

Survey and monitoring of black petrels on Great Barrier Island, 2000/01

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Survey and monitoring of black petrels on Great Barrier Island, 2000/01

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A B S T R A C T

The black petrel (*Procellaria parkinsoni*) is an endemic seabird that 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 2000/01 breeding season, 258 burrows were identified and were intensively monitored over summer. Only 255 burrows were included in the study and of these 168 were used by breeding pairs, 75 by non-breeding adults and the remaining 12 were empty. A range of factors affecting the black petrel breeding success was noted. In April, 129 chicks were present in the study burrows. In early May one chick was killed by a feral cat. This corresponds to a breeding success of 76%. Nine census grids were monitored. A total of 122 burrows were located within the grids and of these, 84 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. An additional five burrows have been dug in four of the nine grids. Extrapolating from these grid burrows we estimate that the black petrel population around the peak of Mount Hobson consists of 1583 breeding pairs. A bird banded in the 1995/96 season as a chick was recaptured this season in the same burrow as last season and it successfully raised a chick. This suggests that the earliest age of first breeding is five years.

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

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1. Introduction

This monitoring work carried out during the 2000/01 breeding season is a continuation of the survey and monitoring study begun in 1995/96 (Bell & Sim 1998a, 1998b, 2000a, 2000b, 2000c). 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 made ensuring that any population changes are detected in time to implement the appropriate management strategies.

2. Objectives

The main objective of this study is to undertake an annual 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. Since this study is a continuation from previous breeding seasons, it will also provide more data to establish current population trends and assist in determining causes and timing of mortality.

In summary, the study objectives 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 monitor the nine census grids. 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.

3. Methods

The nine census grids set up around Hirakimata were re-surveyed to locate any new burrows and to determine this season's occupancy (Figs 1, 2, 3 and 4). During the first monitoring visit (from 15 January to 16 February 2001), the number of study burrows was increased to 255 (Figs 1, 2, 3 and 4). To ensure accurate monitoring of the study burrows, they were accessible either through

the main entrance or via an opening that had 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 (or the band number recorded if a recapture), weighed and returned to the burrow. Eggs or chicks were noted if present; the lack of eggs or chicks identified non-breeding birds. The study burrows were monitored again (2-6 April 2001) and all remaining fledgling chicks were banded. This information was used to determine breeding success and added to the long-term population dynamics data.

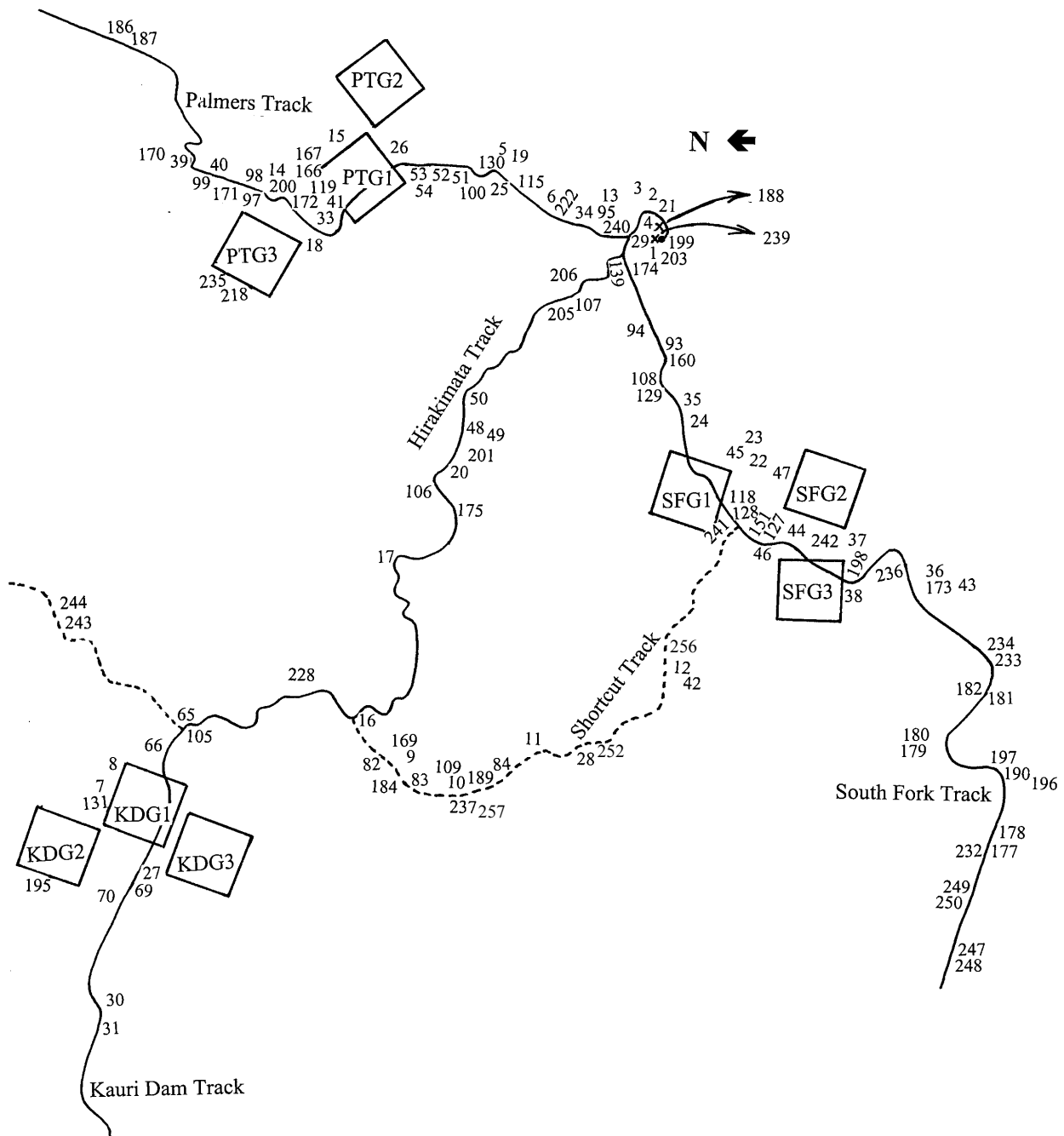


Figure 1. Location of the burrows and census grids around the summit area of Great Barrier Island. Note that Figs 2, 3 and 4 show the burrow numbers within each of the nine census grids.

