

Survey and monitoring of black petrels on Great Barrier Island, 2001/02

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CONTENTS

Abstract	5
1. Introduction	6
2. Objectives	6
3. Methods	7
3.1 Study burrows	7
3.2 Census grids	8
3.3 Satellite transmitters	8
3.4 Night banding	10
4. Results	10
4.1 Number of burrows in the census grids	10
4.2 Study burrows	11
4.3 Banding data	12
4.4 Population estimate	12
4.5 Satellite transmitters	12
5. Discussion	14
5.1 Census grids	14
5.2 Study burrows	14
5.3 Rat and feral cat predation	15
5.4 Chicks	15
5.5 Population estimate	15
5.6 Banding data	16
5.7 Satellite transmitters	16
5.9 Conservation	17
6. Recommendations	18
7. Acknowledgements	19
8. References	19
Appendix 1. Results from the burrows around Mt Hobson (Hirakimata)	20

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ABSTRACT

During the 2001/02 breeding season for black petrel (*Procellaria parkinsoni*), 285 burrows around the summit of Mt Hobson, Great Barrier Island, were identified and intensively monitored over summer. Only 283 burrows were included in the study and of these 192 were used by breeding pairs, 68 by non-breeding adults and the remaining 23 were empty. Several factors affecting black petrel breeding success were noted. In April, 135 chicks were present in the study burrows, corresponding to a breeding success of 70%. Nine census grids were also monitored. A total of 125 burrows were located within the grids and, of these, 81 burrows were used for breeding. An extra three burrows were found in three grids, two of which were newly dug and a previously investigated burrow was now active. Extrapolating from these grid burrows we estimate that the black petrel population around the peak of Mt Hobson consists of 4000 birds. Nine chicks from earlier breeding seasons have been recovered within the Mt Hobson colony area. Of these, three have paired and successfully bred. A male pre-breeder (banded as a chick during the 1996/97 season) was caught on a longline vessel off the Kermadec Group. 'Dummy' satellite transmitters were placed on 24 adults, each incubating an egg. Only three transmitters were not recovered. One transmitter was seen by a Ministry of Fisheries observer near the West Norfolk Ridge (33° 54.6' S, 167° 56' E).

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

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1. Introduction

The black petrel (*Procellaria parkinsoni*), an endemic seabird, breeds on Little and Great Barrier Islands, New Zealand. On Great Barrier Island the main breeding area is around the summit of Mt Hobson (Hirakimata). Monitoring during the 2001/02 breeding season is a continuation of a study begun in 1995/96 (Bell & Sim 1998a, 1998b, 2000a, 2000b, 2000c, 2002), and the data collected will be added to existing information on the black petrel population. This study is designed to ensure that any population changes are detected in time to implement appropriate management strategies.

2. Objectives

The main objective of this study was 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. During discussions with the Seabird Working Group (DOC), extensions to the programme were recommended. These were added to this season's programme.

The study objectives were:

- To monitor a sample of black petrel burrows within the main breeding area. To band all adults present in the burrows during November/December and January/February and all remaining fledgling chicks during April.
- To determine breeding success in the sample of long-term study burrows. Causes of breeding failure, such as predation or disappearance of parents, to be recorded.
- To monitor and re-survey the census grids and study area for new burrows. To 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 Mt Hobson breeding area.
- To undertake a mark/recapture programme at the beginning of the breeding season (November/December) to determine pre-breeder survival, age of first return and age of first breeding; and to band as many birds as possible.
- To confirm the breeding status of adults during each visit to the colony (i.e. to monitor the study burrows at the beginning, middle and end of the breeding season, record breeding status and, where possible, identify the sex of the resident adult and to band all adults present in the burrows).
- To increase the frequency of night banding during the entire breeding season.
- To establish whether satellite transmitters can be carried by black petrels to determine foraging range in the future (i.e. trial 'dummy' transmitters).

3. Methods

3.1 STUDY BURROWS

The study site on Mt Hobson (Fig. 1) was visited from 25 November to 5 December 2001. During this visit the study burrows ($n = 282$) were checked for presence of adults and eggs. Any adult present was removed from the burrows, banded (or had the band number recorded if a recapture) and sexed by viewing the cloaca (if swollen, this indicates the bird is a female; the cloaca is particularly obvious immediately after egg laying), and returned to the burrow. The presence of an egg was noted.

