Survey and monitoring of black petrels on Great Barrier Island, 2003/04

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Elizabeth A. Bell and Joanna L. Sim

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Elizabeth A. Bell and Joanna L. Sim

Wildlife Management International Limited, P.O. Box 14–492, Wellington, New Zealand. Email: wmil@clear.net.nz

ABSTRACT

This report is part of an ongoing long-term study of the black petrel, *Procellaria parkinsoni*, on Great Barrier Island begun in the 1995/96 breeding season. During the 2003/04 breeding season, 327 burrows were checked and intensively monitored over summer; however only 324 burrows were included in the long-term study. Of these study burrows, 208 were used by breeding pairs, 57 by non-breeding adults and the remaining 59 burrows were empty. By 10 May 2004, 108 chicks were still present in the study burrows and 50 others were presumed to have already fledged, corresponding to a breeding success of 76%. Nine census grids were monitored within the study area and accounted for 134 of the inspected burrows, with 78 burrows being used for breeding. Two extra burrows were found in the grids, both of which were newly dug this season. Extrapolating from these grid burrows, we estimated that the black petrel population around the peak of Mount Hobson ranged from 2935 to 4690 birds. There were 12 chicks from earlier breeding seasons recaptured within the Mount Hobson colony area this season. Of these, three paired and bred (one successfully). One chick (banded in 1998/99 season) was also recaptured off the coast of Peru, but this bird has not been recaptured at the Great Barrier colony yet. There were 13 adults colour marked (with fluorescent spray paint), but there were no reported sightings of these birds at sea.

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

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1. Introduction

The black petrel, *Procellaria parkinsoni*, is a medium-sized endemic seabird which breeds on Little and Great Barrier Islands, New Zealand (Heather & Robertson 1996). The main breeding area on Great Barrier I. is around the summit of Mount Hobson (Hirakimata). This monitoring work carried out during the 2003/04 breeding season was a continuation of the survey and monitoring study begun in 1995/96 (Bell & Sim 1998a, 1998b, 2000a, 2000b, 2000c, 2002, 2003a, 2003b), adding to the baseline data on the Great Barrier I. black petrel population. This study will assist in identifying potential effects that long-line fishing, rat and cat predation, and habitat disturbance may have on the population. The population estimate has been updated, ensuring that any population changes will be detected in time to implement the 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 I. via burrow monitoring and the banding of adults and fledglings to establish adult mortality, breeding success and recruitment. Since this study was a continuation from previous breeding seasons, it has also provided more data to establish current population trends and to assist in determining causes and timing of mortality.

In summary, the study objectives were to:

- Monitor a sample of black petrel burrows within the main breeding area and band all adults present in the burrows during November / December and January / February and all remaining fledglings during April / May.
- Determine breeding success in the sample of long-term study burrows and record causes of breeding failure, such as predation or disappearance of parents.
- Monitor and re-survey the census grids and study area for new burrows and band and recapture as many breeding and non-breeding birds present as possible.
- Determine a population estimate by extrapolating from the grid areas to the main Mount Hobson breeding area.
- Undertake a mark / recapture programme and band as many birds as possible at the beginning of the breeding season (November / December) to determine pre-breeder survival, age of first return and age of first breeding.
- Confirm the breeding status of adults during each visit to the colony (i.e. monitor the study burrows at the beginning, middle and end of the breeding season), and where possible, identify the sex of the resident adult.
- Increase night banding during the entire breeding season.
- Colour-mark up to 50 birds to obtain sightings of dispersal and foraging trips from the colony.

3. Methods

3.1 STUDY BURROWS

The study area (30 ha around the summit) was visited from 1 to 12 December 2003, and the study burrows (n = 318) were checked for the presence of adults and eggs. Any adult present was removed from the burrow, banded (or the band number recorded if a recapture), sexed by viewing the cloaca (if swollen the bird is female; the cloaca is particularly obvious immediately after egg laying), and returned to the burrow. The presence of any egg was noted.

During the next visit to the colony (26 January to 20 February 2004), the number of study burrows was increased from 318 to 324 (Figs 1–4). To ensure accurate monitoring, the study burrows 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 (8–10 May 2004) and all remaining fledglings were banded. This information was used to determine breeding success.

3.2 CENSUS GRIDS

The three original grids were selected in areas that had a historical presence of black petrels, different strata, vegetation types and topography and were near known launch sites (Bell & Sim 1998a, 2000a). These original grids were replicated to determine the burrow density, to compare burrow densities across areas and to increase the accuracy of the population estimate (Bell & Sim 2000a, 2000b).

The nine census grids (each 40 × 40 m) set up around Mount Hobson were systematically searched (at 1 m intervals) to locate any new burrows and to determine this season's occupancy (Figs 1–4). The same procedure was followed for all birds in the burrows in the grids as outlined in Section 3.1.

3.3 COLOUR MARKING

Colour marking of a selection of adult black petrels was undertaken again this season. Fluorescent 'Dazzle ™' pink or green spray paint was used. The birds were sprayed on the centre of the back, between the wings and towards the tail (stopping short of the preen gland). With a pillowcase placed over their heads to reduce drift and fumes, the birds were held by one team member and sprayed by another. The paint was allowed to dry for 5 minutes, and then the birds were returned to their burrows. There were 13 birds colour marked (nine breeding adults and four non-breeding adults).