Kauri Dam grid one (KDG1)

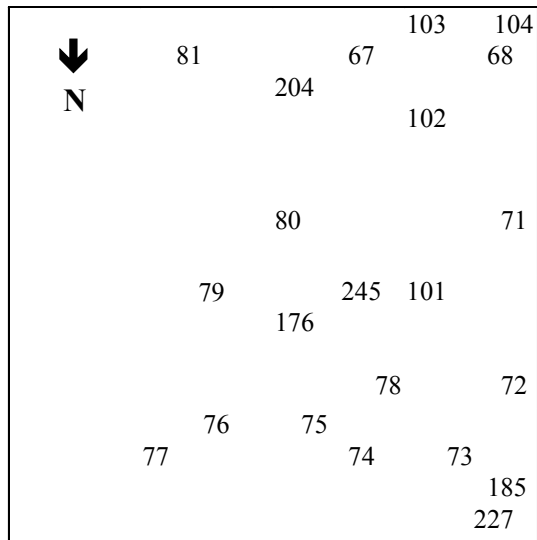
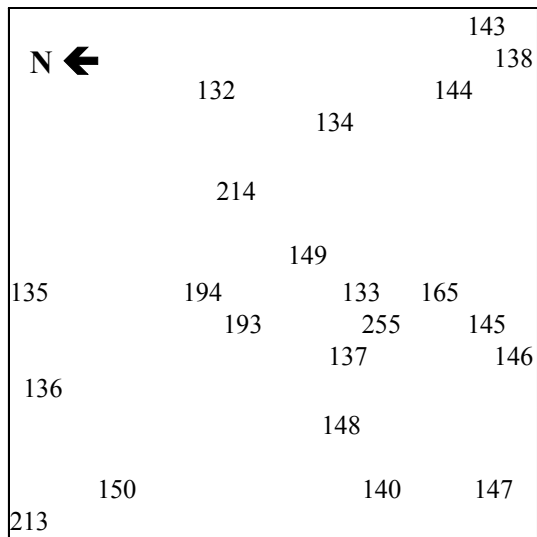


Figure 2. Location of burrows found in the Kauri Dam grid sites (each grid is 40 m × 40 m).

Kauri Dam grid two (KDG2)



Kauri Dam grid three (KDG3)

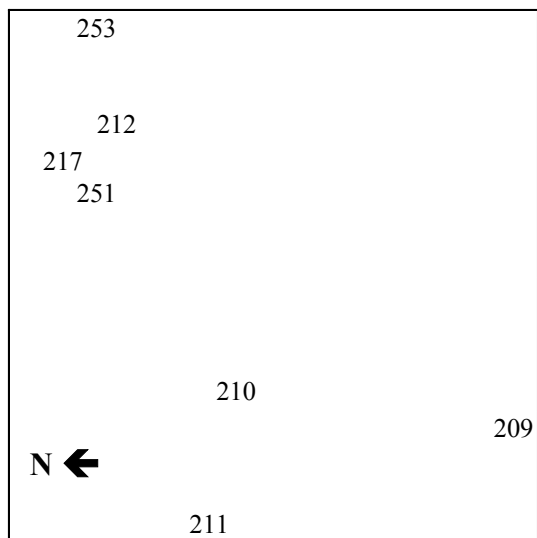
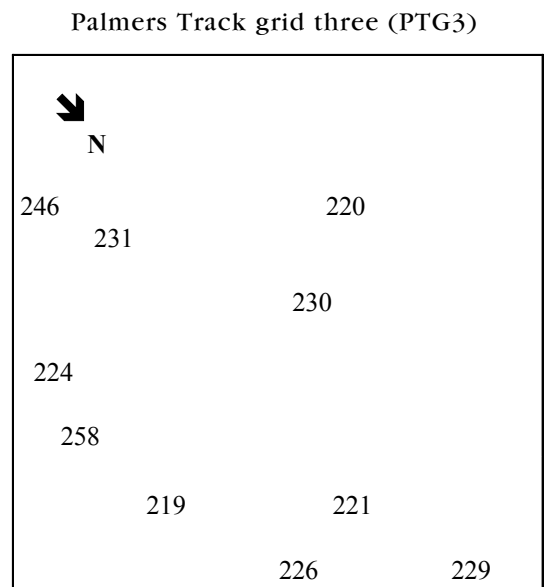
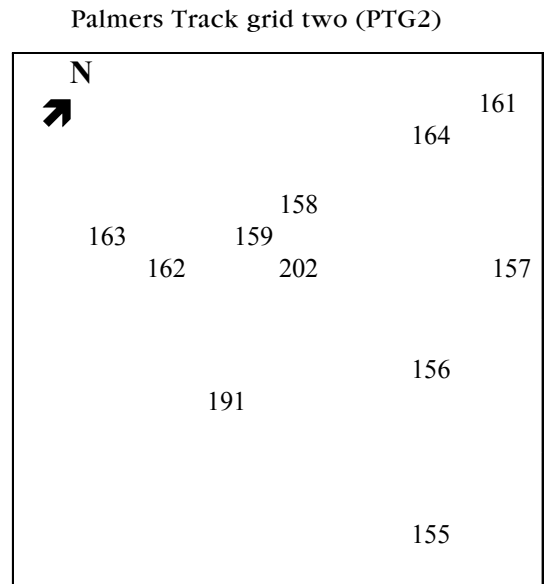
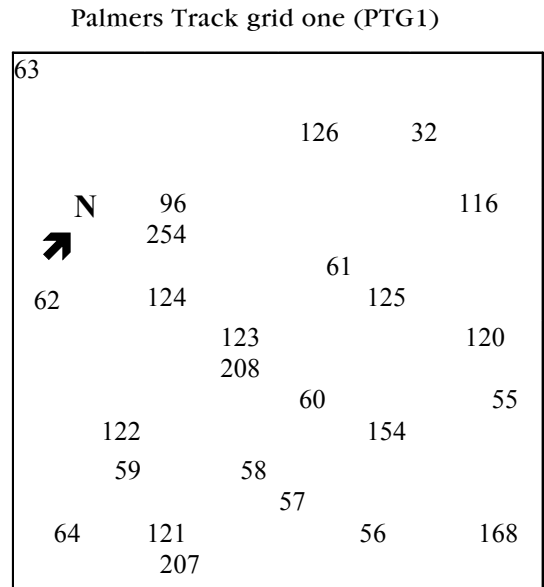


