

Survey and monitoring of black petrels on Great Barrier Island, 1999/2000

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Survey and monitoring of black petrels on Great Barrier Island, 1999/2000

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ABSTRACT

The black petrel (*Procellaria parkinsoni*) is an endemic seabird, which breeds on Little and Great Barrier Islands, New Zealand. The main breeding area on Great Barrier Island is around the highest point, Mount Hobson. During the 1999/2000 breeding season, 250 burrows were identified and were intensively monitored over summer. Only 248 were study burrows and of these 178 were used by breeding pairs, 54 by non-breeding adults and the remaining 16 burrows were empty. A range of factors affecting the black petrel breeding success were noted and in April 131 chicks were present in the study burrows, which meant a breeding success of 73.5%. In addition to monitoring the six census grids already set up around the summit area in previous seasons, three final census grids were established, one in each of the original areas. A total of 117 burrows were located within the nine grids and of these, 80 burrows were being used for breeding. The number of burrows used for breeding within the study grids has increased in all grids that have been monitored for more than one year. Extrapolating from these grid burrows estimates the black petrel population around the peak of Mount Hobson to consist of 3917 birds. A chick banded in the 1995/96 season was recaptured this season suggesting that the age of first return to the natal colony is four years.

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

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1. Introduction

Black petrels, formerly found around North Island and north-western South Island ranges, are now restricted to Little Barrier and Great Barrier Islands. It is a vulnerable, endemic seabird that is the smallest of their genus (Imber 1987). On Great Barrier Island, black petrels breed in burrows generally found in forested areas above 300 m. The main breeding area is around the summit of Mount Hobson (Imber 1987; Scofield 1989). Breeding success of the black petrel is affected by rat and cat predation, with possible impact by the long-line fishing industry.

This monitoring work carried out during the 1999/2000 breeding season is a continuation of the survey and monitoring study begun in 1995/96 (Bell & Sim 1998a, 1998b). Data collected during this monitoring study will be used to determine the population dynamics of the Great Barrier Island population. Continued monitoring will determine any effects that long-line fishing, rat and cat predation and habitat disturbance may have on the overall population. It will also enable a more accurate population estimate to be calculated and ensure that any population changes will be detected in time to implement the appropriate management strategies.

2. Objectives

The main objective of this study is to undertake a census of the black petrel population on Great Barrier Island via burrow monitoring and the banding of adults and fledglings to establish adult mortality, breeding success, and recruitment. As this study is a continuation from previous breeding seasons, it will also provide more data to establish current population trends, and will assist in determining causes and timing of mortality.

In summary, the objectives of the study are:

- To monitor a sample of black petrel burrows within the main breeding area. Band all adults present in the burrows during January and February and all remaining fledgling chicks during the April visit.
- To determine breeding success in the sample of long-term study burrows. Causes of breeding failure, such as predation or disappearance of parents are to be noted.
- To establish the final three replicate census grids (40 × 40 m, one in each of the three environmental strata types). Band as many breeding and non-breeding birds as possible.
- To monitor the six census grids established in the 1995/96 and 1998/99 seasons. Band and recapture as many breeding and non-breeding birds present as possible.
- To determine a population estimate by extrapolating from the grid areas to the main Mount Hobson breeding area.
- To search other areas thought to be suitable for black petrel breeding.

3. Methods

The three census grids set up around Hirakimata during the 1995/96 season (Bell & Sim 1998a) and the 1998/99 season (Bell & Sim 2000b) were re-surveyed to locate any new burrows and to determine this season's occupancy (Figs 1, 2, 3, and 4). A further three census grids were established this breeding season, in close proximity to the other grids, for greater representation of each study site.

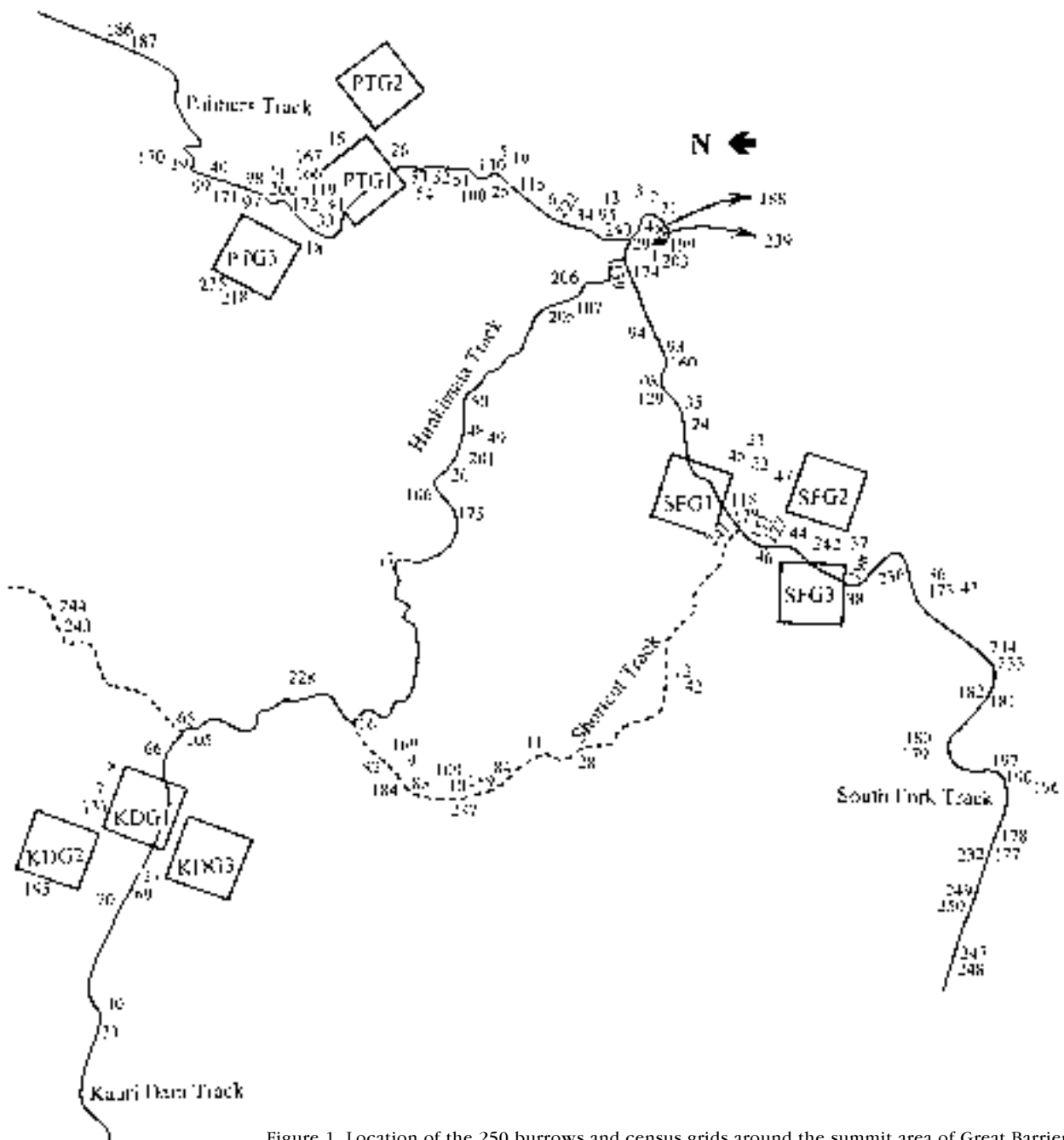
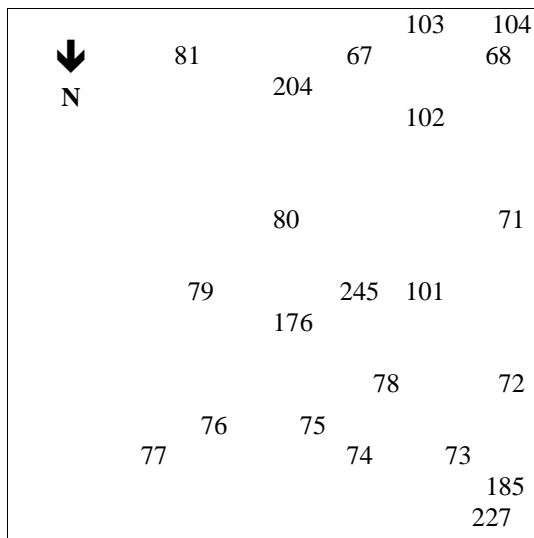