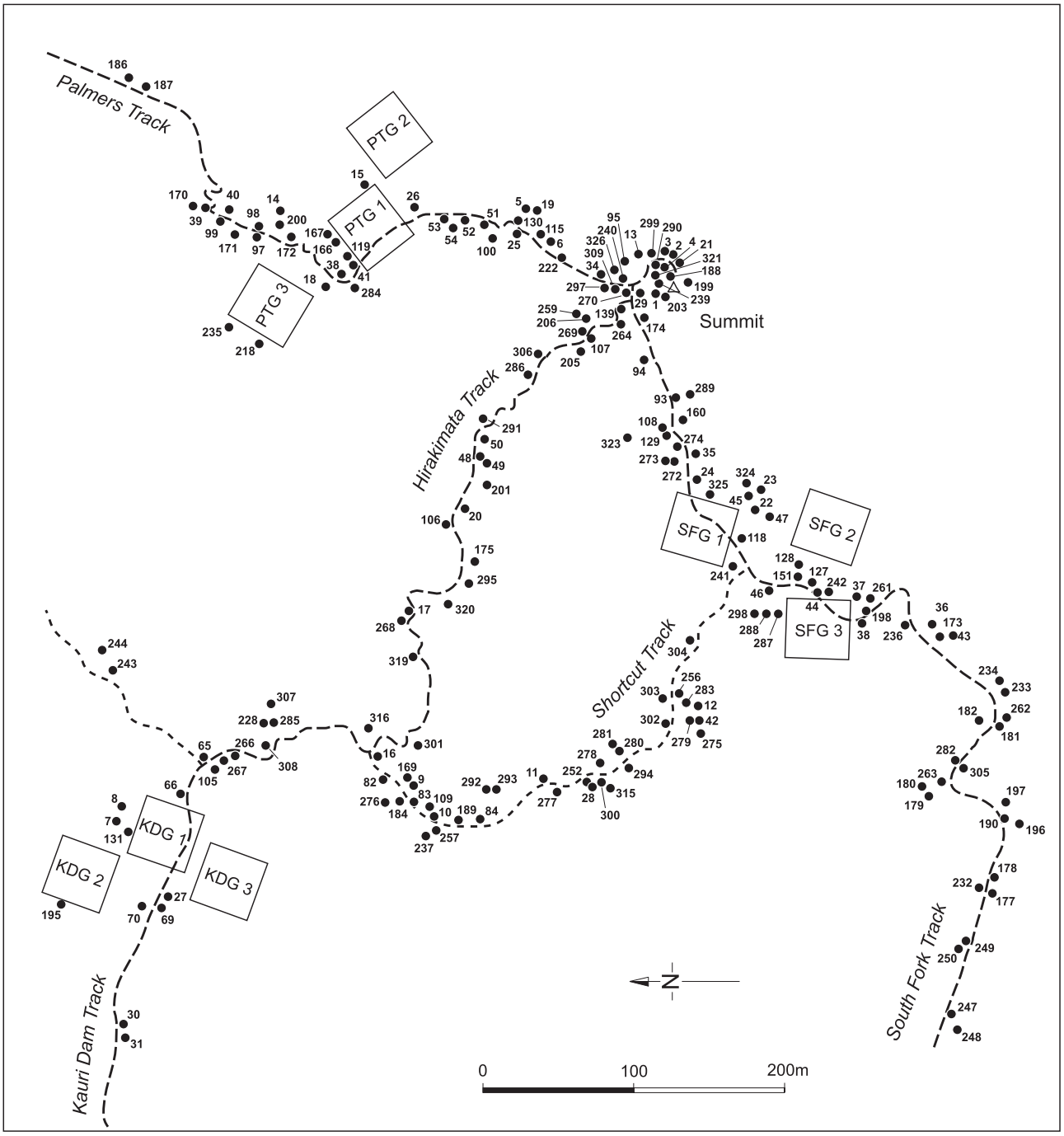
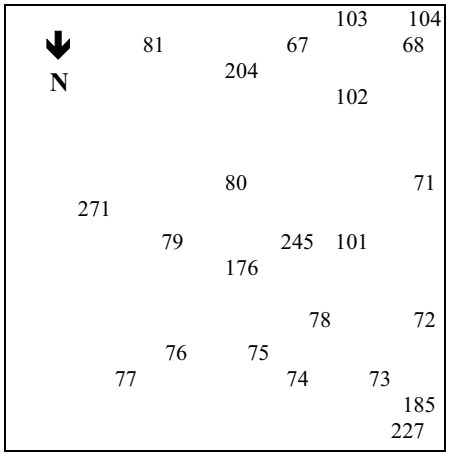


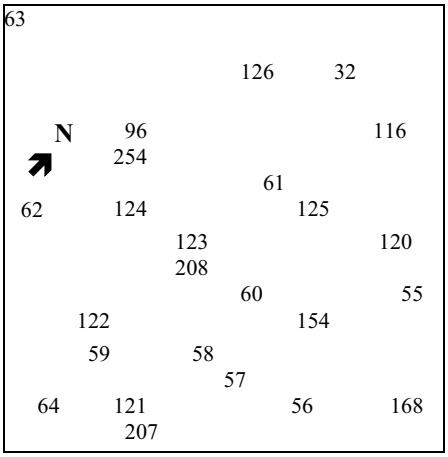
Figure 1. Location of the burrows and census grids around the summit area of Great Barrier Island. Note Figs 2, 3 and 4 show the burrow numbers within each of the nine census grids.

3.4 NIGHT BANDING

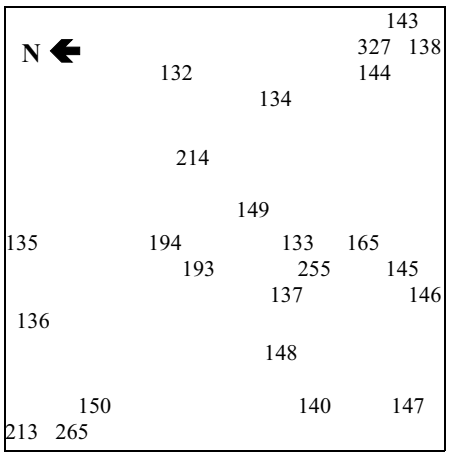
Night banding was undertaken during the December 2003 visit to the study area. This involved searching the study area by walking the track system and capturing any adult on the surface. Several nights were also spent at known launch sites where birds were captured while taking off or landing. All birds were banded or had their band numbers recorded. During this visit sex was determined if possible (by cloacal inspection).



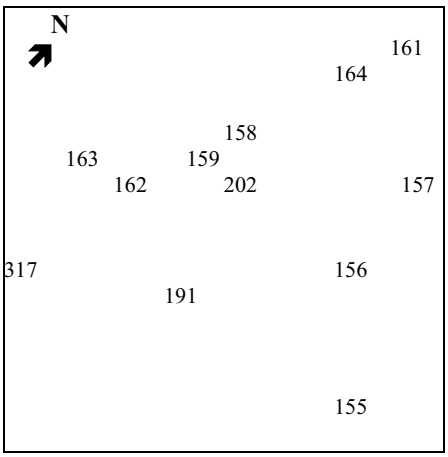
Kauri Dam grid one (KDG1)



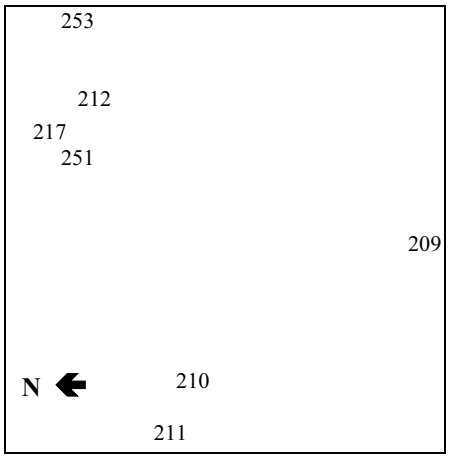
Palmers Track grid one (PTG1)



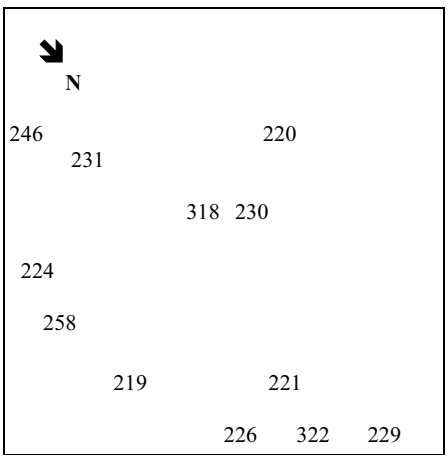
Kauri Dam grid two (KDG2)



Palmers Track grid two (PTG2)



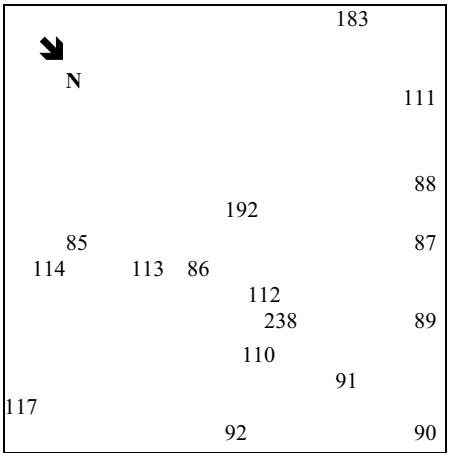
Kauri Dam grid three (KDG3)