Figure 3. Location of burrows found in the Palmers Track grid sites (each grid is 40 m × 40 m).



South Fork Track grid one (SFG1)

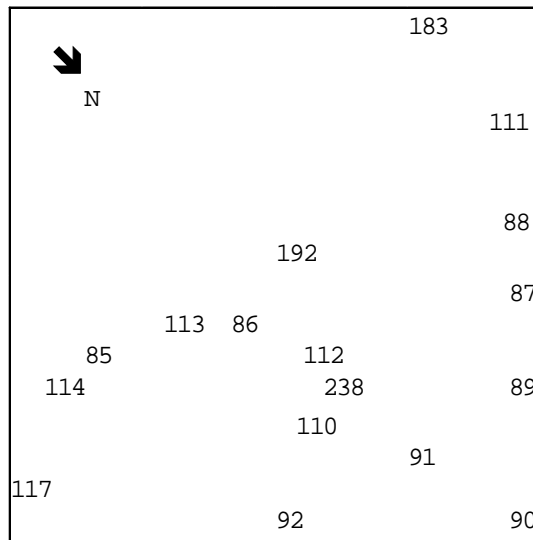
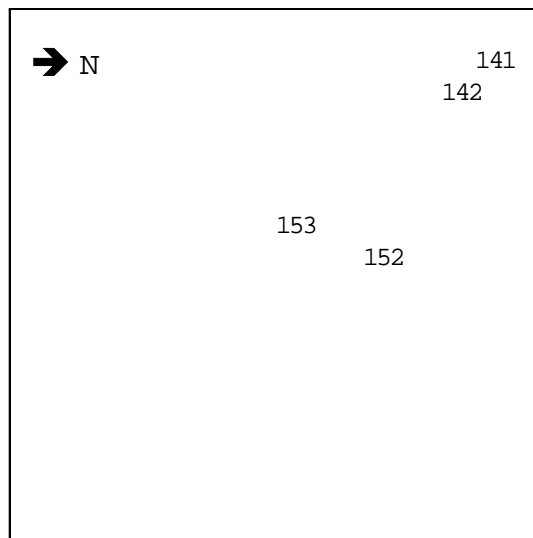
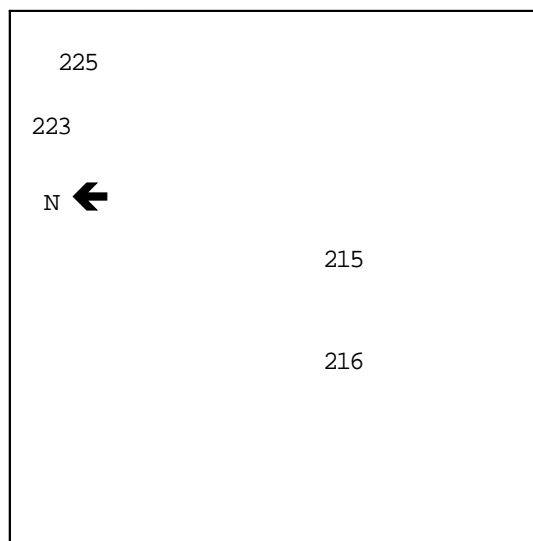


Figure 3. Location of burrows found in the South Fork grid sites (each grid is 40 m × 40 m).

South Fork Track grid two (SFG2)



South Fork Track grid three (SFG3)



4. Results

4.1 NUMBER OF BURROWS IN THE CENSUS GRIDS

A total of 122 burrows were found in the nine census grids (Table 1, Figs 2, 3 and 4). Of these, 76 burrows were used by breeding pairs, 38 were used by non-breeding adults and eight burrows were empty.

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

AREA AND BURROW TYPE	GRID ONE						GRID TWO			GRID THREE	
	1995/96	1996/97	1997/98	1998/99	1999/2000	2000/01	1998/99	1999/2000	2000/01	1999/2000	2000/01
Kauri Dam Grid											
Empty	1	1	1	1	3	1	0	0	0	2	1
Breeding	8	10	8	12	11	12	15	16	13	3	3
Non-breeding	5	5	7	6	8	9	4	5	9	0	3
TOTAL	14	16	16	19	22	22	19	21	22	5	7
Palmer's Track Grid											
Empty	3	0	0	1	1	0	0	0	0	0	2
Breeding	7	13	13	15	18	16	10	9	10	9	6
Non-breeding	3	6	7	6	5	9	1	2	1	0	2
TOTAL	13	19	20	22	24	25	11	11	11	9	10
South Fork Grid											
Empty	2	1	1	0	1	3	1	1	1	1	0
Breeding	5	12	11	11	10	10	2	1	3	3	3
Non-breeding	2	1	3	5	6	4	1	2	0	0	1
TOTAL	9	14	15	16	17	17	4	4	4	4	4
ANNUAL TOTALS	36	49	51	57	63	64	34	36	37	18	21

Extrapolating from the grids, the 'useable' burrow density was 85 burrows/ha, with 53 burrows/ha used for breeding, 26 burrows/ha for non-breeding and six empty burrows per hectare (Table 2). This relates to a ratio of 1:2 for non-breeding to breeding burrows and of 1:13 for empty to occupied burrows (Table 3). There were also 10 'potential' burrows within the grids, which are not included in any burrow estimate. We define 'potential' burrows as those which have been investigated and/or preliminarily dug out, but are not yet being used by breeding or non-breeding petrels.