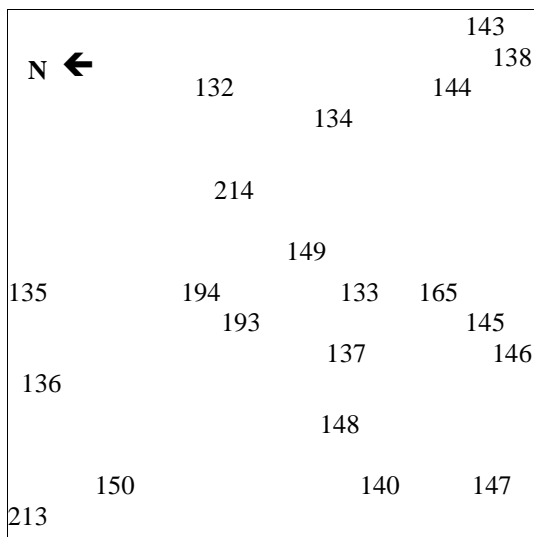
Figure 1. Location of the 250 burrows and census grids around the summit area of Great Barrier Island. Note Figs 2, 3, and 4 show the burrow numbers within each of the nine census grids.

Figure 2. Location of burrows found in the Kauri Dam grid sites (each grid is 40 × 40 m).

Kauri Dam grid one (KDG1)



Kauri Dam grid two (KDG2)



Kauri Dam grid three (KDG3)

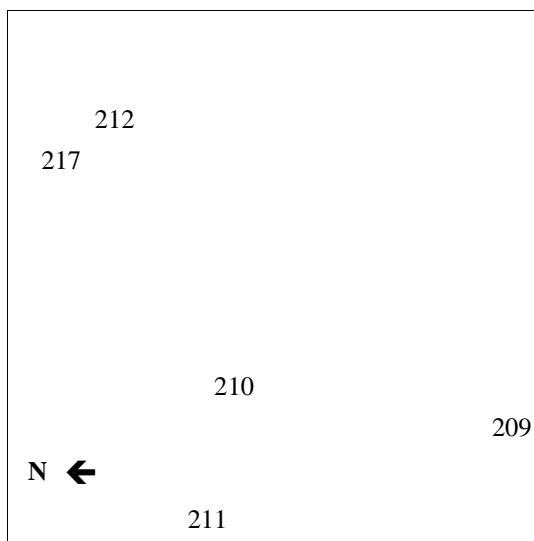


Figure 3. Location of burrows found in the Palmers Track grid sites (each grid is 40 × 40 m).

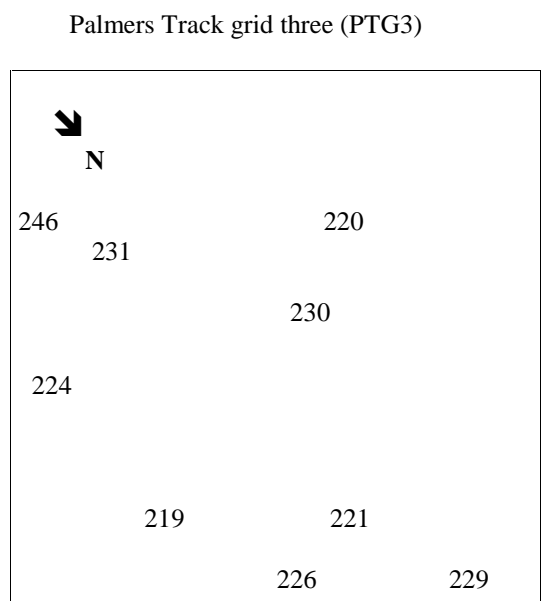
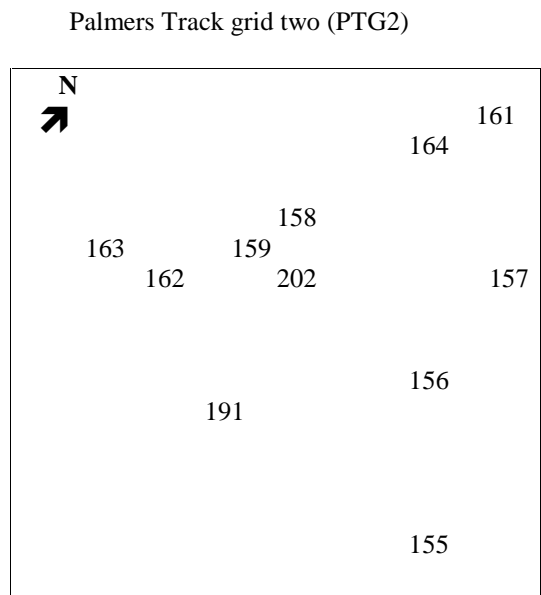
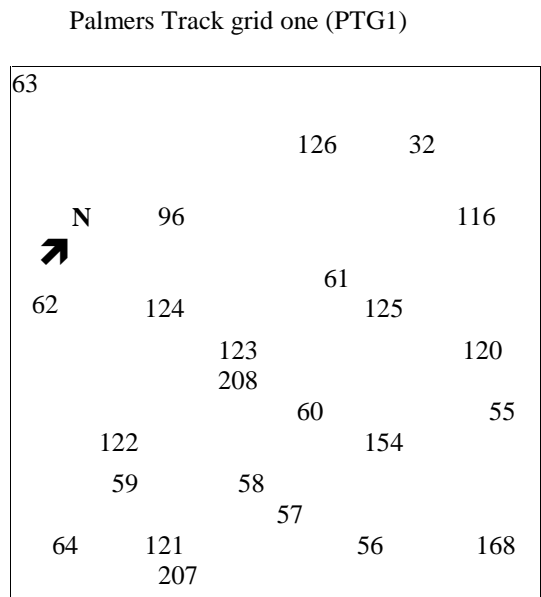
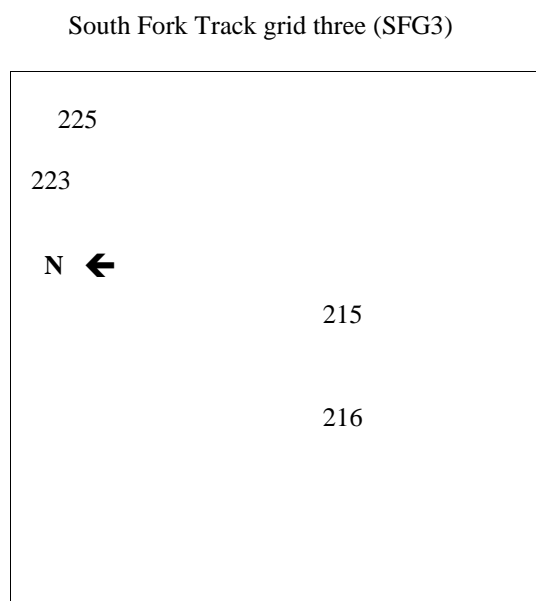
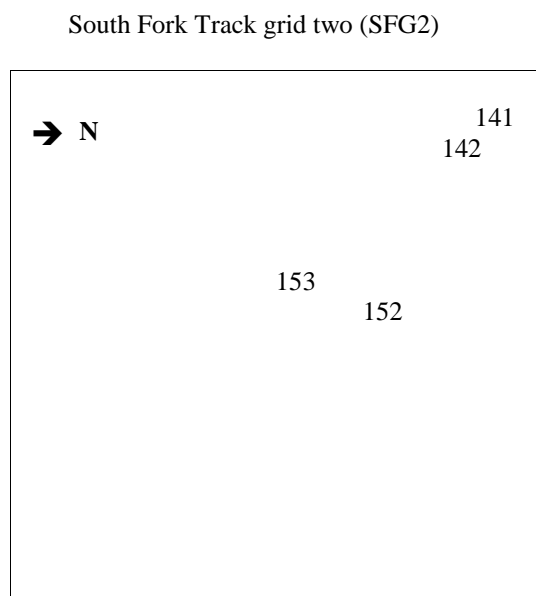
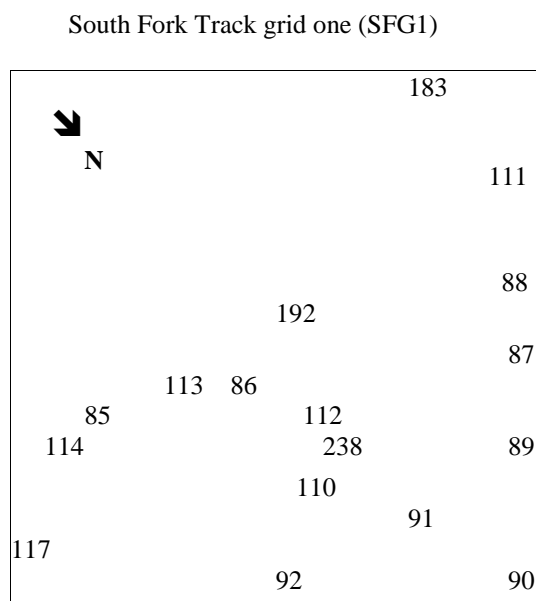