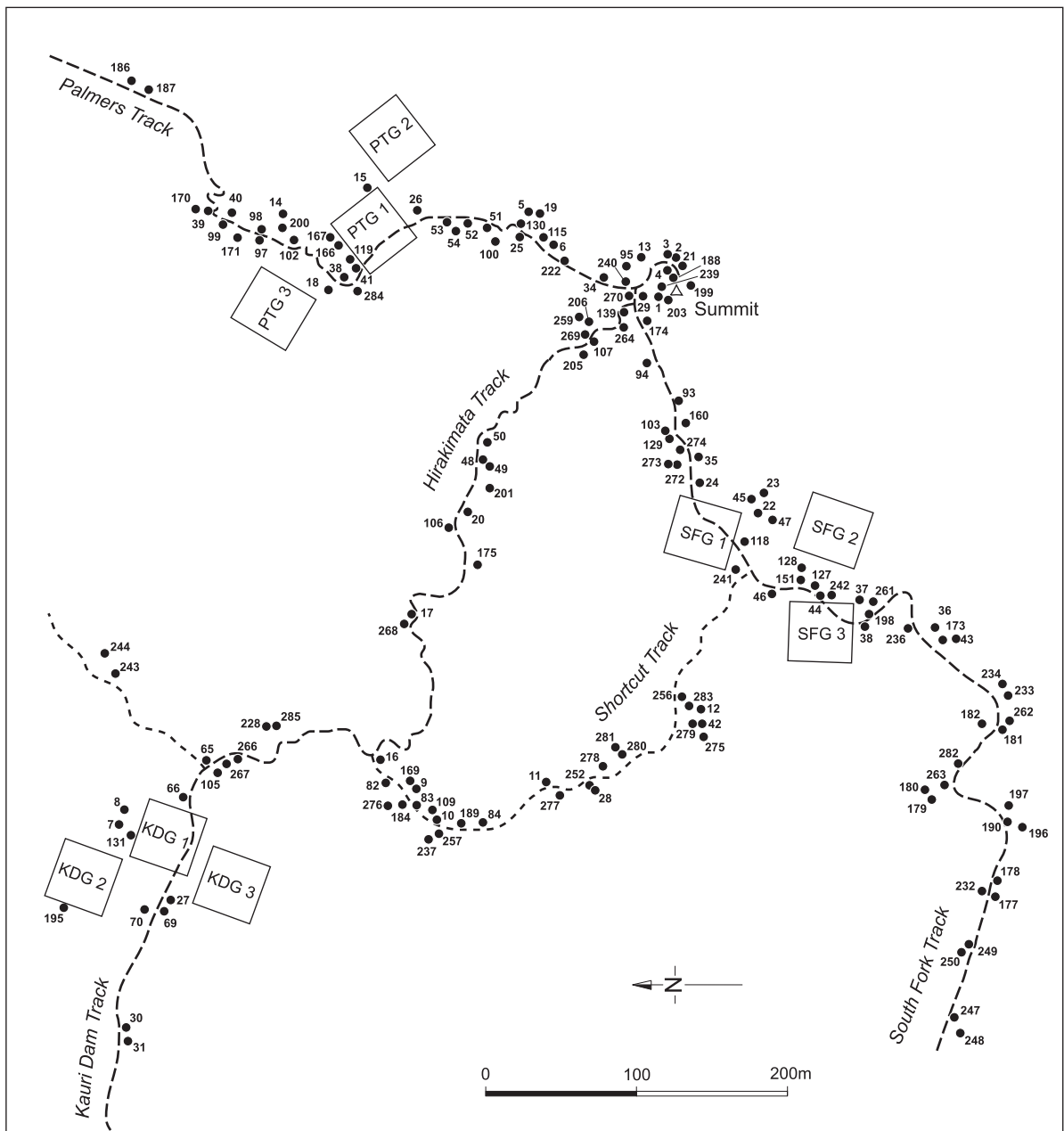
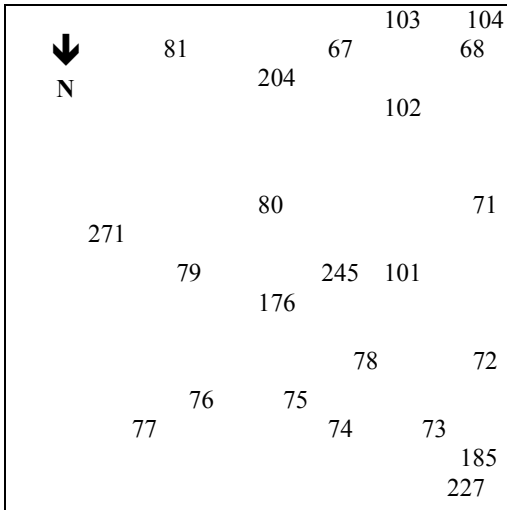
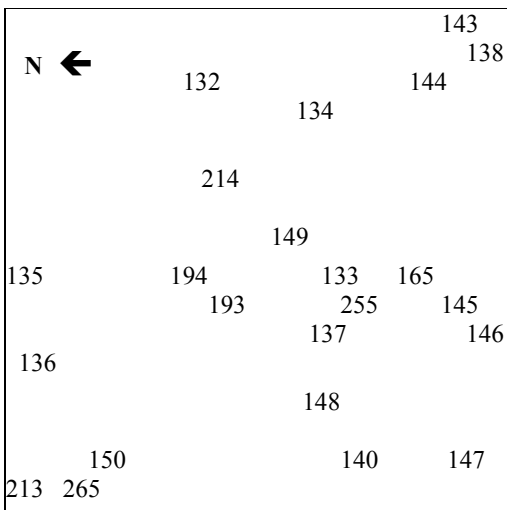


Figure 1. Location of the burrows and census grids around the summit area of Great Barrier Island. Figs 2–4 show the burrow numbers within each of the nine census grids.

Kauri Dam grid one (KDG1)



Kauri Dam grid two (KDG2)



Kauri Dam grid three (KDG3)

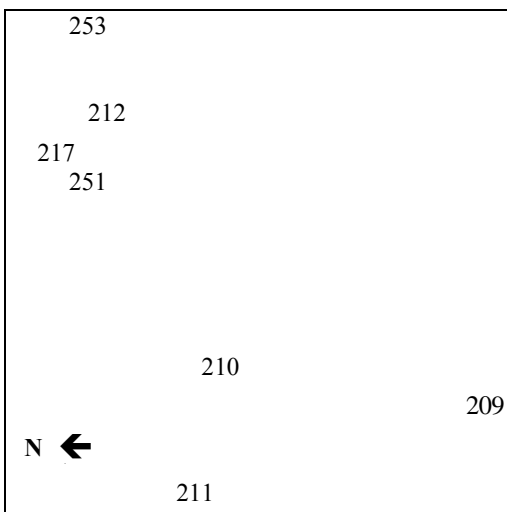


Figure 2. Location of Kauri Dam grid sites (each grid is 40 × 40 m).

During the next visit to the colony (15 January to 16 February 2002), the number of study burrows was increased from 282 to 285 (Figs 1-4). 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 was covered by a piece of plywood, with soil and debris camouflaging the cover.

As in the first visit, any adult present in the burrow was removed, banded (or the band number recorded if a recapture), 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 2002) and all remaining fledgling chicks were banded. This information was used to determine breeding success.

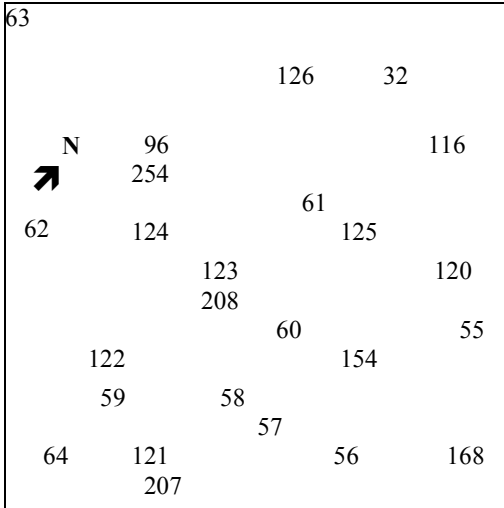
3.2 CENSUS GRIDS

The nine census grids (each 40 × 40 m) set up around Mt Hobson were systematically searched (at 1 m intervals) to locate any new burrows and to determine this season's occupancy (Figs 1-4). Any birds present in a burrow within the census grids were dealt with as explained in Section 3.1.