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	2000/01
'Useable'	75	102	106	95	81	85
Breeding	42	73	67	68	55.5	53
Non-breeding	21	25	35	24	19	26
Empty	12.5	4	4	3	6	6

TABLE 3. OCCUPANCY AND BREEDING STATUS RATIOS FOR BURROWS AROUND THE SUMMIT AREA.

	RATIO					
	1995/96	1996/97	1997/98	1998/99	1999/2000	2000/01
Ratio for non-breeding to breeding burrows	1:2	1:3	1:2	1:3	1:3	1:2
Ratio for empty to occupied	1:5	1:25	1:25	1:31	1:12	1:13

4.2 STUDY BURROWS

Within the 255 study burrows, 168 contained breeding birds, 75 contained non-breeding birds and 12 were empty. There were 40 failures due to various factors (Table 4). In April, 129 chicks were present, however a feral cat in predated a chick early in May. This corresponds to a breeding success of 76% (Table 4).

TABLE 4. BREEDING SUCCESS AND CAUSES OF MORTALITY.

	1996/97	1997/98	1998/99	1999/2000	2000/01
NUMBER OF STUDY BURROWS	118	137	197	248	255
Eggs					
- laid	92	95	142	178	168
- predation (rat)	6	1	2	9	6
- crushed*	5	0	1	10	6
- abandoned	2	1	5	1	3
- infertile	6	4	12	6	8
- dead embryo (at various stages)	0	8	6	13	9
Chicks					
- hatched	73	81	116	139	136
- predation (rat)	0	0	2	0	0
- predation (cat)	0	0	2	2	1
- died (disease)	1	0	0	0	0
- died (starvation)	0	1	0	0	0
- died (unknown causes)	0	0	3	6	7
- fledged [†]	72	80	109	131	128
	78%	84%	77%	73.5%	76%

* 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.

Both parents were identified in 143 of the breeding study burrows, 21 where only one parent was identified and four burrows where no parents were identified (Table 5, Appendix 1). Of the non-breeding burrows, there were 34 burrows where two or more birds were identified, 22 where one was identified and 19 where no birds were present during the day, but the burrows were active at night (Table 5, Appendix 1). The average weight of breeding adults was 785 g, non-breeding adults averaged 701 g and the average combined adult weight was 763 g.

TABLE 5. NUMBER OF STUDY BURROWS WITH IDENTIFIED BIRDS PRESENT.

NUMBER OF BREEDING BURROWS	YEAR					
	1995/96	1996/97	1997/98	1998/99	1999/2000	2000/01
With no parents identified	32	13	12	20	8	4
With one parent identified	13	5	18	30	18	21
With both parents identified	4	79	67	92	152	143
NUMBER OF NON-BREEDING BURROWS	YEAR					
	1995/96	1996/97	1997/98	1998/99	1999/2000	2000/01
With no birds identified	8	5	8	11	7	19
With one bird identified	7	11	16	10	17	22
With two birds identified	-	7	15	21	29	32
With three or more birds identified	-	2	1	2	1	2

4.3 BANDING DATA

There were 404 adults identified during the 2000/01 season (Table 6). Of these, 397 were from the study burrows, with 311 already banded and 86 banded this season. Seven other adults were caught and banded from non-study burrows around the summit area. The 129 chicks present in the study burrows and five chicks in a non-study burrow were also banded (Table 6).

TABLE 6. BANDING AND RECOVERY DATA FROM GREAT BARRIER ISLAND.

	YEAR					
	1995/96	1996/97	1997/98	1998/99	1999/2000	2000/01
Recoveries of birds banded prior to 1995	16	30	23	20	28	27
Recoveries of birds banded in 1995/96	-	15	14	14	16	14
Recoveries of birds banded in 1996/97	-	-	113	85	84	73
Recoveries of birds banded in 1997/98	-	-	-	32	31	29
Recoveries of birds banded in 1998/99	-	-	-	-	98	83
Recoveries of birds banded in 1999/2000	-	-	-	-	-	85
Total recoveries	16	45	150	151	257	311
Number of new adults (banded that season)	41	180	60	130	150	93
Total adults	57	225	210	281	407	404
Number of chicks (banded that season)	59	69	85	117	132	134
Number of chicks recovered alive (returned to colony)	-	-	-	-	1	1
Total number of birds banded	116	294	295	398	539	538
Band recoveries from dead birds	-	-	-	-	1	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 3958 birds (Table 7), consisting of 792 non-breeding birds and 1583 breeding pairs.

TABLE 7. POPULATION ESTIMATE OF BLACK PETRELS AROUND THE HIRAKIMATA AREA.

YEAR	DENSITY (Number/ha)		TOTAL AREA (ha)	POPULATION ESTIMATE	
	BREEDING PAIRS	NON-BREEDING BIRDS		BREEDING PAIRS	NON-BREEDING BIRDS
1995/96 Total	41.67	20.83	30	1250	625
1995/96 GRAND TOTAL (breeders and non-breeders)				3125 individuals	
1996/97 Total	72.92	25	30	2187.5	750
1996/97 GRAND TOTAL (breeders and non-breeders)				5125 individuals	
1997/98 Total	66.67	35.42	30	2000	1062.5
1997/98 GRAND TOTAL (breeders and non-breeders)				5063 individuals	
1998/99 Total	67.71	23.96	30	2031.25	718.75
1998/99 GRAND TOTAL (breeders and non-breeders)				4781 individuals	
1999/2000 Total	55.56	19.44	30	1666.5	583.5
1999/2000 GRAND TOTAL (breeders and non-breeders)				3917 individuals	
2000/01 POPULATION ESTIMATE					
Kauri dam	19.44	14.58	30	583.2	437.4
Palmers track	22.22	8.33		666.6	249.9
South fork	11.11	3.47		333.3	104.1
2000/01 total	52.77	26.38		1583.1	791.4
2000/01 GRAND TOTAL (breeders and non-breeders)				3958 individuals	