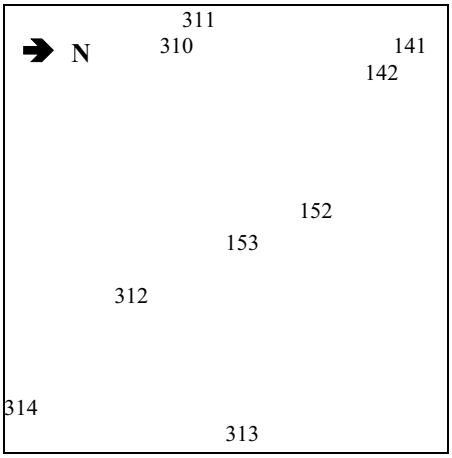
Palmers Track grid three (PTG3)

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

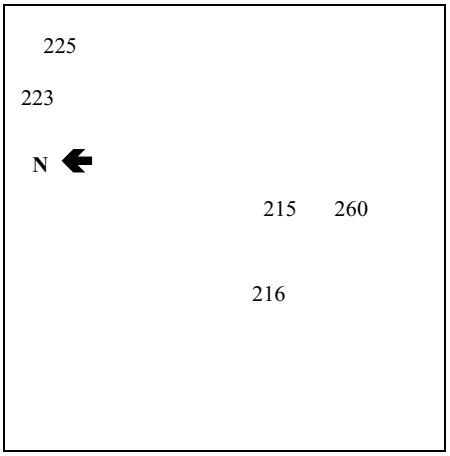
Figure 3. Location of burrows found in the Palmers Track grid sites (each grid is 40 × 40 m).



South Fork Track grid one (SFG1)



South Fork Track grid two (SFG2)



South Fork Track grid three (SFG3)

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

4. Results

4.1 NUMBER OF BURROWS IN THE CENSUS GRIDS

A total of 134 burrows were found in the nine census grids (Table 1, Figs 2–4). Of these, 78 burrows were used by breeding pairs, 27 were used by non-breeding adults and 29 burrows were empty. There were also several 'potential' burrows within the grids, which were not included in any burrow estimate. We defined 'potential' burrows as those which had been investigated and / or preliminarily dug out, but were not yet being used by breeding or non-breeding petrels. These potential burrows were monitored seasonally to check if they had become active (i.e. used by a black petrel).

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

	GRID ONE									GRID TWO						GRID THREE				
	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	98/99	99/00	00/01	01/02	02/03	03/04	99/00	00/01	01/02	02/03	03/04
Kauri Dam grid																				
Empty	1	1	1	1	3	1	4	2	3	0	0	0	1	2	4	2	1	1	1	2
Breeding	8	10	8	12	11	12	11	16	18	15	16	13	16	17	16	3	3	4	3	4
Non-breeding	5	5	7	6	8	9	8	5	2	4	5	9	6	4	4	0	3	2	3	1
Total	**14**	**16**	**16**	**19**	**22**	**22**	**23**	**23**	**23**	**19**	**21**	**22**	**23**	**23**	**24**	**5**	**7**	**7**	**7**	**7**
Palmers Track grid																				
Empty	3	0	0	1	1	0	1	3	3	0	0	0	0	2	1	0	2	3	2	4
Breeding	7	13	13	15	18	16	19	15	14	10	9	10	10	8	7	9	6	6	6	7
Non-breeding	3	6	7	6	5	9	5	7	8	1	2	1	1	2	4	0	2	1	3	1
Total	**13**	**19**	**20**	**22**	**24**	**25**	**25**	**25**	**25**	**11**	**11**	**11**	**11**	**12**	**12**	**9**	**10**	**10**	**11**	**12**
South Fork Track grid																				
Empty	2	1	1	0	1	3	4	4	6	1	1	1	0	0	5	1	0	0	1	1
Breeding	5	12	11	11	10	10	8	6	7	2	1	3	3	3	2	3	3	4	4	3
Non-breeding	2	1	3	5	6	4	5	7	4	1	2	0	1	6	2	0	1	1	0	1
Total	**9**	**14**	**15**	**16**	**17**	**17**	**17**	**17**	**17**	**4**	**4**	**4**	**4**	**9**	**9**	**4**	**4**	**5**	**5**	**5**
Annual totals	**36**	**49**	**51**	**57**	**63**	**64**	**65**	**65**	**65**	**34**	**36**	**37**	**38**	**44**	**45**	**18**	**21**	**22**	**23**	**24**

4.2 STUDY BURROWS

Within the 324 study burrows (those burrows that could be accessed out of the 327 numbered burrows), 208 contained breeding birds, 57 contained non-breeding birds and 59 were empty. There were 50 failures (e.g. loss of eggs, infertility, predation etc., Table 2). This corresponds to a breeding success of 76% (Table 2).

Both parents were identified in 128 of the breeding study burrows, only one parent was identified in 70 and no parent was identified in ten (Appendix 1). Of the non-breeding burrows, there were 11 burrows where two or more birds were identified, 30 where one was identified and 16 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	02/03	03/04
Number of study burrows		118	137	197	248	255	283	318	324
Eggs	Laid	92	95	142	178	168	192	199	208
	Predation (rat)	6	1	2	9	6	5	1	2
	Crushed[a]	5	0	1	10	6	5	14	13
	Abandoned	2	1	5	1	3	9	7	0
	Infertile	6	4	12	6	8	3	2	7
	Dead embryo (at various stages)	0	8	6	13	9	14	19	16
	Disappeared egg[b]	0	0	0	0	0	11	3	0
	Unknown[c]	0	0	0	0	0	0	5	0
Chicks	Hatched	73	81	116	139	136	145	148	170
	Predation (rat)	0	0	2	0	0	0	0	0
	Predation (cat)	0	0	2	2	1	2	3	2
	Died (disease)	1	0	0	0	0	0	0	0
	Died (starvation)	0	1	0	0	0	0	0	0
	Died (unknown causes)	0	0	3	6	7	8	8	10
	Fledged[d]	72	80	109	131	128	135	137[e]	158[f]
Overall breeding success (%)		78	84	77	73.5	76	70	69	76

[a] These eggs were 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, been infertile or contained an embryo which died.

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

[c] There were five burrows not located in May 2003 and as a result it is not known if the eggs hatched successfully. To determine overall breeding success we have been cautious and assumed that they failed.

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

[e] Of these, 78 chicks had already fledged prior to the banding visit, only 59 chicks were banded.

[f] Of these, 50 chicks had already fledged prior to the banding visit, only 108 chicks were banded.

Two male pre-breeders were found in their natal burrows (H31424 in burrow 63 and H31495 in burrow 89, Appendix 1). One (H31424) had attracted a partner to this now vacant burrow and the other (H31495) was still trying to establish 'use' of the burrow, but his female parent kept evicting him over the season.

