391
E44	South Fork Track (beyond steep section)	—	—	Chick, H31392
E45	South Fork Track (beyond steep section)	—	—	Chick, H31393

Appendix 4

RESULTS FROM THE RAT INDEX LINES

DATE (NIGHT OF)	LOCATION	TRAP NO.	SPECIES	WEIGHT (g)	NOTES
5/2/98	South Forks	1a	<i>Rattus exulans</i>	98	male
5/2/98	South Forks	1b	<i>R. exulans</i>	91	male
5/2/98	South Forks	10a	<i>R. rattus frugivorous</i>	142	female
5/2/98	South Forks	10b	<i>R. r. alexandrinus</i>	131	male
5/2/98	South Forks	16a	<i>R. r. alexandrinus</i>	164	male
5/2/98	South Forks	19c	<i>R. r. rattus</i>	157	male
6/2/98	South Forks	1b	<i>R. exulans</i>	79	female
6/2/98	South Forks	9b	<i>R. exulans</i>	73	female
7/2/98	South Forks	19b	<i>R. exulans</i>	83	female
8/2/98	Palmer's	11b	<i>R. r. frugivorous</i>	192	female
8/2/98	Palmer's	17b	<i>R. r. alexandrinus</i>	183	female
8/2/98	Palmer's	24a	<i>R. r. alexandrinus</i>	38	male
8/2/98	Palmer's	25a	<i>R. r. frugivorous</i>	40	male
8/2/98	Palmer's	25b	<i>R. r. alexandrinus</i>	33	male (3 legs)
9/2/98	Palmer's	5a	<i>R. exulans</i>		half eaten, unknown sex, no weight
9/2/98	Palmer's	6b	<i>R. r. frugivorous</i>	30	
9/2/98	Palmer's	7a	<i>R. exulans</i>	47	female
10/2/98	Palmer's	5a	<i>R. r. rattus</i>	30	female, wet weight
10/2/98	Palmer's	14b	<i>R. r. frugivorous</i>	122	female, wet weight
10/2/98	Palmer's	15a	<i>R. r. rattus</i>	49	female, wet weight
10/2/98	Palmer's	15b	<i>R. r. frugivorous</i>	210	male, wet weight
10/2/98	Palmer's	17a	<i>R. r. frugivorous</i>	56	male, wet weight
16/2/98	Kauri Dam	1a	<i>R. exulans</i>	88	male
16/2/98	Kauri Dam	9b	<i>R. r. frugivorous</i>	158	male
18/2/98	Kauri Dam	1b	<i>R. r. alexandrinus</i>	67	male
18/2/98	Kauri Dam	5a	<i>R. exulans</i>	14	male
18/2/98	Kauri Dam	5b	<i>R. exulans</i>	14	male
18/2/98	Kauri Dam	24a	<i>R. r. frugivorous</i>	165	female, possibly pregnant

Appendix 5

RESULTS FROM RAT TRAPS SET AROUND THE HUT

DATE (NIGHT OF)	SPECIES	WEIGHT (g)	NOTES
29/1/98	<i>Rattus rattus frugivorus</i>		male, caught during the day
29/1/98	<i>R. exulans</i>	100	male, caught during the day
30/1/98	<i>R. r. frugivorus</i>	185	male
30/1/98	<i>R. r. frugivorus</i>	158	male
30/1/98	<i>R. r. alexandrinus</i>	164	male
30/1/98	<i>R. r. alexandrinus</i>	164	male
30/1/98	<i>R. r. frugivorus</i>	212	male
30/1/98	<i>R. exulans</i>	84	female
31/1/98	<i>R. exulans</i>	89	male
31/1/98	<i>R. exulans</i>	28	male
1/2/98	<i>R. exulans</i>	98	male
18/2/98	<i>R. r. frugivorus</i>	30	male
18/2/98	<i>R. r. frugivorus</i>	27	male
18/2/98	<i>R. r. frugivorus</i>	26	female
18/2/98	<i>R. r. frugivorus</i>	29	female
18/2/98	<i>R. r. frugivorus</i>	29	female
18/2/98	<i>R. r. frugivorus</i>	30	female
20/2/98	<i>R. r. frugivorus</i>	91	female
20/2/98	<i>R. r. frugivorus</i>	118	male
21/2/98	<i>R. r. rattus</i>	153	male