5. Discussion

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

5.1 CENSUS GRIDS

Three census grids were set up in each of the 1995/96, 1998/99 and 1999/2000 breeding seasons. All nine grids were intensively monitored during the latter part of 2000/01 breeding season, from 15 January to 16 February 2001. Five new

burrows were located in the grids (one in PTG1, PTG3, KDG2 and two in KDG3) and were occupied by non-breeding birds. These birds had newly excavated two of these burrows this season and three were identified as potential burrows last season (but were not being used by black petrels at the time). As this study has continued, the number of burrows within the grids has risen each year. It appears that pre-breeding and non-breeding birds are returning to their natal area and are starting to excavate new burrows.

Since the local environment in each grid varies (falling trees, etc.) the number of optimum burrow sites changes annually as other sites for digging are uncovered. During the monitoring in this breeding season, there were 18 potential burrows identified within the nine grids. All were identified in earlier breeding seasons and were still not being used this year.

This season's ratio of 1:13 empty to occupied burrows is very similar to last season's (1:12), which is probably due to the similar number of burrows (255 compared with 248) and similar number of returning birds during both breeding seasons. The ratio of non-breeding burrows to breeding burrows was 1:2, which is lower than the 1996/97, 1998/99 and 1999/2000 seasons (all 1:3), identical to the 1995/96 and 1997/98 seasons and higher than Imber (1:1, 1987) and Scofield (1:1, 1989).

5.2 STUDY BURROWS

A further seven study burrows were added to the 248 previously identified. There were 128 breeding successes and 40 breeding failures this season, equating to an overall breeding success rate of 76%. This breeding success is similar to previous years (range 73.5%–84%) and 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). It would be valuable to return to the colony early in the breeding season (late November or early December) to undertake a survey of the study burrows during the first phase of egg laying to gain a more accurate idea of the number of breeding burrows. Since the first monitoring visit is in January, some eggs may have already been predated or crushed, and this would reduce the number of known breeding burrows and hence increase the breeding success estimate.

5.3 RAT AND FERAL CAT PREDATION

There was only one cat predation event (0.5%), while rats predated 3.5% of the eggs laid within the study burrows this season. Cat sign was found throughout the study area and close to burrows where cat predation has occurred in two previous seasons (South Fork Track). However, the cat predation that occurred this season was along Palmers Track. Juvenile petrels are vulnerable to feral cat predation as soon as they leave the burrows to strengthen wings and practise flying (Warham 1996). It is still important to continue cat trapping in the area.

5.4 ADULTS

A total of 404 adult black petrels were identified this season. The average adult weight (of all adults combined) was 763 g (compared with 770 g from Scofield 1989). The average weight for a breeding adult was 785 g compared with 701 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 65 and 91 g.

This season's average weight of breeding adults was heavier than all other seasons. However, there is only a difference of 30 g (755 g to 785 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, decreased again in 1999/2000 and increased this season. However, as with the breeding birds, there is not much difference in non-breeder weights over all seasons—only 23 g (678 g to 701 g). Again, this may depend on the timing of weighing, but may also relate to the availability of food and overall condition of the birds.

5.5 CHICKS

There were 129 chicks still present in the study burrows in April. Similar to last year, several chicks were very small. The poor condition of some chicks suggests that either only one parent is feeding them or, if both parents are still feeding, the food quality (or quantity) has been reduced. All chicks, including the runts, were banded, but it will be important to see if there are remains of any runt in the burrows next season. It is interesting to note that a runt from last season (H25629) fledged in late May, but did not survive the first flight. A tourist recovered the carcass along the Windy Canyon track. This might mean that although very small chicks may develop enough to fledge, it would be unlikely that they make the first flight to South America, which, in turn, would reduce juvenile survival estimates. It is important to note that the condition of chicks (size and weight) appears to have deteriorated over the past three seasons. It would be interesting to determine whether the adults are having problems locating adequate quantities of food, the quality was as good or 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), the population of the Great Barrier Island black petrels is estimated at 3958 birds. This estimate is similar to the 1999/2000 season, but less than earlier years; 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 statistically sounder population estimate for the entire study area.

Since 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

The first return of a chick (H30930) banded in the 1995/96 season occurred in the 1999/2000 season. This bird was recovered in the same burrow this season, and was incubating an egg that later successfully hatched a chick. This suggests the minimum age of first breeding is five years. It is important to monitor for more returned chicks throughout the summit area.

5.8 CONSERVATION

Large numbers of people visit Mount Hobson each year. As in all the other breeding seasons, these visitors had little or 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, since certain places along these tracks have high burrow densities.

Despite new signage in the area, public fouling and littering continues to be a major problem in the summit area. This situation needs to be monitored to see if the new publicity, brochures and signage will make a difference in the long term. Further interpretative material (replacing the older illegible signs) would help educate 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.

Black petrel bycatch by the domestic long-line fishing industry has been recorded in previous seasons. Petrels 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 affect the entire population by reducing recruitment and productivity. Black petrels have delayed maturity, low reproduction rates and high adult survivorship, and any change in adult survivorship, however small, will affect the population greatly (Murray et al. 1993). If breeding adults continue to be caught on long-lines, this species could