4.3 BANDING DATA

There were 447 adults identified during the 2003/04 season (Table 3), with 380 already banded and 67 banded this season. There were 108 chicks still present in the study burrows and two chicks in extra non-study burrows that were also banded (Table 3).

Since the first banded chick was recaptured in the 1999/00 season, 28 have been recaptured as pre-breeders, non-breeders or breeding adults (Table 4). Nine of these have bred over four seasons (2000/01 to 2003/04; Bell & Sim 2002, 2003a, 2003b), with seven breeding successfully over that period. Of the 12 'chicks' that returned this season, seven attempted to breed, with three successfully raising chicks of their own. This means the earliest age at first breeding based on currently available information ranges from 5 to 7 years (Table 4). The remaining chicks have not bred, although several were recaptured while calling to attract a mate.

TABLE 3. BANDING, RECAPTURE AND RECOVERY DATA FROM GREAT BARRIER ISLAND BY YEAR.

	95/96	96/97	97/98	98/99	99/ 00	00/01	01/02	02/03	03/04
Recaptures of birds banded:									
Prior to 1995	19	31	24	23	29	27	27	27	21
1995/96	–	14	14	14	16	14	11	12	12
1996/97	–	–	113	86	84	73	63	57	43
1997/98	–	–	–	32	32	30	28	24	18
1998/99	–	–	–	–	95	82	71	64	49
1999/00	–	–	–	–	–	86	75	66	47
2000/01	–	–	–	–	–	–	51	52	41
2001/02	–	–	–	–	–	–	–	68	88
2002/03	–	–	–	–	–	–	–	–	61
Total recaptures	**19**	**45**	**151**	**155**	**256**	**312**	**326**	**370**	**380**
Number of new adults (banded that season)	41	179	60	129	145	97	114	179	67
Total adults	**60**	**224**	**211**	**284**	**401**	**409**	**440**	**549**	**447**
Number of chicks (banded that season)	59	69	85	116	137	137	160	62	110
Total number of birds	**119**	**293**	**296**	**400**	**538**	**546**	**600**	**611**	**557**
Number of chicks recaptured alive (returned to colony)	–	–	–	–	1	2	11	18	13
Band recoveries from dead birds	–	1	1	–	2	1	2	2	–

4.4 POPULATION ESTIMATE

Extrapolating from the census grid data to the 30 ha area around the summit area of Mount Hobson, the black petrel burrow-occupying population is estimated to be between 2935 and 4690 adult birds (3813 ± 877 birds, Table 5), consisting of 563 (± 143) non-breeding adults and 3250 (± 734) breeding adults (i.e. approximately 1625 breeding pairs). Over the past five seasons during which the nine census grids have been monitored, the population estimates have been very similar (ranging from 3500 to 4000 birds ± 860–980: Table 6).

TABLE 4. NUMBER OF RECAPTURES, AGE AT FIRST RECAPTURE AND AGE AT FIRST BREEDING FOR RECAPTURED 'CHICKS' BANDED ON MOUNT HOBSON, GREAT BARRIER ISLAND.

BIRD	BAND	LAST RECAPTURED	NUMBER OF RECAPTURES (season)	AGE AT FIRST RECAPTURE (years)	AGE AT FIRST BREEDING (years)
1	H25664	2002/03	1	3	–
2	H30924	2003/04	2	7	–
3	H30908	2002/03	2	6	6
4	H30930	2003/04	5	4	5
5	H31076	2002/03	1	5	–
6	H31080	2002/03	1	4	–
7	H31081	2002/03	2	4	–
8	H31082	2001/02	1	4	–
9	H31089	2003/04	2	5	6
10	H31194	2001/02	1	5	5
11	H31366	2003/04	2	5	6
12	H31370	2002/03	1	5	–
13	H31377	2001/02	1	4	–
14	H31382	2003/04	3	4	5
15	H31405	2003/04	2	6	7
16	H31406	2001/02	1	5	–
17	H31424	2003/04	2	6	–
18	H31473	2002/03	1	4	–
19	H31474	2002/03	1	4	–
20	H31490	2002/03	1	4	–
21	H31495	2003/04	2	4	–
22	H31527	2002/03	1	4	–
23	H31542	2003/04	2	4	–
24	H25546	2003/04	1	5	5
25	H25631	2003/04	1	4	–
26	H25663	2003/04	1	4	–
27	H31383	2003/04	1	6	6
28	H31536	2003/04	1	5	–
Mean ± SEM			1.5 ± 0.17	4.6 ± 0.17	5.7 ± 0.24

4.5 COLOUR MARKING

Thirteen adults were colour marked (nine breeding adults and four non-breeding adults). Breeding birds were only marked if they had already failed to breed. The non-breeding birds continued to try to attract a partner (calling from the burrow at night). Unfortunately bad weather (cold, wet and windy) reduced the number of birds that could be colour marked safely and quickly.

It was hoped that these birds would be sighted by the public, fishers and / or observers to give basic foraging data, but despite good media coverage through newspapers and television, no sightings have been reported to date.

TABLE 5. 2003/04 POPULATION ESTIMATE OF BLACK PETRELS IN THE 30 ha SUMMIT AREA AROUND MOUNT HOBSON, GREAT BARRIER ISLAND.

	DENSITY (number/ha)		POPULATION ESTIMATE (30 ha)	
	BREEDING ADULTS	NON-BREEDING ADULTS	BREEDING ADULTS	NON-BREEDING ADULTS
Grid One (KDG1)	225	12.5	6750	375
Grid Two (KDG2)	200	25	6000	750
Grid Three (KDG3)	50	6.25	1500	187.5
Grid Four (PTG1)	175	50	5250	1500
Grid Five (PTG2)	87.5	25	2625	750
Grid Six (PTG3)	87.5	6.25	2625	187.5
Grid Seven (SFG1)	87.5	25	2625	750
Grid Eight (SFG2)	25	12.5	750	375
Grid Nine (SFG3)	37.5	6.25	1125	187.5
Mean ± SEM	108.3 ± 24.5	18.75 ± 4.8	3250 ± 734.2	562.5 ± 143.2
Total population estimate			3813 ± 877	
Population estimate range			2935 to 4690 adults	

TABLE 6. ANNUAL MEAN POPULATION ESTIMATE SINCE 1999/2000 BREEDING SEASON FOR BLACK PETREL USING THE 30 ha AREA AROUND MOUNT HOBSON, GREAT BARRIER ISLAND.

YEAR	BREEDING ADULTS	NON-BREEDING ADULTS	TOTAL POPULATION ESTIMATE	RANGE
1999/2000	2938 ± 800	583 ± 186	3521 ± 986	2535 to 4507
2000/01	2792 ± 676	792 ± 235	3584 ± 911	2673 to 4495
2001/02	3375 ± 699	625 ± 168	4000 ± 867	3133 to 4867
2002/03	3250 ± 718	771 ± 148	4021 ± 866	3155 to 4887
2003/04	3250 ± 734	563 ± 143	3813 ± 877	2935 to 4690

5. Discussion

The black petrel population on Great Barrier I. has been monitored since the 1995/96 breeding season (Bell & Sim 1998a, 1998b, 2000a, 2000b, 2000c, 2002, 2003a, 2003b).