Figure 4. Location of burrows found in the South Fork grid sites (each grid is 40 × 40 m).



During the first monitoring visit (from 17 January to 23 February), the number of study burrows was increased from the 118 (in the 1996/97 season, Bell & Sim 1998a) to 248 (Figs 1, 2, 3, and 4). To ensure accurate monitoring of the study burrows, they were either accessible through the main entrance or via an opening that has been excavated through the burrow roof into the chamber. This opening is covered by a piece of plywood, and soil and debris camouflage the cover.

Any adult present in the burrow was removed, banded, weighed, and returned to the burrow. Eggs or chicks were noted, if present, and the lack of eggs or chicks identified non-breeding birds. The study burrows were monitored again (10–14 April) and all remaining fledgling chicks were banded. This information was used to determine breeding success and added to the long-term population dynamics data.

During February, rat index lines were set up as directed in Cunningham & Moors (1993) covering the entire study area using the track system (Hirakimata, Shortcut, South Fork, and Palmers Tracks). Observations were also made on feral cat and rat predation, and pig rooting.

During the summer monitoring period, visits were made to two different areas to determine whether black petrels were still present. On 13 February Mount Matawhero was visited and a small area near the Kauri dam was surveyed. Between 23–25 February the summit Tataweka and surrounding area within the Te Paparahi Stewardship Area (or Northern Block) was also visited and preliminarily surveyed.

4. Results

4.1 NUMBER OF BURROWS IN THE CENSUS GRIDS

A total of 117 burrows were found in the nine census grids (Table 1, Figs 2, 3, and 4), and of these, 80 burrows were used by breeding pairs, 28 were used by non-breeding adults and nine burrows were empty.

Extrapolating from the grids, the ‘useable’ burrow density was 81 burrows/ha with 55.5 burrows/ha used for breeding, 19 burrows/ha for non-breeding and 6 empty burrows per hectare (Table 2). This relates to a ratio of 1:3 for non-breeding to breeding burrows and 1:12 ratio of empty to occupied burrows. There were also 20 ‘potential’ burrows within the grids, which are not included in any burrow estimate. We define ‘potential’ burrows as ones which have been investigated and/or preliminarily dug out, but not yet being used by breeding or non-breeding petrels.

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

BURROW TYPE	GRID ONE					GRID TWO		GRID THREE
	1995/96	1996/97	1997/98	1998/99	1999/2000	1998/99	1999/2000	1999/2000
Kauri Dam Grid								
Empty	1	1	1	1	3	0	0	2
Breeding	8	10	8	12	11	15	16	3
Non-breeding	5	5	7	6	8	4	5	0
TOTAL	14	16	16	19	22	19	21	5
Palmers Track Grid								
Empty	3	0	0	1	1	0	0	0
Breeding	7	13	13	15	18	10	9	9
Non-breeding	3	6	7	6	5	1	2	0
TOTAL	13	19	20	22	24	11	11	9
South Fork Grid								
Empty	2	1	1	0	1	1	1	1
Breeding	5	12	11	11	10	2	1	3
Non-breeding	2	1	3	5	6	1	2	0
TOTAL	9	14	15	16	17	4	4	4
Annual totals	36	49	51	57	63	34	36	18

TABLE 2. ESTIMATED BURROW DENSITY AROUND THE SUMMIT AREA.

BURROW TYPE	NUMBER OF BURROWS PER HECTARE				
	1995/96	1996/97	1997/98	1998/99	1999/2000
'Useable'	75	102	106	95	81
Breeding	42	73	67	68	55.5
Non-breeding	21	25	35	24	19
Empty	12.5	4	4	3	6

4.2 STUDY BURROWS

Within the 248 study burrows, 178 contained breeding birds, 54 contained non-breeding birds and 16 burrows were empty. There were 47 failures due to various factors (Table 3). In April, 131 chicks were present which corresponds to a breeding success of 73.5% (Table 3).

This season was the second occasion that a feral cat(s) predated black petrel chicks. Chicks from two study burrows were predated. One occurred at the same burrow (92) as last season. The remains of another black petrel chick were found on the disused Kauri dam track, but this chick was not from a study burrow in the area. There were also several predated corpses of Cook's petrel (*Pterodroma cookii*) found around the summit area. A tabby cat was seen near

TABLE 3. BREEDING SUCCESS AND CAUSES OF MORTALITY.

	1996/97	1997/98	1998/99	1999/2000
Number of study burrows*	118	137	197	248
Eggs - laid	92	95	142	178
- predation (rat)	6	1	2	9
- crushed [†]	5	0	1	10
- abandoned	2	1	5	1
- infertile	6	4	12	6
- dead embryo (at various stages)	0	8	6	13
Chicks - hatched	73	81	116	139
- predation (rat)	0	0	2	0
- predation (cat)	0	0	2	2
- died (disease)	1	0	0	0
- died (starvation)	0	1	0	0
- died (unknown causes)	0	0	3	6
- fledged [‡]	72	80	109	131
Overall breeding success (%)	78%	84%	77%	73.5%

* The aim has changed since the 1995/96 season. More burrows have been added to reach 250 study burrows.

[†] These eggs have been crushed by the parents or during fighting with interloping birds and only shell fragments were recovered from the burrow. Some may have been predated by rats, infertile or contained an embryo which died.

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

the Windy Canyon lookout by two different groups of tourists. A cat was heard in the study area, but trapping was not successful. Large cat scats were found in the area that included the burrows where predation occurred.