be drastically affected. It is important to continue to monitor the Great Barrier Island black petrel population. Long-term population data can be used to develop an accurate population model to assess adult survivorship, mortality, productivity and breeding. A good population model will assess various factors affecting the black petrel population and help to determine the overall effects of bycatch 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 is 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 Hiramata study area be visited in November for two weeks to enable pair bonding and pre-breeding behaviour to be monitored. This would also allow a large number of birds to be banded or recaptured (hence identifiable) easily as the birds are generally outside the burrows at this time. This would enable a mark-recapture programme to be established, and to gain a better population estimate and baseline data for modelling. At the same time, the study burrows can also be checked for breeding status, to give a more accurate estimate of breeding success. It will also provide an opportunity to recapture returning birds banded as chicks in this study.
- The summer monitoring visit should take place in February and be reduced to three weeks. This would still enable the study burrows to be monitored intensively, the adults to be identified, and the breeding status in the burrows to be determined. The April monitoring visit should remain one week long.
- The Northern Block (Tataweka) be visited in November to survey the black petrel population to gain a more accurate estimate of the population in that area.
- Census grids be established on other high points around the Mount Hobson area (e.g. Mount Heale, Mount Matawhero, Hogs Back). This would ensure that a better estimate for the black petrel population on Great Barrier Island could be made. These sites should be monitored as long as the study continues.
- Cat trapping be established over the black petrel breeding season, November to June, especially during pre-laying (November) and the fledging period (May to June).
- The walkway system be continued down Palmers (Windy Canyon) and South Fork Tracks. Construction should be completed between July and October, when the chicks have fledged and before the adults return. Known petrel burrows can be identified so that the construction team can avoid them.

7. Acknowledgements

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APPENDIX 1

Results from the burrows around Hirakimata.

Note: shaded entries are non-study burrows (cannot reach the resident birds).

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
1			Empty
2	H25408	800 g	Chick H29925
	H25438	800 g	
3	H31267	740 g	Chick H29924
	H31109	830 g	
4	H27542	810 g	Chick H29923
	H25481	870 g	
5	H31161	680 g	Non-breeder
6	H31216	790 g	Chick H29917
	H31576	750 g	
7	H31272	850 g	Chick H31952
	H30854	840 g	
8	H31103	800 g	Chick H31953
	H31273	-	
9	H25427	720 g	Non-breeder
	H29679	690 g	
10	H28015	640 g	Chick H28079
	H31584	820 g	
11	H31585	710 g	Non-breeder
	H29688	670 g	
12	H28060	610 g	Non-breeder
13	H31281	725 g	Chick H29922
	H25418	750 g	
14	H31284	820 g	Rat Predation
	H31202	820 g	
15			Empty
16	H31004	750 g	Chick H32064
	H31296	700 g	
17	H31108	800 g	Chick H32065
	H28009	700 g	
18	H31204	815 g	Infertile
	H25434	710 g	
19	H31162	760 g	Non-breeder
20	H25696	610 g	Non-breeder
	H29683	690 g	
21	H31235	800 g	Chick H29926
	H31019	860 g	
22	H31214	850 g	Chick H32055
	H25492	800 g	
23	H31157	660 g	Infertile
	H31117	840 g	
24	-	-	Crushed egg
25	H25487	820 g	Chick H29918
	H31217	865 g	
26	H23014	820 g	Chick H29915
	H31218	750 g	

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
27	H28046	770 g	Non-breeder
28	H31231	670 g	Dead chick
	H31114	750 g	
29	H31210	640 g	Dead chick
	H28004	890 g	
30	H25446	750 g	Chick H31963
	-	-	
31	H31101	900 g	Infertile
	H31237	790 g	
32 (PTG1)	H25480	770 g	Chick H32077
	H31466	750 g	
33	H31123	720 g	Chick H32093
	H31244	890 g	
34	H31121	820 g	Chick H29920
	-	-	
35	H31249	900 g	Chick H32073
	H13641	870 g	
36	H31129	860 g	Chick H28090
	H25520	710 g	
37	H31107	840 g	Dead chick
	H28036	730 g	
38	-	-	Abandoned
	-	-	
39	H25426	890 g	Chick H32080
	H31578	790 g	
40	H31111	780 g	Chick H32082
	H31122	790 g	
41	H31112	710 g	Crushed egg
	H31209	810 g	
42	-	-	Abandoned
	-	-	
43	H31586	870 g	Rat predation
	H31016	810 g	
44	H31130	900 g	Chick H28094
	H25424	790 g	
45	H29651	640 g	Non-breeder
46	H28813	770 g	Chick H28095
	H28019	680 g	
47	H31005	800 g	Chick H32054
	H31018	750 g	
48	H31003	815 g	Chick H32069
	H26991	800 g	
49	H31243	770 g	Chick H32068
	H31010	810 g	
50	H31282	710 g	Chick H32070
	H25476	800 g	

Appendix 1 *continued.*

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
51	H22169 H25582	720 g 680 g	Non-breeder
52	H31289 H31255	730 g 740 g	Chick H29917
53	H31021 H31022	810 g 760 g	Chick H29916
54	-	-	Non-breeder
55 (PTG1)	H23635 -	870 g -	Dead embryo
56 (PTG1)	H31152 H31152	800 g 800 g	Dead chick
57 (PTG1)	H28013 -	690 g -	Chick H32097
58 (PTG1)	H28029 H31205	690 g 760 g	Chick H32099
59 (PTG1)	H31125 H31220	855 g 780 g	Chick H29902
60 (PTG1)	-	-	Non-breeder
61 (PTG1)	H29684 H30878	670 g 720 g	Non-breeder
62 (PTG1)	H31257 H25486	700 g 640 g	Non-breeder
63 (PTG1)	H28055	650 g	Non-breeder
64 (PTG1)	H31286 H30861	750 g 810 g	Chick H29903
65	H31460 H27548	840 g 730 g	Chick H29929
66	- H25407	- 780 g	Chick H29932
67 (KDG1)	H31270 H31271	780 g 680 g	Chick H29934
68 (KDG1)	H31154 H31172	850 g 780 g	Chick H29938
69	H31240 H27604	790 g 740 g	Dead chick
70	H25401 H27665	750 g 880 g	Dead chick
71 (KDG1)	H31023 H31242	850 g 820 g	Chick H31958
72 (KDG1)	-	-	Non-breeder
73 (KDG1)	H28572 H31300	760 g 790 g	Chick H29950
74 (KDG1)	H29693	580 g	Non-breeder
75 (KDG1)	H30867 H31147	710 g 740 g	Non-breeder
76 (KDG1)	- H31001	- 890 g	Crushed egg