5.1 CENSUS GRIDS

Nine grids were intensively monitored over three periods during the 2003/04 breeding season and two new burrows were located in the grids (one in PTG3 and one in KDG2). Both were occupied by breeding pairs and both successfully fledged chicks. As this study has continued, the number of burrows found within the grids has risen regularly. It appears that pre-breeding and non-breeding birds are returning to their natal area and are starting to excavate new burrows. This is confirmed by the recapture of male pre-breeders returning to their natal burrows (Section 4.2).

Although new burrows have been found in the census grids, this does not necessarily mean that more birds are present in the colony, as some birds appear to move between burrows and some original burrows are no longer active. It should be noted that over the past two seasons the search effort has increased, which may have affected the probability of detecting burrows.

Using data from the past five breeding seasons, the ratio of non-breeding to breeding burrows (1 : 3 ± 0.3) has been very similar to previous seasons (1 : 3 or 1 : 2, Bell & Sim 2000a, 2000b, 2000c, 2002, 2003a, 2003b). This may be explained by a consistent numbers of birds returning to the colony to breed each season. It is interesting to note that there were more empty burrows this season (59 or 18%) than previously recorded (12% in 2002/03, 8% in 2001/02, 5% in 2000/01, 6% in 1999/2000 and 7% in 1998/99) and the percentage of empty burrows has steadily increased. This may be related to adult mortality, but will need to be monitored over the next few seasons.

5.2 STUDY BURROWS

A further six study burrows were added to the 318 previously identified. There were 158 breeding successes and 50 breeding failures this season, equating to an overall breeding success rate of 76%. This breeding success is higher than in the previous two years (Table 2), but still less than the most successful season to date (1997/98), and is higher than reported in earlier studies in 1977 (50%) and 1978 (60%) (Imber 1987) and in 1988/89 (62%) (Scofield 1989). It should be noted that it was assumed that 50 chicks fledged safely before the banding visit in May. If any of these chicks had died or been predated earlier in the season, this would reduce the breeding success. Chicks were assumed to have fledged successfully if traces of down, quill sheaths, pin feathers and / or recent activity in the burrow could still be identified during the May visit.

5.3 PREDATION

There were two cat predation events (1% of all breeding attempts) on chicks, while rats predated 1% of the eggs laid within the study burrows this season. Predation by cats occurred close to the summit and a tabby cat was seen on two occasions on the boardwalk during daylight hours (once by a tourist and once by the author (JS)). On one occasion the cat had an unidentified 'black' bird in its jaws. Juvenile petrels are vulnerable to feral cat predation as soon as they leave the burrows to strengthen wings and practise flying (Warham 1996). Over ten chicks have been predated by cats over the past six seasons (Table 2). Cat trapping was carried out for a week during the February visit, but was unsuccessful due to a lack of suitable bait and the short time-frame. It is important to continue cat trapping in the area before, during and after the black petrel breeding season.

It was also noted that pigs were using the summit area. This is the first time that pigs have been recorded at, or very close to, the summit. Previous activity was restricted to the lower hills. It will be very important to monitor any increased pig activity as pigs are known predators of petrels (Warham 1996), able to dig petrels from their burrows.

Rabbit sign was also noted in the South Forks area. Although rabbits do not predate eggs, chicks or adults directly, their competition for burrows may impact on the petrel population. The presence of rabbits could also increase the number of cats in the area. Monitoring for rabbit activity around the petrel colony should be continued.

5.4 CHICKS

There were 108 chicks still present in the study burrows in May 2004. Compared with previous seasons, most chicks were in very good condition and, because this trip was later, were about to fledge. Only four chicks were small or in poor condition; two had avian pox. A very lethargic, fully feathered chick was found on the surface with severe avian pox (open abscesses into the brain cavity, half the bill missing etc.) and was humanely put down. It was not known if this chick came from one of the study burrows in the area. The other chick, which was from a study burrow, was in good health, fully feathered and appeared to have the 'dry' form of avian pox on its face only. It was not present in the burrow the following day and was assumed to have fledged. Although mild cases of avian pox may not adversely limit fledging chances, overall survival could be reduced (Hansen 2001).

The chick-banding trip, although earlier than the previous season, was still late in the overall breeding season, which meant some chicks had already fledged. Chicks were noted trying to fledge on most nights, using trees and rocks in the area.

5.5 POPULATION ESTIMATE

Extrapolating from the census grids to the Mount Hobson summit area (30 ha), the population of the Great Barrier I. black petrels is estimated at 3813 ± 877 adults (ranging from 2935 to 4690, Table 5), which is well within the overall range that has been recorded over the past five seasons. However, this estimate will be an overestimate as it has been extrapolated from areas that are known to contain high burrow densities. The 30 ha study site has areas of varying burrow densities which need to be factored in.

To gain a better population estimate for the whole of Great Barrier I., further surveys would have to be undertaken in other areas. Black petrels are known to nest in the Northern Block, other high points around the summit area, in small pockets of private land and 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 give more accuracy to the population estimate, and allow stratification within the study site. These grids could be established on or near the Hog's Back, Mount Heale and Mount Matawhero. It is interesting to note that several pairs of black petrels have been found well below 300 m a.s.l. This opens up the possibility that other birds are also now breeding at lower elevations; this should be investigated further.

5.6 BANDING DATA

A total of 557 banded birds were identified this season: 447 adults and 110 fledglings (Table 3). There were 380 recaptures of previously banded birds including 13 that were returned chicks (Table 3).

Ten chicks were recaptured in their natal area (less than 20 m from their 'hatching' burrow) and two were recaptured in their natal burrows. The other chicks were caught over 100 m away from their natal areas.

Since the first chick was recaptured in the 1999/00 season, 28 have been recaptured. Nine of these have bred during this period, which means age of first recorded breeding is between 5 and 7 years (mean: 5.7 ± 0.24, Table 4). It is important to check for more returned chicks and maintain intensive burrow monitoring where there have been returned 'chicks' present. Many of the returned chicks were recaptured at night during the December visit, so it is important to maintain a high level of searching at this time. Further, these data allow for mark / recapture analyses, which could greatly assist in understanding the demographics of this species.

5.7 CONSERVATION

As in previous seasons, large numbers of the public continue to visit Mount Hobson and this still has little or no obvious direct impact on the breeding success of the black petrel. As stated in earlier reports (Bell & Sim 2000a, 2000b, 2000c, 2002, 2003a, 2003b), the construction of raised walkways around the

summit has decreased damage to the overall 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 strongly recommended. It is understood that a funding request has been put forward by the Great Barrier Area Office (D. Tawa, pers. comm.). We recommend that any construction should be done with full consultation with the appropriate experts to prevent the accidental destruction of burrows (certain places along these tracks have high burrow densities) and important plant species around the summit area. It should be noted that an increased length of boardwalk could give feral cats easier access into the summit area than the present very wet and muddy tracks. However this impact is likely to be limited, due to the boardwalk being present only around the summit area and not over the whole length of the track systems.

New signs at the summit have increased awareness of the black petrel breeding area; however, signs at the entrances to the track systems which lead to the summit still need to be replaced (most are illegible). 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. It is understood that there are plans to replace the signs as soon as possible.