Both parents were identified in 152 of the breeding study burrows, 18 where only one parent was identified and eight burrows where no parents were identified (Table 4, Appendix 1). Of the non-breeding burrows, there were 30 burrows

TABLE 4. NUMBER OF STUDY BURROWS WITH IDENTIFIED BIRDS PRESENT.

NO. OF BREEDING BURROWS	YEAR				
	1995/96	1996/97	1997/98	1998/99	1999/2000
With no parents identified	32	13	12	20	8
With one parent identified	13	5	18	30	18
With both parents identified	4	79	67	92	152
NO. OF NON-BREEDING BURROWS	YEAR				
	1995/96	1996/97	1997/98	1998/99	1999/2000
With no birds identified	8	5	8	11	7
With one bird identified	7	11	16	10	17
With two birds identified	-	7	15	21	29
With three or more birds identified	-	2	1	2	1

where two or more birds were identified, 17 where one was identified and seven where no birds were present during the day, but the burrows were active at night (Appendix 1). The average weight of breeding adults was 756 g, non-breeding adults averaged 688 g and the average combined adult weight was 741 g.

4.3 BANDING DATA

There were 404 adults identified during the 1999/2000 season (Table 5). Of these, 398 were from the study burrows, with 255 already banded and 143 banded this season. One already banded bird was banded as a chick during the 1995/96 season. Six other adults were caught in non-study burrows around the summit area, Tataweka or Mount Matawhero. The 131 chicks present in the study burrows and one chick in a non-study burrow were also banded (Table 5).

TABLE 5. BANDING AND RECOVERY DATA FROM GREAT BARRIER ISLAND.

	YEAR				
	1995/96	1996/97	1997/98	1998/99	1999/2000
Number of recoveries of birds banded prior to 1995	16	30	23	22	28
Number of recoveries of birds banded in 1995/96	-	15	14	14	17
Number of recoveries of birds banded in 1996/97	-	-	113	102	101
Number of recoveries of birds banded in 1997/98	-	-	-	15	14
Number of recoveries of birds banded in 1998/99	-	-	-	-	95
Total recoveries	16	45	150	153	255
Number of new adults (banded that season)	41	180	60	129	149
Total adults	57	225	210	282	404
Number of chicks banded that season	59	69	84	117	132
Total number of birds banded	116	294	294	399	536
Band recoveries from dead birds	-	-	-	-	1

4.4 POPULATION ESTIMATE

Extrapolating from the census grid data, to the 30-hectare area around the summit area of Mount Hobson, the black petrel population is estimated at 3917 birds (Table 6). The preliminary surveys of Matawhero and Tataweka showed that black petrels do occur on other areas of Great Barrier Island, but in much lower densities than around Mount Hobson. Only one burrow (containing a male incubating a chick) was found on Tataweka and a small cluster (approximately 50 × 50 m) of 10–20 burrows was found in the Matawhero area.

TABLE 6. POPULATION ESTIMATE OF BLACK PETRELS AROUND THE HIRAKIMATA AREA.

YEAR	DENSITY (Number/ha)		TOTAL AREA 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)	41.67	20.83	30	1250 3125 individuals	625
1996/97 Total 1996/97 GRAND TOTAL (Breeders and non-breeders)	72.92	25	30	2187.5 5125 individuals	750
1997/98 Total 1997/98 GRAND TOTAL (Breeders and non-breeders)	66.67	35.42	30	2000 5063 individuals	1062.5
1998/99 Total 1998/99 GRAND TOTAL (Breeders and non-breeders)	67.71	23.96	30	2031.25 4781 individuals	718.75
1999/2000 POPULATION ESTIMATE					
Kauri Dam	20.83	9.03	30	624.9	270.9
Palmers Track	25	4.86		750	145.8
South Fork	9.72	5.56		291.6	166.8
1999/2000 Total	55.56	19.44		1666.5	583.5
1999/2000 GRAND TOTAL (Breeders and non-breeders)				3917 individuals	

4.5 RAT DATA

A rat index line was completed in February. The results are shown in Table 7 and were calculated using the formulas devised by Cunningham & Moors (1993). Twenty-two rats in total were caught and both *Rattus rattus* (all three colour morphs) and *R. exulans* were caught (Table 7, Appendix 2)

TABLE 7. RAT INDEX LINE DATA.

YEAR	NO. OF RATS CAUGHT	NO. OF TRAPS SPRUNG	TOTAL TRAP NIGHTS	'LOST' TRAP NIGHTS	CORRECTED TRAP NIGHTS	RAT INDEX
1997/98	28	43	450	35.5	414.5	6.75 rats/100 trap nights
1998/99	18	33	550	25.5	524.5	3.43 rats/100 trap nights
1999/2000	22	41	450	31.5	418.5	5.26 rats/100 trap nights

4.6 VISITOR NUMBERS

Although there was high numbers of visitors to Mount Hobson (631 during January and 358 in February and March), the petrels did not appear to be disturbed by this, even those with burrows directly adjacent to the track.

5. Discussion

The black petrel population on Great Barrier Island has been monitored since the 1995/96 breeding season (& Sim 1998a, 1998b, 2000a, 2000b).

5.1 CENSUS GRIDS

Three census grids were set up in 1995/96, 1998/99 and this season. All nine grids were intensively monitored during the latter part of the breeding season, from 17 January to 23 February. Eight new burrows were found in the original census grids and were occupied by non-breeding birds. Four of these burrows had been newly excavated by non-breeders this season, three were identified as potential burrows last season (but were not being used by black petrels at the time) and a burrow shared an entrance with another study burrow (the tunnel and chamber were directly opposite the other tunnel and chamber). As this study has continued, the number of burrows within some of the grids (KDG1, KDG2, PTG1 and SFG1) has risen slightly each year. It appears that pre-breeding and non-breeding birds are returning to their natal area and are starting to excavate new burrows. In some grids we have identified old burrows which have collapsed and become unusable.

As the local environment in each grid varies (trees falling, etc.) the number of optimum burrows sites changes annually as better sites for digging are uncovered. During the monitoring in this 1999/2000 breeding season there were 20 potential burrows identified within the 9 grids. Eleven were identified in earlier breeding seasons and were still not being used this year. The remaining nine burrows were newly identified this season (most of these were found in the three newly established grids).

A comparison of the 'old' and 'new' grids shows distinctly different numbers of burrows in some areas. Both KDG1 and KDG2 had 22 and 19 burrows respectively but KDG3 only has 5. KDG3 has a much steeper slope and more dense undergrowth than the other two grids. PTG1 has 24 burrows while PTG2 and PTG3 have 11 and 9 respectively. Both PTG2 and PTG3 also have large areas that have very dense vegetation. SFG1 has 17 burrows whereas both SFG2 and SFG3 only have 4 in each. Both SFG2 and SFG3 have steeper slopes, large boulders scattered throughout and dense or tangled vegetation. Although steeper areas are more suitable for available launch sites, the dense and tangled vegetation may be too difficult for the black petrel to manoeuvre through. The steeper terrain may also have less suitable areas for digging burrows (i.e. less earth). The three original grid sites straddle main ridges with good deep soil coverage and are directly adjacent to a known launch site. These grids have generally open ground cover with only a few areas of dense undergrowth.

As in all the previous years, the burrows were occupied at a much higher ratio than found in previous studies (1:12). Imber (1987) and Scofield (1989) both had ratios of about 1:1 empty to occupied burrows. This season's ratio of 1:12 is less than 1997/98 (1:25) and 1998/99 (1:31), but is higher than 1995/96 (1:1)

and 1996/77 (1:7). This is due to the increase in burrow numbers and to a higher number of empty burrows this year (compared to 1997/98 and 1998/99). This occupation rate is probably due to a large number of returning birds during the 1999/2000 breeding season.