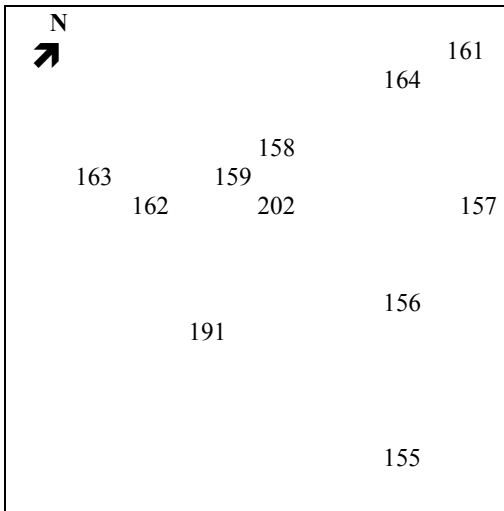
3.3 SATELLITE TRANSMITTERS

Each dummy transmitter weighted 22 g, had a streamlined front and measured 20 mm × 66 mm × 13 mm with a 'battery' (16 mm × 25 mm × 7 mm) protruding out from the lower right side and a 200 mm length of wire to represent the antenna, similar to the design in Söhle et al. (2000). Twenty-four dummy transmitter models were used. Of these, four were attached with glue only, eight with tape only (using either Tesa™ or Duct™ tape) and 12 with a combination of tape, sewing and glue (using a design developed by I. Söhle, pers. comm.). Ten transmitters were attached on 20 January 2002 and the remaining 14 on 21 January 2002. Five were placed on known males and one on a known female; the other birds were of unknown sex. Transmitters were placed on incubating birds and, where possible, were left on for one foraging trip only. The burrows were monitored daily (and on some nights if required to recapture a parent feeding a chick). As soon as the parent returned from the foraging trip (varied between 7-17 days), the transmitter was removed.

Palmers Track grid one (PTG1)



Palmers Track grid two (PTG2)



Palmers Track grid three (PTG3)

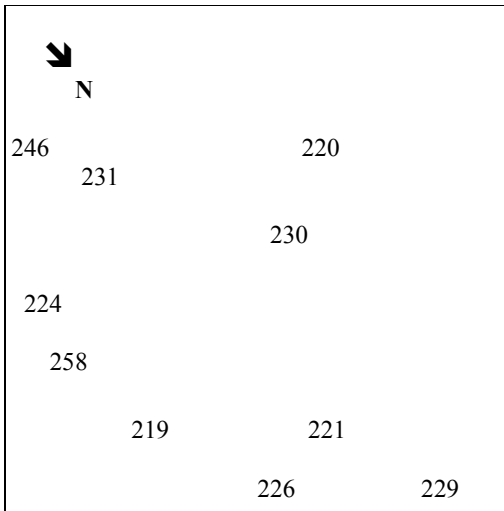
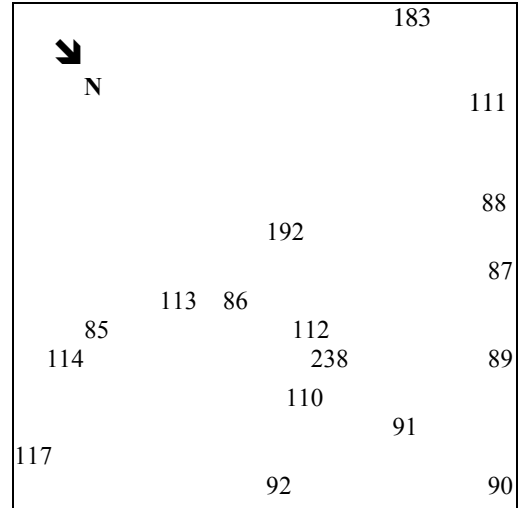
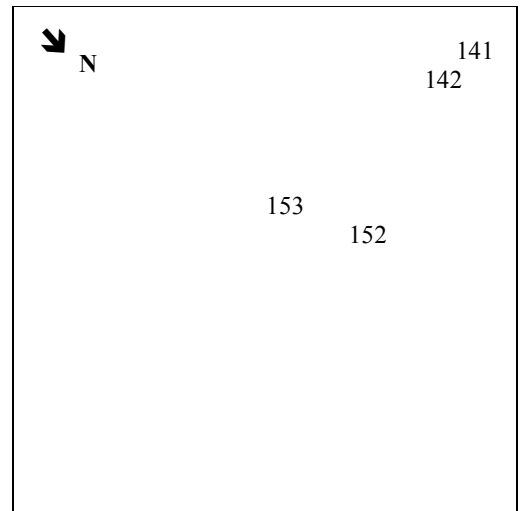


Figure 3. Location of Palmers Track grid sites (each grid is 40 × 40 m).

South Fork Track grid one (SFG1)



South Fork Track grid two (SFG2)



South Fork Track grid three (SFG3)

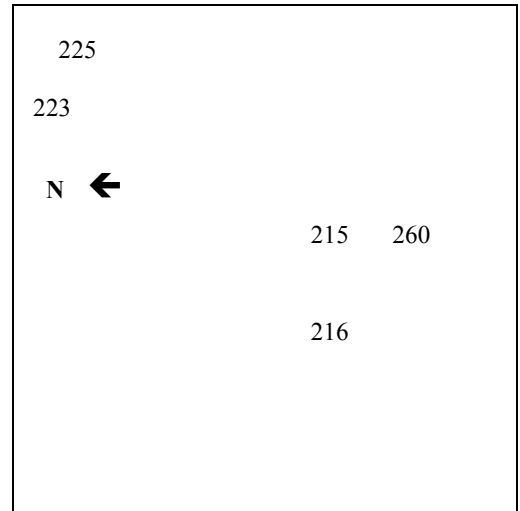


Figure 4. Location of South Fork Track grid sites (each grid is 40 × 40 m).

3.4 NIGHT BANDING

In both the November/December 2001 and January/February 2002 visits to the study area, night banding was undertaken. This involved searching the study area by walking the track system and capturing any adult on the surface. Several nights were also spent at known launch sites and birds were captured while taking off or landing. All birds were banded or had their band numbers recorded. During the November/December 2001 visit, sex was determined if possible (by cloacal inspection).

4. Results

4.1 NUMBER OF BURROWS IN THE CENSUS GRIDS

A total of 125 burrows were found in the nine census grids (Table 1, Figs 2–4). Of these, 81 burrows were used by breeding pairs, 30 were used by non-breeding adults and 14 burrows were empty. There were also 6 ‘potential’ burrows within the grids, which were not included in any burrow estimate (we define ‘potential’ burrows as those which have been investigated and/or preliminarily dug out, but were not yet being used by breeding or non-breeding petrels).

Extrapolating from the grids, the ‘useable’ burrow density was 87 (\pm 17) burrows/ha, with 56 (\pm 13) burrows/ha used for breeding, 21 (\pm 6) burrows/ha

TABLE 1. TYPE AND NUMBER OF BURROWS WITHIN THE CENSUS GRIDS ON GREAT BARRIER ISLAND.