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
77 (KDG1)	H31274 H30870	710 g 760 g	Chick H31955
78 (KDG1)	H25512 H31102	730 g 720 g	Chick H31954
79 (KDG1)			Empty
80 (KDG1)	H29682 H25404	660 g 700 g	Non-breeder
81 (KDG1)	H29680	610 g	Non-breeder
82	H31253 H30889	910 g 810 g	Chick H28077
83	H25413 H31012	680 g 860 g	Rat predation
84	H29677	720 g	Non-breeder
85 (SFG1)	H25478 H31118	830 g 770 g	Chick H32057
86 (SFG1)	H25569	720 g	Non-breeder
87 (SFG1)	- H28028	- 820 g	Dead embryo
88 (SFG1)			Empty
89 (SFG1)	H31233 H30910	830 g 780 g	Chick H32059
90 (SFG1)	H25409 H25432	805 g 690 g	Chick H32060
91 (SFG1)	-	-	Non-breeder
92 (SFG1)	H31261 H31119	795 g 740 g	Chick H32063
93	H30856 H27552	840 g 750 g	Crushed egg
94	H23018 H31028	800 g 750 g	Chick H32075
95	H30880 H25425	730 g 920 g	Chick H29921
96 (PTG1)	H31011 H31287	680 g 710 g	Chick H29914
97	H30872 H31263	660 g 950 g	Chick H32085
98	H31283 H30890	700 g 790 g	Chick H32084
99	H31262 H31201	790 g 610 g	Chick H32081
100	H29660 H29667	700 g 700 g	Non-breeder
101 (KDG1)	H25692 H25588	660 g 890 g	Non-breeder
102 (KDG1)	H25511 H30866	825 g 800 g	Chick H29933

Appendix 1 *continued.*

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
103 (KDG1)	H31588 H29690	810 g 860 g	Chick H29937
104 (KDG1)	-	-	Non-breeder
105	H14018 H25444	770 g 670 g	Dead embryo
106	H31038 H25458	760 g 800 g	Crushed egg
107	H25688 -	820 g -	Chick H32071
108	H25452 H25477	850 g 790 g	Chick H32074
109	H31052 -	750 g -	Non-breeder
110 (SFG1)	H31008 H31007	800 g 820 g	Chick H32061
111 (SFG1)	H28033	620 g	Abandoned
112 (SFG1)			Empty
113 (SFG1)	H28052	850 g	Chick H32062
114 (SFG1)	H25453 H31142	700 g 720 g	Chick H32056
115	H31031	71 g	Non-breeder
116 (PTG1)	H25435 H25411	700 g 885 g	Chick H32078
117 (SFG1)	-	-	Non-breeder
118	H29672	770 g	Non-breeder
119	H25454 H31055	740 g 730 g	Chick H32094
120 (PTG1)	H28056	800 g	Non-breeder
121 (PTG1)	H31032 -	800 g -	Chick H32098
122 (PTG1)	H31051 H31050	700 g 820 g	Chick H31200
123 (PTG1)	H31053 -	880 g -	Chick H29913
124 (PTG1)	H29659 H29669 H28032	610 g 700 g 680 g	Non-breeder
125 (PTG1)	-	-	Breeder
126 (PTG1)	H29658 H25577	740 g 670 g	Non-breeder
127	H25415 H31128	910 g 860 g	Chick H28097
128	H31054 H25495	710 g 850 g	Chick H32051

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
129	H25417	670 g	Non-breeder
130	H28212 H25457	610 g 870 g	Dead embryo
131	H25421 H29692	830 g 780 g	Chick H31951
132 (KDG2)	H29681 H31568	835 g 800 g	Chick H29947
133 (KDG2)	H25430 H25507	810 g -	Non-breeder
134 (KDG2)	H27568 H31589	900 g 820 g	Chick H29946
135 (KDG2)	H25463 H25447	790 g 830 g	Chick H29942
136 (KDG2)	H29691 H29699	705 g 675 g	Non-breeder
137 (KDG2)	-	-	Non-breeder
138 (KDG2)	H25448 H31565	800 g 750 g	Chick H29948
139	H14012 H23035	670 g 710 g	Chick H32072
140 (KDG2)	H31400 H25686 H28074	640 g 850 g 680 g	Non-breeder
141 (SFG2)	-	-	Breeder
142 (SFG2)	- H28027	- 780 g	Chick H32052
143 (KDG2)	H25469 H28021	760 g 910 g	Chick H29949
144 (KDG2)	H25459 -	820 g -	Infertile
145 (KDG2)	H25474 H25504	720 g 750 g	Chick H29944
146 (KDG2)	H25460 H25473	720 g 830 g	Chick H29945
147 (KDG2)	H25461 H25482	920 g 680 g	Non-breeder
148 (KDG2)	H27534 H25483	920 g 800 g	Chick H29939
149 (KDG2)	H25507	640 g	Non-breeder
150 (KDG2)	H25471 H25493	810 g 870 g	Chick H29941
151	H25593 H29674	710 g 800 g	Chick H28096
152 (SFG2)	- H31453	- 720 g	Chick H32053
153 (SFG2)	-	-	Empty
154 (PTG1)	H25484 H25499	970 g 720 g	Dead embryo