The ratio of non-breeding burrows to breeding burrows was 1:3, which is identical to 1998/99 and 1996/97 seasons, but higher than 1995/96 (1:2), 1997/98 (1:2), Imber (1:1, 1987) and Scofield (1:1, 1989). This may be due to larger numbers of breeding birds this season (similarly in the 1996/97 and 1998/99 seasons) compared to 1995/96, 1997/98 and the Imber and Scofield seasons. With the exception of this season, the non-breeding to breeding burrow ratio has altered from 1:2 to 1:3 every two years.

5.2 STUDY BURROWS

A further 51 study burrows were added to the 197 previously identified during the 1996/97 and 1998/99 seasons (Bell & Sim 1998a, 1998b, 2000b). There were 47 breeding failures this season and this equates to an overall breeding success rate of 73.5%. This breeding success is lower than previous years—1996/97 (78%), 1997/98 (84%) and 1998/99 (77%). However, it is still a very successful breeding year despite higher rat and cat predation and more crushed eggs and dead embryos. The breeding success is higher than the earlier research by Imber (50% in 1977, 60% in 1978, see Imber 1987) and Scofield (62% in 1988/89, see Scofield 1989).

There were six infertile eggs and one abandoned egg this season, which is the lowest percentage recorded during this study. Like the 1998/99 season, several of the infertile eggs were located in burrows with 'new' partnerships (two were non-breeding birds last year and one pair abandoned their egg last year) that suggests they are younger, more inexperienced birds. Therefore some of these infertile egg occurrences may be due to one of the pair not being ready for breeding yet, or both birds 'practising' breeding. The number of crushed eggs, however, has increased to ten. Unless a dead embryo was recovered with the egg fragments, these failures were noted as 'crushed', so some of these crushed eggs may have been predated by rats or been infertile eggs that the parents have purposely destroyed after beginning to go rancid. There were also a large number of dead embryos (13, 7.3%). Some adults will continue to incubate the egg long after the embryo has died within the egg and begun to smell. Eventually these birds abandon the egg, which was recovered and opened by the authors to identify the reason for the failure.

5.3 RAT AND FERAL CAT PREDATION

Rats predated 5% of the eggs laid which is higher than the 1995/96, 1997/98 and 1998/99 seasons, but less than the 1996/97 season. This does not appear to relate to the rat densities in the summit area. The highest rat densities were noted in the 1997/98 season (6.75 rats/100 trap nights) when predation was only 1%, and when rat densities were the lowest (1998/99, 3.43 rats/100 trap

nights) the predation level was also 1%. Rat density has increased (5.56 rats/100 trap nights) compared to last season, as has the predation level (5%), but as the rat lines run through the same area as the census grids, but not completely through all nine grids, it is difficult to directly correlate the two factors. Rat densities may be higher in some areas such as Kauri Dam grid 2 where three (out of the nine) eggs were predated. Both Imber (1987) and Scofield (1989) also recorded rat predation during their studies; however rat densities were much lower (1 rat/98 trap nights) than those recorded during this study. Although the percentage of rat predation varies annually, it is still a major mortality factor and as such it is important to continue to monitor the density of rats in the study area.

This breeding season was the second occasion during this study that feral cats predated chicks from study burrows. The remains of both chicks were found approximately one to two metres from the burrow entrance. Each corpse had crushed bones and one of the skulls was missing which are classic indicators of a cat feeding. One predation occurred at the same burrow (92) as last season. This development suggests that a cat has 'learnt' where to obtain an easy meal. The other predation occurred in a burrow only 20 m away from burrow 92. Several large cat scats were found in the area. It is very important to trap for this cat (and any others) to prevent further predation of other birds in the area.

Most of the black petrel burrow entrances are too small for cats to gain access. (Passages are too narrow and long to reach the chamber.) Juvenile petrels become vulnerable to feral cat predation as soon as they leave the burrows to strengthen wings and practise flying (Warham 1996). With the number of black petrel chicks being predated by feral cats increasing over the past two years, it is imperative that trapping is carried out during the breeding season and, if possible, into the fledging period.

5.4 ADULTS

A total of 404 adult black petrels were identified this season. The average adult weight (of all adults combined) was 741 g (compared to 770 g from Scofield 1989). The average weight for a breeding adult was 756 g compared to 688 g for a non-breeding adult. This difference is due to differing physical requirements needed for incubation, and chick feeding. Since starting this study the difference in weight between breeding and non-breeding birds has been between 60 and 100 g.

With the exception of 1997/98, this season's average weight of breeding adults was lighter than all other seasons. There is only a difference of 11 grams (755–776 g) between all seasons, but it is interesting to note that weights are consistently heavy one year and lighter the next. Although this may be an artefact of the timing of weighing (i.e. stage of incubation and time since last feeding), it may have a bearing on the availability and quality of prey food each year. It is also interesting that the non-breeding birds do not have the same pattern. Weight decreased over the first three seasons and then increased in 1998/99 before dropping again this season. However, like the breeding birds, there is not much difference in non-breeder weights over all seasons—only 15

grams (679–694 g). Again this may depend on the timing of weighing, but it may also relate to the availability of food and overall condition of the birds.

During this season, in burrow 72, the female partner was noted incubating for over 20 days before abandoning the egg. This bird's partner never returned and by the time the first bird returned to continue incubation the embryo had died. The missing parent could have died at sea, been caught by a fishing vessel, been hung up in a tree or spent too long at sea foraging for food. It will be important to monitor this burrow during the next breeding season to see if the male returns or whether the female moves to another burrow to breed with a new mate.

5.5 CHICKS

There were 131 chicks still present in the study burrows in April. Similar to last year, four chicks were very small (ranging from 310 g to 570 g, compared to the average chick weight of approximately 1000 g). Two chicks were not very well-developed—still downy, with barely any feather development (only the wing feathers were beginning to pin), very thin and were quite lethargic (Burrows 84 and 174, Appendix 1). The poor condition of the chicks suggests either that only one parent is feeding them, or if both parents are still feeding, that the food quality (or quantity) has been reduced. Both chicks were banded, but it will be interesting to see if there is any evidence of the chicks next season. Last season two chicks in similar conditions appear to have fledged successfully as there is no trace of them in or around the burrow.

The other two chicks (Burrows 193 and 258) were also in poor condition, but not as dramatically as the chicks in burrows 174 and 84. These chicks were small, but only partially downy, and had a reasonable layer of body fat. One chick (Burrow 193) was hatched on the same day as a neighbouring chick (Burrow 194), but only weighed half as much. Perhaps the parents were having difficulty finding enough food, not bringing large quantities, or only one parent was feeding this chick. It is important to note that the condition of chicks has deteriorated over the past two seasons. The earlier seasons did not have chicks that were in such 'bad shape'. It would be useful to determine whether the adults are having problems locating adequate quantities of food, whether the quality was as good, or whether the birds were having to travel further to feed which reduces the number of feeds to the chicks.

5.6 POPULATION ESTIMATE

Extrapolating from the census grids to the Mount Hobson summit area (30 ha) gives the population estimate of the Great Barrier Island black petrels to be 3917 birds. This estimate is less than previous years and this is a direct result of increasing the number of census grids from three to nine. Replicating the grids gives a better idea of burrow density within each distinct area and, as a result, gives a more statistically sound population estimate for the entire study area.