AREA AND BURROW TYPE	GRID ONE							GRID TWO				GRID THREE		
	95/ 96	96/ 97	97/ 98	98/ 99	99/ 00	00/ 01	01/ 02	98/ 99	99/ 00	00/ 01	01/ 02	99/ 00	00/ 01	01/ 02
Kauri Dam grid														
Empty	1	1	1	1	3	1	4	0	0	0	1	2	1	1
Breeding	8	10	8	12	11	12	11	15	16	13	16	3	3	4
Non-breeding	5	5	7	6	8	9	8	4	5	9	6	0	3	2
TOTAL	14	16	16	19	22	22	23	19	21	22	23	5	7	7
Palmers Track grid														
Empty	3	0	0	1	1	0	1	0	0	0	0	0	2	3
Breeding	7	13	13	15	18	16	19	10	9	10	10	9	6	6
Non-breeding	3	6	7	6	5	9	5	1	2	1	1	0	2	1
TOTAL	13	19	20	22	24	25	25	11	11	11	11	9	10	10
South Fork Track grid														
Empty	2	1	1	0	1	3	4	1	1	1	0	1	0	0
Breeding	5	12	11	11	10	10	8	2	1	3	3	3	3	4
Non-breeding	2	1	3	5	6	4	5	1	2	0	1	0	1	1
TOTAL	9	14	15	16	17	17	17	4	4	4	4	4	4	5
ANNUAL TOTALS	36	49	51	57	63	64	65	34	36	37	38	18	21	22

for non-breeding and $9 (\pm 1)$ burrow/ha that were empty. Over the past three seasons when the nine census grids have been monitored, the densities have been very similar ('useable' ranging from 81 to 87 burrows/ha; breeding, 53-56 burrows/ha; non-breeding, 19-26 burrows/ha; and empty, 6-10 burrows/ha (Bell & Sim 2000c, 2002; Table 1)).

4.2 STUDY BURROWS

Within the 283 study burrows (in those where birds could be reached), 192 contained breeding birds, 68 contained non-breeding birds, and 23 were empty. There were 57 failures due to various factors (loss of eggs, predation, infertile egg, etc., Table 2). This corresponds to a breeding success of 70% (Table 2).

Both parents were identified in 158 of the breeding study burrows. There were 30 burrows where only one parent was identified and 4 burrows where no parents were identified (Appendix 1). Of the non-breeding burrows, there were 35 burrows where two or more birds were identified, 19 where one was identified and 14 where no birds were present during the day, but the burrows were active at night (Appendix 1).

TABLE 2. BREEDING SUCCESS AND CAUSES OF MORTALITY IN THE STUDY BURROWS ON GREAT BARRIER ISLAND.

		96/97	97/98	98/99	99/00	00/01	01/02
Number of study burrows		118	137	197	248	255	283
Eggs	laid	92	95	142	178	168	192
	predation (rat)	6	1	2	9	6	5
	crushed ^a	5	0	1	10	6	5
	abandoned	2	1	5	1	3	9
	infertile	6	4	12	6	8	3
	dead embryo (at various stages)	0	8	6	13	9	14
	disappeared egg ^b	0	0	0	0	0	11
Chicks	hatched	73	81	116	139	136	145
	predation (rat)	0	0	2	0	0	0
	predation (cat)	0	0	2	2	1	2
	died (disease)	1	0	0	0	0	0
	died (starvation)	0	1	0	0	0	0
	died (unknown causes)	0	0	3	6	7	8
	fledged ^c	72	80	109	131	128	135
Overall breeding success (%)		78	84	77	73.5	76	70

^a Eggs have been crushed by the parents or during fighting with interloping birds and only shell fragments recovered from the burrow. Some may have been predated by rats, infertile or contained an embryo which died.

^b Eggs were present in November/December, but gone when first checked in the following January. Many of the burrows had been cleaned out and the adults were not caught again.

^c All chicks still present at end of April trip. It is assumed all will fledge safely.

4.3 BANDING DATA

There were 462 adults identified during the 2001/02 season (Table 3). Of these, 446 were from the study burrows, with 344 already banded and 102 banded this season. Sixteen other adults were caught (2 already banded) from non-study burrows around the summit area. The 135 chicks present in the study burrows and 23 chicks in non-study burrows were also banded (Table 3).

TABLE 3. BANDING AND RECAPTURE DATA FOR BLACK PETRELS FROM GREAT BARRIER ISLAND.

	95/96	96/97	97/98	98/99	99/00	00/01	01/02
Recaptures of birds banded prior to 1995	18	30	23	22	28	26	26
Recaptures of birds banded in 1995/96	-	14	14	14	17	15	13
Recaptures of birds banded in 1996/97	-	-	113	86	85	74	75
Recaptures of birds banded in 1997/98	-	-	-	32	32	30	33
Recaptures of birds banded in 1998/99	-	-	-	-	95	82	71
Recaptures of birds banded in 1999/00	-	-	-	-	-	86	77
Recaptures of birds banded in 2000/01	-	-	-	-	-	-	51
Total recaptures	18	44	150	154	257	313	346
Number of new adults (banded that season)	41	180	60	129	149	97	116
Total adults	59	224	210	283	406	410	462
Number of chicks (banded that season)	59	69	85	117	133	137	158
Total number of birds	118	293	295	400	539	547	620
Number of chicks recaptured alive (returned to colony)	-	-	-	-	1	1	9
Band recoveries from dead birds	-	1	1	-	2	1	2

4.4 POPULATION ESTIMATE

Extrapolating from the census grid data to the 30 ha around the summit of Mt Hobson, the black petrel population can be estimated at 4000 ± 867 birds (Table 4). This consists of 625 ± 168 non-breeding birds and 3375 ± 699 breeding adults. Over the past three seasons when the nine census grids have been monitored, the population estimates have been very similar (ranging from 3917 to 4000 birds (Bell & Sim 2000c, 2002; Table 5)).

4.5 SATELLITE TRANSMITTERS

Once the 24 'dummy' transmitters were attached, the birds remained in the burrows incubating their eggs for between 1 and 10 days. Two birds abandoned their eggs, each for one night only, and the transmitters were removed on their return. One of these birds abandoned the egg again and the egg failed to hatch. With the exception of this abandoned egg, attaching the transmitters did not generally affect breeding outcome. All but three eggs hatched, and of those one

TABLE 4. 2001/02 DENSITIES AND POPULATION ESTIMATES OF BLACK PETRELS IN THE 30 ha SUMMIT AREA AROUND MT HOBSON, GREAT BARRIER ISLAND.

	DENSITY (no./ha)		POPULATION (30 ha)	
	Breeding adults	Non-breeding adults	Breeding adults	Non-breeding adults
Grid One (KDG1)	100	31.25	3000	937.5
Grid Two (KDG2)	37.5	6.25	1125	187.5
Grid Three (KDG3)	50	6.25	1500	187.5
Grid One (PTG1)	237.5	31.25	7125	937.5
Grid Two (PTG2)	125	6.25	3750	187.5
Grid Three (PTG3)	75	6.25	2250	187.5
Grid One (SFG1)	137.5	50	4125	1500
Grid Two (SFG2)	200	37.5	6000	1125
Grid Three (SFG3)	50	12.5	1500	375
Mean	112.5 ± 25.5	20.83 ± 6.25	3375 ± 698.8	625 ± 168.3
Total population estimate range			3133–4867 adults	
2001/02 Population estimate (Breeder and non-breeder)			4000 ± 867 adults	

TABLE 5. ANNUAL MEAN POPULATION ESTIMATE SINCE 1999/2000 BREEDING SEASON FOR BLACK PETREL, USING THE 30 ha AREA AROUND MT HOBSON, GREAT BARRIER ISLAND.