One black petrel was caught and returned from within the New Zealand fisheries during the past fishing year, 1 October 2002 to 30 September 2003 (C.J.R. Robertson, pers. comm.). There have been a recorded total of nine black petrels caught as bycatch on domestic longline vessels in the New Zealand fisheries between 1 October 1996 and 30 September 2002 (Robertson et al. 2004). One of these was a pre-breeder, banded by the authors as a chick in 1996/97, and probably on its first return to the colony (Robertson et al. 2003, 2004). All of these birds have been caught on domestic pelagic longline vessels between November and April, either east of North Cape, near the Kermadec Islands or north of Great Barrier I. (Robertson et al. 2003, 2004). This means that many may have been adults either returning to breed or already incubating an egg or feeding a chick (Robertson et al. 2004), so that their deaths would result in a breeding failure, reducing overall productivity and recruitment. It is interesting to note that a pre-breeding adult (banded by the authors in the 1998/99 season) was captured off Peru and was released alive (C.J.R. Robertson, pers. comm.). The level of bycatch for black petrels and other seabirds outside New Zealand waters is unknown and may impact on the population dynamics of the species. Black petrels have delayed maturity, low reproduction rates and high adult survivorship, so that 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 in New Zealand and overseas, this species could be drastically affected. It is important to continue to monitor the Great Barrier I. 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 good population model will assess factors affecting the black petrel population and help determine the overall effects of bycatch by the long-line fishing industry.

6. Recommendations

The authors recommend that:

- Monitoring of the black petrel population (using the study burrows) is continued at Great Barrier I. up to and including the 2008/09 breeding season. This will ensure that 10 years of comparative data are collected to determine the population dynamics of black petrels, allowing us to develop a population model to determine survivorship, mortality and the effects of predation, long-line fishing and other environmental factors (e.g. El Niño).
- The November / December visit to the study area is continued. This will allow a large number of birds to be banded or recaptured easily, as many birds are often outside the burrows at this time. It will also enable continuation of the mark-recapture programme. At the same time, the study burrows could be checked for breeding status, to give a more accurate estimate of breeding success and determine the sex of adults. This would also provide an opportunity to recapture returning birds banded as chicks.
- The January / February visit is continued. This will enable intensive monitoring of the study burrows, allow the adults to be identified and help determine breeding status in the burrows. The April / May visit should also continue, allowing time to band the surviving chicks.
- A sample of 50 birds carry GPS data loggers and / or transponders to investigate foraging distances and locations, water temperature and flight patterns.
- The Northern Block (Tataweka) is visited in November to survey the black petrel population and gain a more accurate estimate of the population there.
- Census grids are established on other high points around the Mount Hobson area (e.g. Mount Heale, Mount Matawhero and Hog's Back). This will ensure that a better estimate for the black petrel population on Great Barrier I. is made. These sites should be monitored as long as the study continues.
- Cat trapping during the black petrel breeding season, November to June, especially during pre-laying (November) and the fledging period (May to June), is established.
- The walkway systems down Palmers (Windy Canyon) and South Fork Tracks is continued. Construction should be completed between July and mid-October, when the chicks have fledged and before the adults return. Known petrel burrows could be identified for the construction team to avoid.

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Appendix 1

RESULTS FROM THE BURROWS AROUND HIRAKIMATA

Study burrows within census grids have the location (PTG1, 2, 3; SFG1, 2, 3; or KDG1,2,3) noted. Occupants of burrows are represented by band number or by a question mark (?) if the individual was not captured. Where known, sex of bird is indicated in parentheses: male (M); female (F).

BURROW	BAND	OUTCOME
1		Empty
2	H33252 (M)	Non-breeder
3	H31109 (M)	Dead chick
	H31382 (F)	
4	H23017 (M)	Cat predation
	?	
5	H31161 (M)	Infertile
	H33325 (F)	
6	H14014	Non-breeder
7	H31272 (M)	Dead embryo
	H30854 (F)	
8	H31103 (M)	Chick H34707
	H31273 (F)	
9	H31994	Non-breeder
	H33256	
10	H32901 (M)	Chick H33336
	H29680 (F)	
11		Empty
12	H33612 (M)	Chick H33342
	H33695 (F)	
13	H25418 (F)	Non-breeder
14	H31202 (M)	Non-breeder
15	?	Non-breeder
16	H31004 (F)	Chick H33335
	H32002 (M)	
17	H31108 (M)	Chick (fledged
	H28009 (F)	before banding)
18	H31204	Chick H33358
	H33326	
19		Empty
20	H33316	Non-breeder
21	H31235	Rat predation
	H33726	
22	H31214 (F)	Chick H33280
	H33320 (M)	
23		Empty
24	H31405	Dead chick
	H33773	
25	H25487	Chick (fledged
	H31217	before banding)
26	H23014 (M)	Dead embryo
27	?	Non-breeder
28		Empty
29	H28004 (M)	Non-breeder
30	H25446 (M)	Chick H33399
	?	
31	H31101 (M)	Chick (fledged
	?	before banding)
32 (PTG1)	H33268	Non-breeder
33	H31244 (F)	Chick H33365
	H28076 (M)	
34	H33305	Chick H33387
	H33746	
35	H33654 (M)	Chick H33287
	?	
36	H31129	Chick H33274
	?	
37	H31107 (M)	Chick H33346
	?	
38		Empty
39	H25426 (M)	Chick (fledged
	?	before banding)
40		Empty
41	H31112 (M)	Chick H33364
	?	
42	H29676	Chick H33341
	H31383	
43	H31016	Non-breeder
	H31586	
44	H31130 (M)	Dead embryo
	H25424 (F)	
45	H33258	Non-breeder
46	H28813	Chick H33279
	H31982	
47	?	Crushed egg
	H31018 (M)	
48	H31003 (M)	Chick H33352
	H26991 (F)	
49	H31243 (M)	Dead embryo
	H31010 (F)	

Appendix 1 continued.