This season Mount Matawhero was briefly visited, and a small group of burrows were noted. The density of burrows was much lower in this area than around the summit (pers. obs.). Generally the dense ground vegetation and low scrub canopy appeared to deter the birds from colonising much of the area. The small cluster of burrows were located within a small area of little to no ground cover in mature forest close to the old Kauri Dam. There were approximately 10 to 15 burrows. Four had chicks present, one had a parent (suspected to be male) guarding a chick and the contents of the other burrows could not be determined (although three were definitely active with fresh digging and droppings in the entrances).

The Northern Block (Tataweka) was also visited this season and only one active burrow was located during the three-day search. This burrow was located approximately halfway down from the summit. There was a male black petrel guarding a very small chick. Two other abandoned burrows were noted at Tataweka (the summit) and another burrow had been destroyed by feral pigs. It was noted that the topography, ground substrate, and vegetation at the summit were different from the Mount Hobson environment. Nikau (*Rhopalostylis sapida*), tawa (*Beilschmiedia tawa*) and puriri (*Vitex lucens*) were the dominant canopy species and cutty grass (*Carex* sp.) and dense fern species covered the forest floor. These species are not as common on Mount Hobson at the same elevation. The substrate was also very rocky and this would decrease the number of available burrow sites for the black petrels. As we continued down the track the environment became more suitable for black petrels, the substrate became less rocky, and the ground vegetation became more scattered (although it was still very dense in places). During a two-week search covering the same area, Scofield located eight burrows (six active, Scofield 1989). Although only a short time has been spent in this area it appears that the density of black petrels is much lower than that found at Mount Hobson. A survey in November/December would give a better idea of the actual numbers in the area as the birds are very vocal at this time of the breeding season (clacking to attract partners) and would be easier to locate.

The present population estimate is only for the area directly around Mount Hobson, and other areas surveyed around the island do not have the same densities. Using only data collected from around the summit does not give an accurate estimate for the entire black petrel population on Great Barrier Island. To determine this, more study grids should be set up on other high points around Mount Hobson (for example Hog Back, Mount Heale and Mount Matawhero).

5.7 BANDING DATA

An adult black petrel (H28005) from burrow 199 was recovered dead on Matarangi Beach, Coromandel Peninsula, on 29 May this year. When banded this bird was guarding a chick (which was also banded in April). The timing of the adult's mortality is very important as the chick may or may not have fledged by this stage. It is not known why this parent died, and until the burrow is checked again next season it is unknown whether the chick actually fledged. In fact even

if there is no evidence of a chick next season, it is impossible to know whether the chick fledged as any remains may have been dragged away by rats. Whether the chick fledged prior to the adults death has a direct bearing on its condition (weight, fat levels, etc.) and chances of surviving the migration to Central America. Only continued monitoring and burrow searches in this area over the next four to seven years could possibly recapture this chick when it returns as a pre-breeder.

The first return of a chick (H30930) banded in the 1995/96 season occurred this season. This bird was recovered in a new burrow (203), only 10 m from its natal burrow. This means minimum age at first return to the natal colony is four years. Although this bird had been excavating a chamber and had dragged some vegetation into the burrow to build a slight nest, it was a pre-breeder and did not appear to have attracted a mate. It will be very important to continue to monitor this bird and burrow to determine age at first breeding.

5.8 CONSERVATION

Mount Hobson is visited by a considerable number of the public each year. This season there were 631 visitors during January and a further 358 in February and March. As in all the other breeding seasons, these visitors had little to no direct impact on the breeding success of the black petrel. The construction of raised walkways around the summit has decreased damage to the environment, and to the burrows. However serious erosion continues to occur along the summit ends of the South Fork and Palmers Tracks (pers. obs.) Extended walkway construction in these areas is recommended. This should be done with full consultation, to prevent the accidental destruction of burrows, because certain places along these tracks have high burrow densities.

Public fouling and littering continues to be a major problem in the summit area. This season DOC has released a new brochure on Great Barrier Island that contains the latest information on the black petrel and this long-term study. DOC also placed new small signs on each of the boardwalks leading to the summit, informing visitors to stay on the tracks to prevent disturbance to nesting black petrels and damage to endangered plants in the area. It will be interesting to monitor whether these signs help reduce the littering and fouling in the area. Further interpretative material (replacing the older illegible signs) would help educate the visitors about the unique habitat and black petrels around the summit area. This material could be placed at all track entrances and on the summit platform.

Despite limited observer data, black petrel by-catch by the domestic long-line industry has been recorded in previous seasons. Any petrel caught on long lines between December to June could be incubating an egg and/or feeding a chick and this would result in breeding failure. Overall this will effect the entire population by reducing recruitment and productivity. Black petrels have delayed maturity, low reproduction rates, and high adult survivorship, and any change, however small, in adult survivorship will effect the population greatly (Murray et al. 1993). If large numbers of breeding adults continue to get caught on long-lines, this species could be drastically effected. It is important to

continue to monitor the Great Barrier Island black petrel population. This long-term population data can be used to develop an accurate population model to determine adult survivorship, mortality, productivity and breeding. A good population model will assess the various factors affecting the black petrel population and help to determine the overall effects of by-catch in the long-line fishing industry.

6. Recommendations

The authors recommend that:

- Monitoring of the black petrel population (using the long-term study burrows) should continue at Great Barrier Island for at least a further five breeding seasons.

This will ensure enough comparative data will be collected for determining the population dynamics of black petrels, in particular the development of a population model to determine survivorship, mortality and the effects of predation, long-line fishing and other environmental factors.

- The Northern Block (Tataweka) be visited in November to survey the black petrel population to obtain a more accurate estimate of the population in that area.
- Census grids are established on other high points around the Mount Hobson area (e.g. Mount Heale, Mount Matawhero, Hogs Back). This will ensure a better estimate for the black petrel population on Great Barrier Island can be calculated. These sites should be continually monitored as long as the study continues.
- The Great Barrier Island black petrel population is visited 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 (hence identifiable) easily 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 should remain five weeks long, as this gives a clearer picture of breeding behaviour and results, and the April period stay as one week.
- Rat index lines are still run in the study area. This will ensure data on species present, total rat densities, and densities within distinct areas will be collected and can be related to effects on petrel mortality.
- Cat trapping over the black petrel breeding season, November to June, especially during pre-laying (November) and the fledging period (from May to June), should be established.
- Continuation of the walkway system down Palmers (Windy Canyon) and South Fork Tracks occurs. 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).

7. Acknowledgements

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Appendix 1

RESULTS FROM THE 250 BURROWS

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
1			Empty
2	H25408	800g	Chick H25627
	H25438	800g	
3	H31267	520g	Crushed egg
	H31109	900g	
4	H27542	640g	Crushed egg
	H25481	830g	
5	H31020	680g	Chick H29991
	H31161	680g	
6	H31216	640g	Chick H29993
	H31576	770g	
7	H31272	800g	Chick H25674
	H30854	-	
8	H31103	760g	Chick H25675
	H31273		
9	H31597	770g	Non-breeder
10	H28015	650g	Non-breeder
	H31584	650g	
11	H31585	-	Non-breeder
	H25594	750g	
12			Empty
13	H31281	790g	Chick H29998
	H25418	560g	
14	H31284	760g	Chick H29970
	H31202	800g	
15			Empty
16	H31004	770g	Dead embryo
	H31296	740g	
17	H31108	720g	Chick H25603
	H28009	820g	
18	H31204	640g	Infertile
	H25434	720g	
19	H31162	570g	Chick H29992
	H30859	630g	
20			Empty
21	H31235	840g	Chick H25628
	H31019	620g	
22	H31214	-	Chick H25656
	H25492	830g	
23	H31157	660g	Dead embryo
	H31117	-	
24			Empty