YEAR	BREEDING ADULTS	NON-BREEDING ADULTS	TOTAL POPULATION	RANGE
1999/2000	2938 ± 800	583 ± 186	3521 ± 986	2535–4507
2000/01	2792 ± 676	792 ± 235	3584 ± 911	2673–4495
2001/02	3375 ± 699	625 ± 168	4000 ± 867	3133–4867

was infertile, one died at the pipping stage, and the third was the abandoned egg.

Twenty-one transmitters were recovered (20 in February 2002 and 1 in April 2002). Three transmitters were lost at sea. Two birds were not recaptured, although one (with a tape-only transmitter) continued to feed its chick, but did not return when we were monitoring the burrow at night, and the other's egg died at pipping and its partner cleaned the burrow out before its return (this glue-only transmitter was recovered in the burrow in April). It was thought that the bird with the missing tape-only transmitter could have removed it, as the bird was very aggressive and had spent time pecking at it while still in the burrow incubating. At least five of the transmitters showed signs of being pecked by the birds.

The transmitters were easily attached and removed. The quickest method was glue only (c. > 5 min), followed by tape only (> 10 min), and then the combination method (10–15 min). The glue-only method was the least successful, with two transmitters lost at sea and one recovered in a burrow. One tape-only transmitter was also lost at sea. One of the combination transmitters (tape/sew/glue) nearly fell off the bird, with only a small section of tape

attached on recapture. If this bird had returned to sea, it was thought that this transmitter would have been lost.

The length of time at sea (foraging trip) ranged from 1 to 17 nights. One transmitter was seen by a Ministry of Fisheries observer on 22 January 2002 at 33° 54.6´S, 167° 56´E (West Norfolk Ridge). At the time at least 25 black petrels were observed near the boat, feeding on offal and discards (R. Blezard pers. comm.).

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, 2002).

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 three periods of 2001/02 breeding season, 25 November to 5 December 2001, 15 January to 16 February 2002 and 2-6 April 2002. Three new burrows were located in the grids (one in KDG1, KDG2 and SFG3), with two of these being occupied by breeding pairs, and the other by a non-breeding bird. The non-breeding bird had excavated the burrow this season. As this study has continued, the number of burrows found within the grids has risen each year (Table 1). It appears that pre-breeding and non-breeding birds are returning to their natal area and are starting to excavate new burrows.

During the monitoring this 2001/02 season, six potential burrows were identified within the nine grids. All had been identified in earlier breeding seasons and were still not in use.

5.2 STUDY BURROWS

A further 28 study burrows were added this 2001/02 season to the 255 previously identified. There were 135 breeding successes and 57 breeding failures this season, equating to an overall breeding success rate of 70%. This breeding success is slightly lower than in previous years (Table 2), but still higher than reported in the earlier research by Imber (1987) in 1977 (50%) and in 1978 (60%) and Scofield (1989) in 1988/89 (62%). The lower success rate for 2001/02 may be explained by the November/December trip to the colony. In previous years an egg laid early in the season which may already have failed, been crushed and removed from the burrow by the time we visited the colony in January, would not have been recorded. This 2001/02 season however, 11 eggs that were present in November/December 2001 had disappeared by the

return visit in January 2002 (6%). Adding this percentage to the breeding success rate would place the season within the range of previous years. It will be interesting to continue this monitoring stage to enable a 'correction' factor to be added to the earlier seasons.

5.3 RAT AND FERAL CAT PREDATION

There were two incidents of cat predation (1%) on chicks, while rats predated 3% of the eggs laid within the study burrows this season. As in 2000/01 season, both cat predation events occurred along Palmers Track. Juvenile petrels are vulnerable to feral cat predation as soon as they leave the burrows to strengthen their wings and practise flying (Warham 1996). It is important to continue cat-trapping in the area.

5.4 CHICKS

In April, 135 chicks were still present in the study burrows. As in the two previous seasons, several chicks were quite small or in poor condition (e.g. lethargic, no pin feathers, poor feather development). This may suggest that only one parent is feeding them or, if both parents are still feeding, that the food quality (or quantity) has been reduced. One chick had what appeared to be avian pox. This chick was banded, but may not survive. While slow development and poor condition may not prevent fledging, it would make it unlikely that the bird could 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, feather development and weight) appears to have deteriorated over the past four seasons. It would be interesting to determine whether the adults are having problems locating adequate quantities of food, having to travel further to feed and whether food quality was good enough to raise a healthy chick.

5.5 POPULATION ESTIMATE

Extrapolating from the nine census grids (1.44 ha in total) to the Mt Hobson summit area (30 ha), the population of the Great Barrier Island black petrels is estimated at 4000 birds. This estimate is similar to those for the 1999/2000 and 2000/01 seasons (Table 5), but less than for earlier years (Bell & Sim 1998a, 1998b, 2000a, 2000b). This is likely to be a direct result of increasing the number of census grids from three to nine and decreasing error margins. Increasing the number of 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.

To expand this population estimate to Great Barrier Island as a whole, further census grids would have to be established in other areas on the island. Black petrels are known to nest in the Northern Block (Tataweka), other high points

around the summit area, in small pockets of private land, and recently, towards the southern end of the island. Census grids or further intensive surveys in these areas would give a better idea of density and range around the island. Increasing the number of census grids using other areas around the summit would refine accuracy to the population estimate and might enable a population estimate for the entire island to be extrapolated from these multiple grids (in each known black petrel breeding area). These grids could be established on or near the Hogs Back, Mt Heale and Mt Matawhero.

5.6 BANDING DATA

A total of 620 birds were identified this season. Of these, 462 were adults and 158 were fledglings. There were 346 recaptures of previously banded birds and of these nine were returned chicks; of these, two were female and seven were males. These chicks had been banded in the 1995/96 (2), 1996/97 (2) and 1997/98 (5) breeding seasons. Three of them were breeding (only one successfully raised a chick), which gives ages of first recorded breeding being at five years (two chicks) and six years (one chick). Both females and five of the seven males were recaptured in their natal area (less than 50 m from their 'hatching' burrow). The remaining males were caught 150 m and 500 m away from their natal areas. It is important to monitor for more returned chicks throughout the summit area.