BURROW	BAND	OUTCOME
50	H33747	Non-breeder
	H33254	
51	H29670 (F)	Chick H33384
	H22169 (M)	
52	H31289 (M)	Chick H33383
	H31255 (F)	
53		Empty
54		Empty
55 (PTG1)	H23635 (M)	Chick H33368
	H33638 (F)	
56 (PTG1)	H33304	Chick H33369
	?	
57 (PTG1)	H31153	Chick H33370
	?	
58 (PTG1)	H28029	Chick H33371
	H31205	
59 (PTG1)	H31125 (M)	Chick H33372
	H31220 (F)	
60 (PTG1)		Empty
61 (PTG1)	H25505 (F)	Chick H33377
	H30878 (M)	
62 (PTG1)	H31257 (M)	Chick H33382
	H25486 (F)	
63 (PTG1)	H31424 (M)	Non-breeder
	H33267 (F)	
64 (PTG1)	H33713 (F)	Chick H33373
	H31366 (M)	
65	H31460 (F)	Rat predation
	H27548 (M)	
66	?	Non-breeder
67 (KDG1)	H31270 (F)	Chick (fledged
	H31271 (M)	before banding)
68 (KDG1)	H32005 (F)	Chick H33396
	H31172 (M)	
69	H27604 (M)	Chick H33397
	H31240 (F)	
70	H33092 (M)	Dead chick
	H27665 (F)	
71 (KDG1)	?	Dead embryo
	H31242 (M)	
72 (KDG1)	H32907 (M)	Chick (fledged
	?	before banding)
73 (KDG1)	H28572 (M)	Chick (fledged
	H30876 (F)	before banding)
74 (KDG1)	H31974 (F)	Chick H34709
	H29693 (M)	
75 (KDG1)	H25421	Chick H34710
	H33314	
76 (KDG1)	H33758	Dead embryo
	H31089	
77 (KDG1)	H25407 (F)	Chick H34711
	H30870 (M)	
78 (KDG1)	H25512 (F)	Chick H34708
	H30867 (M)	
79 (KDG1)		Empty
80 (KDG1)	H29682 (F)	Chick H34712
	H25404 (M)	
81 (KDG1)	H31155 (F)	Chick H33392
	?	
82	H31978 (F)	Chick (fledged
	H30889 (M)	before banding)
83	H25631	Non-breeder
84	H29677 (M)	Crushed egg
	H31179 (F)	
85 (SFG1)	H33762 (F)	Non-breeder
	H31118 (M)	
86 (SFG1)		Empty
87 (SFG1)	H32033 (M)	Non-breeder
88 (SFG1)		Empty
89 (SFG1)	H30910 (F)	Non-breeder
	H31495 (M)	
90 (SFG1)	H32935 (F)	Chick H33284
	H33097 (M)	
91 (SFG1)	?	Non-breeder
92 (SFG1)	H33660 (F)	Cat predation
	H32928 (M)	
93	H33655 (F)	Chick (fledged
	?	before banding)
94	H23018 (M)	Infertile
	?	
95	?	Crushed egg
	H25425 (F)	
96 (PTG1)	?	Non-breeder
97	H30872 (M)	Chick (fledged
	?	before banding)
98		Empty
99	?	Chick (fledged
	H31201 (F)	before banding)
100	H29660 (M)	Chick H33385
	H29667 (F)	
101 (KDG1)	H25692 (F)	Chick (fledged
	H25588 (M)	before banding)
102 (KDG1)	H22511 (M)	Chick H33393
	H30866 (F)	
103 (KDG1)	H31588 (M)	Chick H33395
	H29690 (F)	
104 (KDG1)		Empty
105		Empty
106	H31038 (M)	Chick H33297
	H25458 (F)	
107	?	Dead embryo
	H33764 (M)	
108	H25417 (F)	Chick H33290
	H25452 (M)	

Appendix 1 continued.

BURROW	BAND	OUTCOME
109	H31052 (F)	Chick H33337
	H25428 (M)	
110 (SFG1)	H31008 (M)	Crushed egg
	?	
111 (SFG1)	H28033 (F)	Chick H33283
	H31986 (M)	
112 (SFG1)		Empty
113 (SFG1)	H25409 (F)	Chick H33282
	H33322 (M)	
114 (SFG1)	H25453 (M)	Chick (fledged
	H31142 (F)	before banding)
115	H31031 (M)	Chick H33386
	?	
116 (PTG1)	H25411 (F)	Chick H33378
	H25435 (M)	
117 (SFG1)	H29675 (M)	Non-breeder
	?	
118	H33259	Dead embryo
	H33321	
119	H25454 (F)	Chick H33366
	H31055 (M)	
120 (PTG1)		Non-breeder
121 (PTG1)	H25455	Infertile
	H31032	
122 (PTG1)	?	Non-breeder
123 (PTG1)	H31053 (M)	Chick H33380
	H31246 (F)	
124 (PTG1)	?	Chick H33381
	?	
125 (PTG1) *	?	Breeder
126 (PTG1)	H25577 (M)	Chick H33379
	?	
127	H25415 (M)	Chick (fledged
	H31128 (F)	before banding)
128	H31054 (M)	Chick (fledged
	H25495 (F)	before banding)
129		Empty
130	H33091	Non-breeder
	H33260	
131		Empty
132 (KDG2)		Empty
133 (KDG2)	H25430	Chick (fledged
	?	before banding)
134 (KDG2)	H33313	Non-breeder
135 (KDG2)	H25463	Chick H34703
	H25447	
136 (KDG2)	H29691 (F)	Chick H34702
	H29699 (M)	
137 (KDG2)	H25494 (M)	Chick H34704
	H31572 (F)	
138 (KDG2)	H33306 (M)	Chick (fledged
	H31565 (F)	before banding)
139	H14012 (F)	Crushed egg
	H23035 (M)	
140 (KDG2)	H32010	Non-breeder
141 (SFG2) *	?	Non-breeder
142 (SFG2)	H28026 (M)	Chick (fledged
	?	before banding)
143 (KDG2)		Empty
144 (KDG2)	H25459 (M)	Chick (fledged
	?	before banding)
145 (KDG2)	H25474	Chick (fledged
	H25504	before banding)
146 (KDG2)	H25460 (M)	Chick (fledged
	H25473 (F)	before banding)
147 (KDG2)	H28023 (M)	Dead chick
	?	
148 (KDG2)	H27534 (M)	Chick (fledged
	?	before banding)
149 (KDG2)	?	Infertile
	?	
150 (KDG2)	?	Chick H34701
	H25493 (M)	
151	H25593 (M)	Chick H33343
	H29674 (F)	
152 (SFG2)	H31983 (M)	Chick H33344
	H33761 (F)	
153 (SFG2)	?	Non-breeder
154 (PTG1)	?	Non-breeder
155 (PTG2)	?	Chick (fledged
	H33792 (M)	before banding)
156 (PTG2)	H31558	Chick H33376
	H31559	
157 (PTG2)		Empty
158 (PTG2)	?	Dead embryo
	H31451 (M)	
159 (PTG2)	H25441 (F)	Chick H33375
	H31557 (M)	
160	H25690 (M)	Chick H33291
	H29671 (F)	
161 (PTG2)	H31542	Non-breeder
162 (PTG2)	H29658	Crushed egg
	?	
163 (PTG2)	H33658	Non-breeder
164 (PTG2)	H33606 (M)	Chick H33374
	H31151 (F)	
165 (KDG2)	H29661 (F)	Chick H34705
	?	
166	H25437 (M)	Chick H33367
	H31122 (F)	

* Non-study burrow (cannot reach resident birds).

Appendix 1 continued.