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
25	H25487	820g	Chick H29989
	H31217	700g	
26	H23014	810g	Chick H29987
	H31218	800g	
27	H28046	770g	Non-breeder
	H25551	670g	
28	H31231	740g	Chick H25637
	H31114	800g	
29	H31210	700g	Non-breeder
	H28004	660g	
30	H25445	-	Dead embryo
	H25446	570g	
31	H31101	750g	Infertile
	H31237	800g	
32 (PTG1)	H25480	700g	Dead embryo
	H31466	740g	
33	H31123	790g	Chick H29982
	H31244	830g	
34	H31248	840g	Chick H29995
	H31121	820g	
35	H31249	880g	Chick H25664
	H13641	790g	
36	H31129	760g	Chick H25646
	H25520	830g	
37	H31107	680g	Non-breeder
	H28036	670g	
38	H25592	660g	Non-breeder
	H25602	640g	
39	H25426	750g	Non-breeder
	H31578	730g	
40	H31111	490g	Chick H29966
	H31122	790g	
41	H31112	520g	Chick H29981
	H31209	-	
42	H31586	660g	Non-breeder
	H25506	-	
	H25569	760g	
43	H31016	810g	Non-breeder
44	H31130	760g	Chick H25651
	H25424	-	
45			Empty
46	H28813	760g	Chick H25652
	H28002	710g	

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
47	H31005 H31018	780g 760g	Chick H25655
48	H31003 H26991	610g 830g	Chick H25607
49	H31243 H31010	580g 740g	Chick H25608
50	H31282 H25476	750g 790g	Crushed egg
51	H22169 H25582	610g 780g	Non-breeder
52	H31289 H31255	700g 690g	Chick H29988
53	H31021 H31022	620g 860g	Predation (rat, egg)
54	H30884	700g	Non-breeder
55 (PTG1)	H28011 H23635	640g 780g	Non-breeder
56 (PTG1)	H31152 H31152	760g 700g	Chick H25613
57 (PTG1)	H28013 H31153	810g 680g	Non-breeder
58 (PTG1)	H28029 -	730g -	Chick H25624
59 (PTG1)	H31125 H31220	- 700g	Chick H25622
60 (PTG1)	H25456 H31034	790g -	Infertile
61 (PTG1)	H31113 H30878	- 870g	Chick H25609
62 (PTG1)	- -	- -	Chick H25626
63 (PTG1)	H31247 H31206	- 840g	Chick H29986
64 (PTG1)	H31286 -	720g -	Chick H25615
65	H31460 H27548	740g 850g	Chick H25597
66	H25406/H28007 H25407	750g 820g	Dead embryo
67 (KDG1)	H31270 H31271	610g 670g	Chick H25598
68 (KDG1)	H31154 H31172	670g -	Non-breeder
69	H31240 H27604	750g 740g	Chick H29955
70	H25401 H27665	800g 710g	Chick H25682
71 (KDG1)	H31023 H31242	610g 780g	Chick H25683
72 (KDG1)	H31155	820g	Abandoned

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
73 (KDG1)	H28572 H31300	840g 670g	Chick H25673
74 (KDG1)	H31592	690g	Non-breeder
75 (KDG1)	H30867 H31147	800g 710g	Non-breeder
76 (KDG1)	H25402 H31001	790g 920g	Chick H25672
77 (KDG1)	H31274 H30870	650g 660g	Chick H25670
78 (KDG1)	H25512 H31102	630g 730g	Non-breeder
79 (KDG1)	H13618 H25403	710g 640g	Chick H25671
80 (KDG1)	H31104 H25404	830g 750g	Dead embryo
81 (KDG1)			Empty
82	H31253 H30889	810g 700g	Chick H25630
83	H25413 H31012	770g 700g	Chick H25632
84	H31179	810g	Chick H25636
85 (SFG1)	H25478 H31118	- 930g	Chick H25659
86S (SFG1)	H28037	760g	Non-breeder
87 (SFG1)	H31259 H28028	610g 640g	Non-breeder
88 (SFG1)			Empty
89 (SFG1)	H31233 H30910	760g 740g	Chick H25661
90 (SFG1)	H25409 H25432	910g 650g	Crushed egg
91 (SFG1)	-	-	Non-breeder
92 (SFG1)	H31261 H31119	680g 750g	Predation (cat, chick)
93	H30856 H27552	860g 950g	Chick H25667
94	H23018 H31028	840g 670g	Chick H25668
95	H30880 H25425	570g 900g	Chick H29997
96 (PTG1)	H31011 H31287	760g 690g	Chick H29985
97	H30872 H31263	760g 800g	Chick H29969
98	H31283 H30890	830g 690g	Chick H29968

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
99	H31262 H31201	760g 720g	Chick H29965
100	H25485 H31268	830g 800g	Dead chick
101 (KDG1)	H25588	760g	Non-breeder
102 (KDG1)	H25511 H30866	810g 800g	Dead embryo
103 (KDG1)	H31588 -	770g- -	Chick H29954
104 (KDG1)			Empty
105	H14018 H25444	630g -	Dead embryo
106	H31038 H25458	760g 720g	Chick H25605
107	H31582 H28003	680g 840g	Non-breeder
108	H25452 H25477	870g 570g	Chick H25666
109	H31052 H25428	860g 900	Chick H25633
110 (SFG1)	H31008 H31007	800g 820g	Chick H25663
111 (SFG1)	H25431	690g	Infertile
112 (SFG1)	-	-	Non-breeder
113 (SFG1)	H28050	630g	Non-breeder
114 (SFG1)	H25453 H31142	740g 690g	Predation (cat, chick)
115	H25433 H31031	830g 720g	Chick H29994
116 (PTG1)	H25435 H25411	960g 640g	Chick H29984
117 (SFG1)	H25560 H28804	780g 690g	Chick H25657
118	H25486 H25467	630g 800g	Chick H25658
119	H25454 H31055	720g 830g	Chick H29983
120 (PTG1)			Empty
121 (PTG1)	H31032 H25455	860g 880g	Chick H25614
122 (PTG1)	H31051 H31050	840g 800g	Chick H25623
123 (PTG1)	H31053 H31246	780g 800g	Chick H25625
124 (PTG1)	H25567 H28032	660g 780g	Dead chick
125 (PTG1)	-	-	Breeder

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
126 (PTG1)	H25577	750g	Non-breeder
127	H25415 H31128	810g 640g	Chick H25653
128	H31054 H25495	910g 690g	Chick H25654
129	H25417 H28038	780g 680g	Chick H25665
130	H28212 H25457	720g 690g	Chick H29990
131	-	-	Non-breeder
132 (KDG2)	H31567 H31568	620g 650g	Non-breeder
133 (KDG2)	H25430 H28025	850g 860g	Chick H25677
134 (KDG2)	H27568 H31589	850g 610g	Chick H25676
135 (KDG2)	H25463 H25447	770g 830g	Chick H29960
136 (KDG2)	H28024	640g	Non-breeder
137 (KDG2)	H31572 H25494	700g 695g	Predation (rat, egg)
138 (KDG2)	H25448 H31565	700g 680g	Non-breeder
139	H14012 H23035	630g 850g	Dead chick
140 (KDG2)	H25482 H28047	800g 890g	Chick H29957
141 (SFG2)	-	-	Non-breeder
142 (SFG2)	H28026 H28027	710g 670g	Non-breeder
143 (KDG2)	H25469 H28021	700g 650g	Predation (rat, egg)
144 (KDG2)	H25459 H31566	820g 620g	Crushed egg
145 (KDG2)	H25474 -	750g -	Chick H29962
146 (KDG2)	H25460 H25473	710g 860g	Chick H25681
147 (KDG2)	H25461 H28022	890g 720g	Chick H29956
148 (KDG2)	H27534 H25483	710g 760g	Predation (rat, egg)
149 (KDG2)	H25462 H25507	- 810g	Chick H25678
150 (KDG2)	H25471 -	790g -	Chick H29959
151	H25593 H25580	690g 620g	Non-breeder