5.7 SATELLITE TRANSMITTERS

The transmitter trial was very successful. The dummy transmitters were easily attached and removed and, of the 24 applied, 21 were recovered. The transmitters did not appear to affect the outcome of breeding.

The quickest method was glue only; however, this was the least successful, with two transmitters lost at sea. Although relatively easy to remove, the construction (material attached to the base of the transmitter) meant it would be difficult to reuse in the same field season (as is hoped to do when using 'real' transmitters). Another important factor is the amount of glue, as too much can melt the transmitter and even burn the skin (both birds and people).

The tape-only method was also relatively quick to attach and detach, followed the combination method. The combination method was the most awkward, requiring tape, needles, strong cotton and glue. Although a tape-only transmitter was lost, this was the easiest method to manage in the field (both attaching and removing) requiring only a roll of tape.

It would be possible to get information on short-term foraging trips (1-12 days) during the breeding season when satellite transmitters become small enough to fit black petrels (approximately 25 g). At present, satellite transmitters can be placed on Westland petrels (*Procellaria westlandica*) and, as technology develops, it should be possible to fit them on black petrels. For this trial the transmitters weighed 22 g, which is just over 3% of the average weight of a breeding black petrel (700 g) and within the recommended range for size and

weight of transmitters (5% of the bird's body weight, C.J.R. Robertson, pers. comm.). However, most transmitters weigh over this at present. It is important to trial 'dummy' transmitters further to determine behavioural changes during incubation and chick rearing. It is also important to investigate the possibility of the black petrels wearing the transmitters for multiple foraging trips to determine whether attachment for longer terms affects the behaviour of the birds, or their survivorship or attendance at the colony, as has been shown in sooty shearwaters, *Puffinus griseus* (Söhle et al. 2000).

5.9 CONSERVATION

Large numbers of the public continue to visit Mt Hobson and, as in other breeding seasons, 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 burrows. However, serious erosion continues to occur along the summit ends of the South Fork and Palmers Tracks (E. Bell, pers. obs.) Extended walkway construction in these areas is recommended. This should be done with full consultation with the authors to prevent the accidental destruction of burrows, since certain places along these tracks have high burrow densities.

Although new signage has been placed close to the summit, elsewhere old illegible interpretive signs still need to be replaced on Great Barrier Island. With the high number of visitors to the island, this is an excellent opportunity to increase public awareness of endemic species and conservation issues that affect them. This is particularly important in relation to littering and public fouling, which continues to be a problem in the summit area.

A male pre-breeder (banded as a chick during the 1996/97 season, H31091) was caught on a longline vessel off the Kermadec Group (C.J.R. Robertson, pers. comm.). This bird was likely to have been on its first return (age 4 years) to New Zealand. Bycatch of black petrels on the domestic longline fishing industry has been recorded previously (Robertson et al. 2003). Black petrels caught on longlines between December to June could be incubating an egg and/or feeding a chick. Not only would this result in a breeding failure, reducing overall productivity and recruitment, but it directly decreases adult survivorship. 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 longlines, 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, recruitment, mortality and productivity. A population model will assess factors affecting the black petrel population and help to determine the overall effects of bycatch in the longline fishing industry.

6. Recommendations

Monitoring of the black petrel population (using the study burrows) should continue at Great Barrier Island until 2005/06. This will ensure adequate comparative data are collected to determine the population dynamics of its black petrels, in particular the development of a population model to determine survivorship, mortality and the effects of predation, longline fishing and other environmental factors.

The November/December visit to the study area should continue. This would allow a large number of birds to be banded or recaptured easily, as the birds are generally outside the burrows at this time. It would also enable a mark-recapture programme to be established. At the same time, the study burrows could be checked for breeding status, to give a more accurate estimate of breeding success. This would also provide a chance to recapture returning birds banded as chicks.

The January/February visit should continue and remain at three weeks duration. This would still enable the study burrows to be monitored intensively, allow the adults to be identified and determine breeding status in the burrows. The April period should continue and remain one week long. This would allow time to band the surviving chicks.

The dummy satellite transmitter trial should be repeated, with transmitters being placed on the birds in December and removed in January/February to determine by which attachment methods they stay secure in the long term.

A sample of 25 breeding birds and 25 non-breeding birds should be colour-marked (with dazzle spray) to determine foraging locations, using sightings from Ministry of Fisheries observers and the public.

The Northern Block (Tataweka) should be visited in November/December to survey the black petrel population to gain a more accurate estimate of the population in that area.

Census grids should be established on other high points around the Mt Hobson area (e.g. Mt Heale, Mt Matawhero, Hogs Back). This will ensure that a better estimate of the black petrel population on Great Barrier Island can be made. These sites should be monitored as long as the study continues.

Cat-trapping should 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 down Palmers (Windy Canyon) and South Fork Tracks should be continued. 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 burrows around Mt Hobson (Hirakimata)

Note that bold entries are non-study burrows (i.e. cannot reach the resident birds) and those study burrows within census grids have the location noted (PTG1, 2, 3; SFG1, 2, 3 or KDG1, 2, 3).

BURROW	BAND	OUTCOME
1	H32013 H32050	Non-breeder
2	H25408 H32008	Chick H32909
3	H31382 (M) H31109 (F)	Non-breeder
4	H31972 (M) H23017 (M)	Crushed egg
5	H31020 (F) H31161 (M)	Chick H32976
6	H31291 H31576	Non-breeder
7	H31272 H30854	Dead embryo
8	H31103 H31273	Chick H33069
9	H25427 (M) -	Abandoned
10	H32901 H32003	Non-breeder
11		Empty
12	H31194 (M) H28060 (F)	Dead chick
13	H31281 (M) H25418 (F)	Chick H32932
14	H31284 (F) H31202 (M)	Chick H32933
15		Empty
16	H31004 H32002	Dead embryo
17	H31966 (M) H28009 (F)	Chick H32988
18	H31204 H25434	Dead embryo
19	H31971 (F) H31162 (M)	Chick H32975
20	H25696 H29683	Chick H32986
21	H31235 H31019	Chick H32927
22	H31214 H25492	Chick H33030
23	H31157 (F) -	Disappeared egg

BURROW	BAND	OUTCOME
24	-	Non-breeder
25	H25487 H31217	Chick H32978
26	H23014 H31218	Chick H32971
27	H28046 (M) -	Rat predation
28	H31114 (M) -	Disappeared egg
29	H31210 H28004	Disappeared egg
30	H25446 H25445	Chick H33048
31	H31101 (M) -	Abandoned
32 (PTG1)	H25480 (M) -	Dead embryo
33	H31244	Non-breeder
34	H31121 H31248	Chick H32915
35	H32024 H32040 H32045	Non-breeder
36	H31129 H25520	Chick H33008
37	H31107 (F) H28036 (M)	Chick H32998
38		Empty
39	H25426 (M) H31578 (F)	Dead chick
40	H31111 (M) H31122 (F)	Chick H32919
41	H31112 (M) -	Chick H32952
42	H29676 (M) H32004 (F)	Chick H32997
43	H31016 (M)	Non-breeder
44	H31130 H25424	Chick H33016
45	H31995	Non-breeder
46	H28813 (M) H28019 (F)	Non-breeder
47	H31005 H31018	Chick H33031