BURROW	BAND	OUTCOME
167	H28012 (M)	Dead chick
	?	
168 (PTG1)	?	Non-breeder
169		Empty
170	H33770 (F)	Chick H33357
	H31967 (M)	
171	H31110 (F)	Chick (fledged
	?	before banding)
172	?	Non-breeder
173	H31143 (M)	Chick H33273
	?	
174	H28071 (M)	Dead chick
	H33772 (F)	
175	H25503 (M)	Chick H33300
	H28001 (F)	
176 (KDG1)	H27702	Chick (fledged
	?	before banding)
177	H31462	Dead embryo
	?	
178	?	Non-breeder
179	H29694 (M)	Chick H33348
	H29697 (F)	
180	H31560 (M)	Chick (fledged
	?	before banding)
	H33100 [interloper]	
	H33302 [interloper]	
181	H31463 (M)	Chick (fledged
	H31561 (F)	before banding)
182	H25514 (M)	Chick H33271
	H33785 (F)	
183 (SFG1)		Empty
184		Empty
185 (KDG1)		Empty
186	H31577 (M)	Chick H33355
	H29665 (F)	
187	H31047 (M)	Chick H33356
	H31452 (F)	
188	H26956 (F)	Dead embryo
	H28100 (M)	
189	H28015 (F)	Non-breeder
190		Empty
191 (PTG2)	?	Non-breeder
192 (SFG1)		Empty
193 (KDG2)		Empty
194 (KDG2)	H31569 (M)	Chick (fledged
	?	before banding)
195	H33311	Chick H33400
	H33327	
196	H28016 (F)	Chick (fledged
	H29951 (M)	before banding)
197	H25518 (M)	Crushed egg
	H29685 (F)	
198	H25699 (F)	Chick (fledged
	H31593 (M)	before banding)
199	H32009 (F)	Crushed egg
	H29696 (M)	
200	H32006 (F)	Chick (fledged
	H28073 (M)	before banding)
201	H31581 (M)	Chick H33351
	H28002 (F)	
202 (PTG2)	H31556 (F)	Dead embryo
	H28031 (M)	
203	?	Chick (fledged
	H30930 (M)	before banding)
204 (KDG1)	?	Non-breeder
205	H25697	Chick H33353
	H29664	
206		Empty
207 (PTG1)		Empty
208 (PTG1)	H33333	Non-breeder
	H33349	
209 (KDG3)		Empty
210 (KDG3)	H25691 (M)	Chick (fledged
	?	before banding)
211 (KDG3)	H33310 (M)	Infertile
	H29689 (F)	
212 (KDG3)	?	Chick (fledged
	H30869 (M)	before banding)
213 (KDG2)	?	Non-breeder
214 (KDG2)	H25687	Non-breeder
215 (SFG3)		Empty
216 (SFG3)	H28051 (M)	Chick (fledged
	?	before banding)
217 (KDG3)	H31991	Chick H33394
	H32903	
218		Empty
219 (PTG3)		Empty
220 (PTG3)	?	Chick (fledged
	?	before banding)
221 (PTG3)	H29695 (M)	Chick H33361
	?	
222	H28049 (M)	Chick (fledged
	?	before banding)
223 (SFG3)	H31598	Chick H33276
	H28068	
224 (PTG3)	H33756 (M)	Chick H33360
	H25564 (F)	
225 (SFG3)	?	Chick (fledged
	H13634 (M)	before banding)
226 (PTG3)	H27058 (M)	Non-breeder
227 (KDG3)	H25509 (M)	Crushed egg
	H33702 (F)	
228	H33633 (M)	Dead chick

Appendix 1 continued.

BURROW	BAND	OUTCOME
	H33308 (F)	
229 (PTG3)	H28042 (M)	Chick H33362
	H25565 (F)	
230 (PTG3)		Empty
231	H25568 (M)	Chick (fledged
	?	before banding)
232		Empty
233	H29698 (M)	Chick H33272
	H25558 (F)	
234	H25559 (F)	Dead chick
	H25546 (M)	
235	?	Chick (fledged
	H28044 (M)	before banding)
236		Empty
237	H25575	Non-breeder
238 (SFG1)		Empty
239	?	Dead chick
	?	
240	H31973	Chick H33293
	H33777	
241	H33332	Non-breeder
242	H28099 (M)	Chick H33345
	H31998 (F)	
243	H33264	Chick H33390
	?	
244	?	Chick H33391
	H33800	
245 (KDG1)	H33315	Non-breeder
246 (PTG3)	H25586 (M)	Chick H33359
	?	
247		Empty
248	H33727 (F)	Non-breeder
	H28067 (M)	
249	H33760	Chick (fledged
	?	before banding)
250	?	Chick H33347
	H30924 (M)	
251	?	Non-breeder
252	H25695 (F)	Chick H33338
	H28058 (M)	
253		Empty
254		Empty
255		Empty
256		Empty
257	H30877 (M)	Chick H33331
	H33759 (F)	
258 (PTG3)		Empty
259	H32025 (M)	Chick H33354
	H32018 (F)	
260 (SFG3)	H33266	Non-breeder
	H32034	
261	?	Chick H33275
	H33789 (F)	
262	H32902 (F)	Non-breeder
263	H31980	Chick H33269
	?	
264	H32031	Non-breeder
265 (KDG2)	H33312	Chick (fledged
	?	before banding)
266	H31975 (M)	Chick (fledged
	?	before banding)
267	H31989 (M)	Chick H33389
	?	
268		Empty
269		Empty
270	H33669 (M)	Crushed egg
	H33791 (F)	
271 (KDG1)	?	Chick (fledged
	H32920	before banding)
272	**?**	**Chick**
	?	**(out of reach)**
273	H33708	Chick H33285
	H32930	
274	H23034 (M)	Chick H33288
	H33706 (F)	
275	H32037 (M)	Dead chick
	H32046 (F)	
276		Empty
277	H33619	Chick (fledged
	H33620	before banding)
278	H33265	Non-breeder
279		Empty
280	H32929 (M)	Infertile
	H33319 (F)	
281	H33602 (M)	Non-breeder
	H33350 (F)	
282	H33652 (M)	Dead embryo
	?	
283		Empty
284	H32904	Chick H33363
	H32950	
285	H33769	Crushed egg
	?	
286	H33614	Non-breeder
	H33700	
287	H33670 (F)	Chick H33277
	H33699 (M)	
	H33096 [interloper]	
	H33301 [interloper]	
288	?	Chick H33278
	H33671 (M)	
289	H33621	Chick (fledged
	H33650	before banding)

Appendix 1 continued.

BURROW	BAND	OUTCOME
290	H33617	Non-breeder
291	H33618	Non-breeder
292	H33257	Crushed egg
	H33710	
293	?	Dead embryo
	H33317	
294	H32931 (M)	Non-breeder
295	H33263 (F)	Chick (fledged
	H33630 (M)	before banding)
296	H28054 (F)	Crushed egg
	H33682 (M)	
297	H33755 (F)	Infertile
	H28034 (M)	
	H33098 [interloper]	
298	H33646	Dead embryo
	H25579	
299	H33089	Non-breeder
300	H33716	Chick (fledged
	?	before banding)
301	H33768	Chick (fledged
	?	before banding)
302	H33686	Chick H33340
	H33787	
303	H33634	Non-breeder
304		Empty
305	?	Chick H33270
	?	
306		Empty
307	?	Chick H33398
	?	
308		Empty
309	H28020	Chick H33292
	H33328	
310 (SFG2)		Empty
311 (SFG2)		Empty
312 (SFG2)		Empty
313 (SFG2)		Empty
314 (SFG2)		Empty
315	H33714	Chick H33339
	H33318	
316	H33712 (M)	Chick H33334
	H33325 (F)	
317 (PTG2)	?	Non-breeder
318 (PTG3)		Empty
319	H31966	Chick H33388
	H33262	
320	?	Chick H33299
	?	
321	H33775	Chick (fledged
	H33771	before banding)
322 (PTG3)	H25555	Chick (fledged
	?	before banding)
323	H27504	Chick H33289
	H27526	
324	?	Chick H33281
	?	
325	?	Chick H33286
	?	
326	?	Chick H33294
	?	
327 (KDG2)	?	Chick H34706
	?	