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
152 (SFG2)	H28035 H31453	810g 660g	Predation (rat, egg)
153 (SFG2)			Empty
154 (PTG1)	H25484 H25499	- 700g	Infertile
155 (PTG2)	H25497 H31574	- 850g	Dead chick
156 (PTG2)	H31558 H31559	690g -	Non-breeder
157 (PTG2)	H31573 H31219	930g 830g	Chick H25618
158 (PTG2)	H25440 H31451	840g 770g	Predation (rat, egg)
159 (PTG2)	H25441 H31557	590g 730g	Chick H25619
160			Empty
161 (PTG2)	H25488 H25500	730g -	Chick H25616
162 (PTG2)	H25442 H25489	710g 730g	Chick H25617
163 (PTG2)	H25490 -	880g -	Chick H25620
164 (PTG2)	H25443 H25505	- 690g	Chick H25621
165 (KDG2)	H31590 H27708	640g 660g	Non-breeder
166	H25437 H31136	820g 780g	Chick H25610
167	H28012 H31595	660g 710g	Chick H25611
168 (PTG1)	H25449 H31583	740g -	Chick H25612
169	-	-	Non-breeder
170	H25501 H31555	870g 650g	Chick H29964
171	H31110 H28006	700g 800g	Chick H29967
172	H25502 H31048	770g 970g	Chick H29972
173	H31143 H28018	740g 880g	Chick H25645
174	H27728 H28020	- 700g	Chick H25604
175	H25503 H28001	- 740g	Chick H25604
176 (KDG1)	-	-	Non-breeder
177	H31459 H31462	830g 780g	Chick H25639
178	H31168 H25508	780g 810g	Chick H25640

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
179	-	-	Non-breeder
180	H31560 H31169	650g 850g	Chick H25642
181	H31463 H31561	650g 870g	Chick H25644
182	H31580	670g	Non-breeder
183 (SFG1)	H31465 H25515	800g 790g	Chick H25660
184	H28014 H31596	830g 820g	Chick H25631
185 (KDG1)			Empty
186	H31577	710g	Non-breeder
187	H31047 H31452	860g 570g	Chick H29963
188	H26956	650g	Non-breeder
189	H25516 H25517	940g 760g	Chick H25635
190	H25518 H25519	770g 760g	Crushed egg
191 (PTG2)	H28048 H25450	650g 710g	Crushed egg
192 (SFG1)	-	-	Non-breeder
193 (KDG2)	H31571 H25561	820g 820g	Chick H25680
194 (KDG2)	H31569 H31570	900g 740g	Chick H25679
195	H28023 H28555	860g 790g	Chick H29958
196	H28016 H29951	830g 930g	Chick H25641
197	H28017 H25570	810g 670g	Predation (rat, egg)
198	H31563 H31593	- 870g	Chick H25648
199	H28005 H30860	680g -	Chick H29999
200	- -	- -	Chick H29971
201	H28002 H31581	800g 900g	Chick H25606
202 (PTG2)	H31556 H28031	670g 860g	Crushed egg
203	H30930	670g	Non-breeder
204	H28008 H25563	670g 620g	Non-breeder
205	H28010 H28033	600g 700g	Non-breeder
206	H31564 H28034	730g 790g	Chick H30000

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
207	H28030 H31137	650g -	Non-breeder
208	H22167 H25587	780g 750g	Non-breeder
209	H28039 H25562	730g 710g	Chick H25599
210			Empty
211	- -	- -	Chick (out of reach)
212	H28040 H30869	750g 860g	Predation (rat, egg)
213	H28045 H25552	810g 620g	Non-breeder
214	H25595 -	670g -	Chick H29961
215			Empty
216	- -	- -	Chick H25649
217			Empty
218	H28044 -	700g -	Crushed egg
219	- -	- -	Predation (rat, egg)
220	H28043 H25555	730g 710g	Dead embryo
221	- -	- -	Chick H29978
222	H28049 -	710g -	Dead embryo
223	H31598 H25574	790g 750g	Dead embryo
224	H25553 H25564	840g 670g	Dead chick
225	H31600 H13634	790g 740g	Chick H25650
226	H31600 H28041	780g 680g	Chick H29975
227	H25509 H25583	820g 660g	Infertile
228	H29952 H23029	800g 750g	Chick H25684

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
229	H28042 H25565	740g 580g	Chick H29976
230	H25556 -	790g -	Chick H29979
231	H25557 H25568	660g 840g	Chick H29980
232	H31587	-	Non-breeder
233	H25558	660g	Non-breeder
234	H25559 H25571	690g 800g	Dead embryo
235	H25566 H25554	780g 730g	Chick H29977
236	H25572 H25573	740g 630g	Chick H25647
237	H25575 H29953	840g 580g	Chick H25634
238	H31027 -	710g -	Chick H25662
239	H25576 -	590g -	Dead chick
240	- -	- -	Chick H29996
241	H25579 H25600	690g 640g	Non-breeder
242	H27032	710g	Non-breeder
243	H25578 H22170	760g 750g	Chick H25669
244	H25581 H22143	650g 630g	Dead embryo
245	H30871	-	Non-breeder
246	H25586 -	750g -	Chick H29973
247	H25589 H25585	630g 620g	Non-breeder
248	- -	- -	Chick H25638
249	H25590 H25601	750g 610g	Non-breeder
250	H25591 -	660g -	Crushed egg

Appendix 2

RESULTS FROM THE RAT INDEX LINES, HIRAKIMATA TRACK

DATE (night of)	TRAP NO.	SPECIES	WEIGHT (g)	NOTES
24/1/00	21a	<i>Rattus rattus</i>	85	Male, <i>alexandrinus</i>
24/1/00	28b	<i>R. rattus</i>	215	Male, <i>frugivorus</i>
25/1/00	18a	<i>R. exulans</i>	76	Male
25/1/00	19a	<i>R. rattus</i>	83	Male, <i>rattus</i>
25/1/00	19b	<i>R. exulans</i>	97	Female
25/1/00	23a	<i>R. rattus</i>	70	Female, <i>frugivorus</i>
25/1/00	23b	<i>R. exulans</i>	94	Female
25/1/00	28b	<i>R. exulans</i>	80	Female
26/1/00	2b	<i>R. rattus</i>	192	Female, <i>frugivorus</i>
26/1/00	3b	<i>R. exulans</i>	84	Female
26/1/00	14b	<i>R. exulans</i>	106	Male
26/1/00	16b	<i>R. exulans</i>	91	Female
26/1/00	22b	<i>R. rattus</i>	168	Male, <i>frugivorus</i>
26/1/00	27b	<i>R. exulans</i>	104	Male
26/1/00	28a	<i>R. exulans</i>	99	Male
26/1/00	28b	<i>R. rattus</i>	98	Male, <i>alexandrinus</i>
26/1/00	35a	<i>R. rattus</i>	180	Female, <i>frugivorus</i>
27/1/00	1a	<i>R. rattus</i>	34	Male, <i>alexandrinus</i>
27/1/00	1b	<i>R. rattus</i>	28	Male, <i>alexandrinus</i>
28/1/00	2b	<i>R. rattus</i>	35	Male, <i>frugivorus</i>
28/1/00	8a	<i>R. rattus</i>	198	Male, <i>frugivorus</i>
28/1/00	42a	<i>R. rattus</i>	176	Male, <i>rattus</i>