BURROW	BAND	OUTCOME
48	H31003 (M) H26991 (F)	Disappeared egg
49	H31243 H31010	Chick H32984
50	H31282 H25476	Chick H32983
51	H29670 (F) -	Chick H32973
52	H31289 H31255	Chick H32972
53	H31021 H31022	Chick H32970
54		Empty
55 (PTG1)	H23635 (M) -	Chick H32954
56 (PTG1)	H31151 (F) H31152 (M)	Abandoned
57 (PTG1)	H28013 (F) H31153 (M)	Chick H32955
58 (PTG1)	H28029 H31205	Chick H32958
59 (PTG1)	H31125 H31220	Chick H32960
60 (PTG1)	H31034 (M) H25456 (F)	Disappeared egg
61 (PTG1)	H29684 (F) H30878 (M)	Abandoned
62 (PTG1)	H31257 (M) H25486 (F)	Chick H32969
63 (PTG1)	H28055 (M) -	Cat predation
64 (PTG1)	H31286 (F) -	Abandoned
65	H31460 H27548	Dead embryo (at pipping)
66	H31990 H31999	Non-breeder
67 (KDG1)	H31270 H31271	Chick H33039
68 (KDG1)	H32005 (M) H31172 (F)	Non-breeder
69	H27604 (M) H31240 (F)	Chick H33047
70	H31992 (F) H27665 (M)	Non-breeder
71(KDG1)	H31023 H31242	Chick H33063
72(KDG1)	H32907	Non-breeder
73(KDG1)	H28572 (M) H31300 (F)	Chick H33068
74(KDG1)	H31974 H29693	Non-breeder
75(KDG1)	H30867 H31147	Non-breeder

BURROW	BAND	OUTCOME
76 (KDG1)	H25402 (F) H31001 (M)	Non-breeder
77 (KDG1)	H25407 (F) H30870 (M)	Non-breeder
78 (KDG1)	H25512 H31102	Chick H33070
79 (KDG1)		Empty
80 (KDG1)	H29682 (F) H25404 (M)	Chick H33065
81 (KDG1)	H31155 (F) H28046 (M)	Non-breeder
82	H31978 (F) H30889 (M)	Non-breeder
83	H25413 (F) H31012 (M)	Chick H32989
84	H31179 (F) H29677 (M)	Dead embryo
85 (SFG1)	H31406 (F) H31118 (M)	Non-breeder
86 (SFG1)		Empty
87 (SFG1)	H32023 H32033	Non-breeder
88 (SFG1)		Empty
89 (SFG1)	H31233 (M) H30910 (F)	Chick H33025
90 (SFG1)	-	Non-breeder
91 (SFG1)	-	Non-breeder
92 (SFG1)	H31261 (F) H32928 (M)	Rat predation
93	H27552 (F) H30856 (M)	Chick H33022
94	H23018 (M) H31028 (F)	Chick H33021
95	H30880 (M) H25425 (F)	Chick H32923
96 (PTG1)	H31011 (M) H31268 (F)	Chick H32951
97	H30872 (M) H31263 (F)	Cat predation
98	-	Non-breeder
99	H31262 (M) H31201 (F)	Chick H32942
100	H29660 (M) H29667 (F)	Chick H32974
101 (KDG1)	H25692 (F) H25588 (M)	Chick H33066
102 (KDG1)	H25511 (M) H30866 (F)	Chick H33046
103 (KDG1)	H31588 H29690	Chick H33045
104 (KDG1)		Empty
105		Empty
106	H31038 H25458	Dead embryo

BURROW	BAND	OUTCOME
107	H25688 (M)	Non-breeder
108	H25417	Non-breeder
109	H31052 (F) H25428 (M)	Chick H32990
110 (SFG1)	H31008 H31007	Disappeared egg
111 (SFG1)	H31986 (M) H28033 (F)	Chick H33027
112 (SFG1)		Empty
113 (SFG1)	H31987 (M)	Non-breeder
114 (SFG1)	H25453 (M) H31142 (F)	Chick H33029
115	H31031 (M) H32022 (F)	Non-breeder
116 (PTG1)	H25411 H25435	Non-breeder
117 (SFG1)	H31984 (F) -	Disappeared egg
118	H31985 (M) -	Chick H33035
119	H25454 (F) H31055 (M)	Chick H32953
120 (PTG1)		Empty
121 (PTG1)	H25455 H31032	Chick H32957
122 (PTG1)	H31051 H31050	Chick H32959
123 (PTG1)	H31053 (M) H31246 (F)	Chick H32967
124 (PTG1)	H28032 (M) -	Chick H32968
125 (PTG1) –		Breeder
126 (PTG1)	H25577 (M) -	Abandoned
127	H25415 (M) H31128 (F)	Chick H33017
128	H31054 (M) H25495 (F)	Dead chick
129		Empty
130	H28212 (M) H25457 (F) H32007	Chick H32977
131	H25421 H31996	Abandoned (handler disturbance)
132 (KDG2)	H29681 H31568	Dead embryo (at pipping)
133 (KDG2)	H25430 (M) H32027 (F)	Infertile
134 (KDG2)	H25401 (F) H32001 (M)	Non-breeder
135 (KDG2)	H25463 H25447	Chick H33054

BURROW	BAND	OUTCOME
136 (KDG2)	H29691 (F) H29699 (M)	Chick H33053
137 (KDG2)	H25494 (M) H31572 (F)	Chick H33057
138 (KDG2)	H25448 H31565	Crushed egg
139	H14012 (F) H23035 (M)	Chick H32980
140 (KDG2)	H31377 (M) H25686 (M) H32047	Non-breeder
141 (SFG2) –		Breeder
142 (SFG2)	H28026 H28027	Chick H33019
143 (KDG2)	H25469 H28021	Chick H33062
144 (KDG2)	H25459 (M) H31566 (F)	Chick H33061
145 (KDG2)	H25474 H25504	Chick H33059
146 (KDG2)	H25460 H25473	Chick H33058
147 (KDG2)	H25461 (M) H25482 (F)	Chick H33049
148 (KDG2)	H27534 H25483	Chick H33050
149 (KDG2)	H27568 H32010	Non-breeder
150 (KDG2)	H25471 H25493	Chick H33052
151	H25593 H29674	Chick H33018
152 (SFG2)	H31983 (M) H31453 (F)	Chick H33020
153 (SFG2)	-	Non-breeder
154 (PTG1)	-	Non-breeder
155 (PTG2)	H25497 H31574	Dead chick
156 (PTG2)	H31558 H31559	Chick H32962
157 (PTG2)	H31573 (M) -	Dead chick
	H32017 (M)	Interloper
158 (PTG2)	H25440 (F) H31451 (M)	Disappeared egg
159 (PTG2)	H25441 (F) H31557 (M)	Chick H32966
160	H25690 H29671	Chick H33023
161 (PTG2)	H25500 -	Chick H32961
162 (PTG2)	H25442 H25489	Chick H32965