Appendix 1 *continued.*

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
155 (PTG2)	H25497	820 g	Chick H29905
	H31574	830 g	
156 (PTG2)	H31558	810 g	Chick H29904
	H31559	720 g	
157 (PTG2)	H31573	930 g	Rat Predation
	-	-	
158 (PTG2)	H25440	750 g	Non-breeder
	H31451	690 g	
159 (PTG2)	H25441	690 g	Chick H29909
	H31557	810 g	
160	H25690	770 g	Chick H32076
	H29671	800 g	
161 (PTG2)	H25488	840 g	Chick H29911
	H25500	730 g	
162 (PTG2)	H25442	720 g	Chick H29908
	H25489	840 g	
163 (PTG2)	H25490	870 g	Crushed egg
	H25491	720 g	
164 (PTG2)	H25443	790 g	Chick H29910
	H25505	840 g	
165 (KDG2)	H29661	670 g	Non-breeder
	H29700	645 g	
166	H25437	620 g	Chick H32095
	H31136	810 g	
167	H28075	-	Non-breeder
168 (PTG1)	H25449	760 g	Chick H32096
	H31583	770 g	
169			Empty
170			Empty
171	H31110	820 g	Chick H32083
	H28006	720 g	
172	H25502	690 g	Chick H32086
	H31048	910 g	
173	H31143	730 g	Chick H28089
	H28018	790 g	
174	H27543	640 g	Non-breeder
	H28071	720 g	
175	H25503	730 g	Chick H32066
	H28001	910 g	
176 (KDG1)	H27702	760 g	Chick H31956
	H28069	800 g	
177	H31459	720 g	Chick H28084
	H31462	800 g	
178	H31168	680 g	Non-breeder
179	H31058	840 g	Dead chick
	H29697	710 g	
180	H31560	780 g	Chick H28085
	H31169	790 g	
181	H31463	800 g	Chick H28086
	H31561	790 g	
182	H28064	710 g	Non-breeder
	H29654	630 g	

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
183 (SFG1)	-	-	Chick H32058
	H25515	780 g	
184	H28014	860 g	Chick H28078
	H31596	820 g	
185 (KDG1)	-	-	Non-breeder
186	H31577	690 g	Infertile
	H29665	830 g	
187	H31047	790 g	Chick H32079
	H31452	840 g	
188	H28100	880 g	Rat predation
	H26956	620 g	
189	H25427	710 g	Non-breeder
	H28066	660 g	
190	H25518	860 g	Dead embryo
	H25519	820 g	
191 (PTG2)	H28048	700 g	Chick H29906
	H25450	780 g	
192 (SFG1)			Empty
193 (KDG2)	-	-	Non-breeder
194 (KDG2)	H31569	720 g	Abandoned
	H31570	760 g	
195	H28023	800 g	Chick H29940
	H28555	720 g	
196	H28016	760 g	Dead embryo
	H29951	860 g	
197	H28017	740 g	Non-breeder
	H29685	700 g	
198	H25699	690 g	Non-breeder
199	H28076	-	Non-breeder
	H29696	680 g	
200	H29666	620 g	Non-breeder
	H28073	730 g	
201	H31581	810 g	Chick H32067
	H28002	870 g	
202 (PTG2)	H31556	650 g	Chick H29907
	H28031	870 g	
203	H29668	610 g	
	H30930	810 g	
204 (KDG1)	H28008	700 g	Non-breeder
205	H25697	830 g	Non-breeder
	H29664	715 g	
206	-	-	Non-breeder
207 (PTG1)	-	-	Non-breeder
208 (PTG1)	H22167	770 g	Chick H29912
	H25587	760 g	
209 (KDG3)			Empty

Appendix 1 *continued.*

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
210 (KDG3)	H25691 H29663	840 g 720 g	Infertile
211 (KDG3)	H28812 H29689	890 g 810 g	Chick H29936
212 (KDG3)	H28040 H30869	830 g 810 g	Chick H29935
213 (KDG2)	H28045 H25552	850 g 600 g	Rat predation
214 (KDG2)	H25687 -	860 g -	Chick H29943
215 (SFG3)	-	-	Non-breeder
216 (SFG3)	H28051 H29673	700 g 850 g	Chick H28091
217 (SFG3)	-	-	Non-breeder
218	H28053 H25556	760 g 760 g	Non-breeder
219 (PTG3)			Empty
220 (PTG3)	-	-	Non-breeder
221 (PTG3)	H29656 H29695	650 g 740 g	Chick H32091
222	H28049 H29657	720 g -	Non-breeder
223 (SFG3)	H31598 H28068	720 g 770 g	Chick H28092
224 (PTG3)	H25553 H25564	780 g 740 g	Chick H32088
225 (SFG3)	H31600 H13634	810 g 790 g	Chick H28093
226 (PTG3)	- H28041	- 760 g	Chick H32089
227 (KDG3)	H25509 H25583	720 g 720 g	Infertile
228	H29952 H23029	840 g 850 g	Chick H29928
229 (PTG3)	H28042 H25565	880 g 650 g	Chick H32090
230 (PTG3)			Empty
231 (PTG3)	H25557 H25568	820 g 730 g	Chick H32092
232	-	-	Non-breeder
233	H29698 H25558	720 g 860 g	Chick H28087

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
234	H25559 H25571	660 g 795 g	Chick H28088
235	H28061 H28044	710 g 705 g	Non-breeder
236	-	-	Breeding
237	H25575 H29953	790 g 825 g	Chick H28081
238 (SFG1)	H28037 H29655	720 g 620 g	Non-breeder
239	H25698 H25700	680 g 740 g	Non-breeder
240	H25689 -	900 g -	Dead embryo
241	H29675	730 g	Non-breeder
242	H28062 H28099	595 g 695 g	Non-breeder
243	H25578 H22170	800 g 800 g	Chick H29930
244	H25581 H22143	820 g 720 g	Chick H29931
245 (KDG1)	H25693 H30871	720 g 790 g	Chick H31957
246 (PTG3)	H25586 -	880 g -	Chick H32087
247	H28063 H28098	680 g 705 g	Non-breeder
248	H29652 H28067	780 g 860 g	Chick H28082
249	- -	- -	Chick H28083
250	H25591 H25590	770g 880 g	Infertile
251	-	-	Non-breeder
252	H25695 H28059	580 g 755 g	Non-breeder
253	H29662 H28057	750 g 570 g	Non-breeder
254	-	-	Non-breeder
255	-	-	Non-breeder
256	H29687	730 g	Non-breeder
257	H31170 -	720 g -	Chick H28080
258 (PTG3)	-	-	Non-breeder