BURROW	BAND	OUTCOME
163 (PTG2)	H32910 (M) H25491 (F)	Crushed egg
164 (PTG2)	H32573 (M) H31151 (F)	Non-breeder
165 (KDG2)	H29661 (F) H29700 (M)	Chick H33060
166	H25437 (M) H32015 (F)	Non-breeder
167	H28012 (M) -	Disappeared egg
168 (PTG1)	H32016 -	Non-breeder
169		Empty
170	H31967 (M) -	Abandoned
171	H31110 H28006	Chick H32921
172	H25502 H31048	Dead chick
173	H31143 H28018	Chick H33009
174	H28071 - H31973 (M)	Dead embryo Interloper
175	H25503 (M) H28001(F)	Chick H32987
176 (KDG1)	-	Non-breeder
177	H31459 H31462	Chick H33001
178	H32908	Non-breeder
179	H29694 (M) H29697 (F)	Chick H33003
180	H31560 H31169	Dead embryo
181	H31463 (F) H31561 (M)	Chick H33006
182	H25514 (M) H31580	Non-breeder
183 (SFG1)	H31465 H25515	Chick H33028
184	H32916	Non-breeder
185 (KDG1)		Empty
186	H31577 (M) H29665 (F)	Chick H32936
187	H31047 (M) H31452 (F)	Chick H32914
188	H26956 (M)	Non-breeder
189	H28015 H31994	Non-breeder
190	H32036 H32048	Non-breeder
191 (PTG2)	H28048 (F) H25450 (M)	Chick H32963
192 (SFG1)		Empty

BURROW	BAND	OUTCOME
193 (KDG2)	H32041	Non-breeder
194 (KDG2)	H31569 (M) H31570 (F)	Chick H33056
195	H28023 H28555	Chick H33051
196	H28016 (F) H29951 (M)	Chick H33002
197	H28017 (M) -	Infertile
198	H25699 (M) H29686 (F)	Chick H33011
199	H32009 -	Rat predation
200	H32006 (F) H28073 (M)	Chick H32944
201	H31581 H28002	Chick H32985
202 (PTG2)	H31556 (F) H28031 (M)	Chick H32964
203	H29668 (F) H30930 (M)	Crushed egg (handler disturbance)
204 (KDG1)	H31965 (F) H28008 (M)	Crushed egg
205	H25697 H29664	Chick H32982
206	- -	Rat predation
207 (PTG1)	H31137 (M) H31977 (F)	Chick H32956
208 (PTG1)	H25587	Non-breeder
209 (KDG3)		Empty
210 (KDG3)	H25691 (M) H29663 (F)	Chick H33042
211 (KDG3)	H28812 H29689	Chick H33043
212 (KDG3)	H28040 (F) H30869 (M)	Chick H33040
213 (KDG2)		Empty
214 (KDG2)	H25687 H25595	Chick H33055
215 (SFG3)	-	Non-breeder
216 (SFG3)	H28051 H29673	Chick H33013
217 (KDG3)	H31991 H32903	Chick H33041
218	H25556 (M)	Non-breeder
219 (PTG3)		Empty
220 (PTG3)	H25555 (M) H31970 (F)	Chick H32949
221 (PTG3)	H29695 (M) H31969 (F)	Dead embryo
222	H28049 (M) -	Abandoned

BURROW	BAND	OUTCOME
223 (SFG3)	H31598 H28068	Chick H33014
224 (PTG3)	H25553 H25564	Chick H32948
225 (SFG3)	H31600 H13634	Chick H33015
226 (PTG3)	H27058 (M) H28041 (F)	Chick H32937
227 (KDG3)	H25509 (M) H25583 (F)	Chick H33067
228	H29952 (F) H23029 (M)	Chick H33036
229 (PTG3)	H28042 H25565	Chick H32926
230 (PTG3)		Empty
231	H25568 (M) H32014 H32943	Non-breeder
232		Empty
233	H31981 (M) H25558 (F)	Chick H33007
234	H25559 (F) H25571 (M)	Infertile
235	H25566 (F) H28044 (M)	Dead chick
236	H25572 H25573	Chick H33010
237	H25575 H29953	Chick H32991
238 (SFG1)	H28037 (M) H29655 (F)	Chick H33026
239	H25698 (M) H25700 (F)	Chick H32979
240	H25689 (M) H31993 (F)	Chick H32941
241		Empty
242	H28099 H31998	Rat predation
243	H25578 H22170	Chick H33038
244	H25581 H22143	Dead embryo
245 (KDG1)		Empty
246 (PTG3)	H25586 H32026	Chick H32938
247	-	Non-breeder
248	H29652 H28067	Dead embryo (at pipping)
249	H25601 (M) H31997 (F)	Chick H32999
250	H31979 (M) H30924 (F)	Chick H33000
251	-	Non-breeder
252	H28059 -	Chick H32993
253	-	Non-breeder

BURROW	BAND	OUTCOME
254	-	Non-breeder
255	-	Non-breeder
256	H31081	Non-breeder
257	H32901	Non-breeder
258 (PTG3)		Empty
259	H32025 H32018	Chick H32981
260(SFG3)	H32020 H32034	Chick H33012
261	H32021 -	Disappeared egg
262	H32902 H32922	Dead embryo (at pipping)
263	H31980 (F) -	Chick H33004
264	H32028 H28214	Non-breeder
265 (KDG2)	-	Non-breeder
266	H31975 H32000	Non-breeder
267	H31989 (M) -	Chick H33064
268	H32030 H32049	Non-breeder
269	H25688 H32029	Non-breeder
270	H32031 H32011	Disappeared egg
271 (KDG1)	H32913 H32920	Chick H33071
272	- -	Chick H33024
273	H32930	Non-breeder
274	H23034 -	Dead chick
275	H32037 (M) H32046 (F)	Non-breeder
276	H32044 (M)	Non-breeder
277	H32043 -	Chick H32992
278	H32035 H32042	Chick H32994
279	H32038 (F) H31082 (M)	Non-breeder
280	H32929 H32911	Chick H32996
281	H32940 -	Chick H32995
282	- -	Chick H33005
283	H32912 (M)	Non-breeder
284	H32904	Non-breeder
285	H32950 -	Chick H33037