

Surveying and monitoring of black petrels on Great Barrier Island, 1998/99

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CONTENTS

Abstract	5
1. Introduction	6
2. Objectives	6
3. Methods	6
4. Results	8
5. Discussion	12
6. Recommendations	17
7. Acknowledgements	17
8. References	18
Appendix 1	
Results from the burrows	19
Appendix 2	
Results from the rat index lines	23

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ABSTRACT

An endemic seabird, the black petrel (*Procellaria parkinsoni*) breeds on Little and Great Barrier Islands, New Zealand in burrows found 300 metres above sea level. The main breeding area on Great Barrier Island is around the highest point, Mount Hobson. During the 1998/99 breeding season, 202 burrows were identified (of which 197 were study burrows) in this area and intensively monitored during January and February. There were 142 study burrows used by breeding pairs, 42 by non-breeding adults and 13 empty burrows. There were 109 chicks present in April, which meant an overall breeding success rate of 77%. In addition three more census grids were established in the original areas. These and the 1995/96 census grids were intensively monitored. A total of 91 burrows were located within the six grids and of these, 65 burrows were being used for breeding. Extrapolating from these grid burrows estimates the black petrel population around the peak of Mount Hobson to consist of 4062 breeding birds and at least 719 non-breeding birds.

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

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1. Introduction

The work carried out during the 1998/99 breeding season is a continuation of the survey and monitoring study begun in 1995/96 (Bell & Sim 1998a), and continued over subsequent seasons (Bell & Sim 1998b, 2000). The continued monitoring on Great Barrier Island will help define the black petrel population dynamics and determine any effects that long-line fishing, predation and habitat disturbance may have on the overall population. A more accurate population estimate will be able to be made. In the future, this information can be used to develop an accurate population model that will determine any effects the long-line fishing industry (and other mortality factors) might have on the population.

2. Objectives

As a continuation of monitoring during previous breeding seasons, this study will provide more data to establish current population trends of the Great Barrier Island black petrel colony, and assist in determining causes and timing of mortality.

In summary, the objectives were to:

- Monitor a sample of black petrel burrows. Band all adults present in the burrows during January and February and all the remaining fledgling chicks present in April.
- Determine breeding success in the sample of long-term study burrows. Causes of breeding failure, such as predation or disappearance of parents were noted.
- Establish a further replicate census grid (40 × 40 m) in each of the three environmental strata types.
- Monitor the three census grids established in the 1995/96 season. 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.
- Search other areas thought to be suitable for black petrel breeding.

3. Methods

The three census grids set up around Hirakimata during the 1995/96 black petrel breeding season (see Bell & Sim 1998a, figs 1 and 2) were re-surveyed to locate any new burrows and to determine this seasons occupancy. Three new grids (also 1600 m²) were established in close proximity to the original grids

(Palmers Track, Kauri Dam and South Fork Track), but off the track system (Fig. 1), for greater representation of each study site. The location of these grid sites are chosen on three main ridges which face different directions (east, south and north-east). As a result, each grid has quite distinct microclimates and in some cases, vegetation cover. The information gathered from these census grids was used to determine a population and density estimate for black petrels around the Mount Hobson summit area (30 ha).

During the first session in the field (from 25 January to 28 February), the number of study burrows was increased from the 100 selected during the 1996/97 season (Bell & Sim 1998a) to 197 (see Figs 1 and 2). All study burrows are accessible either through the main entrance or via an excavated opening through the roof into the chamber. This opening is covered with a piece of plywood, soil and debris. During the first monitoring session, any adult present in the burrow was removed, banded, weighed and returned to the burrow. Any eggs or chicks in the burrows were noted if present, and the lack of eggs or chicks identified non-breeder birds. The study burrows were monitored again between 14-20 April and all remaining fledgling chicks were banded. This information was used to determine breeding success and continue the collection of long-term population dynamics data.

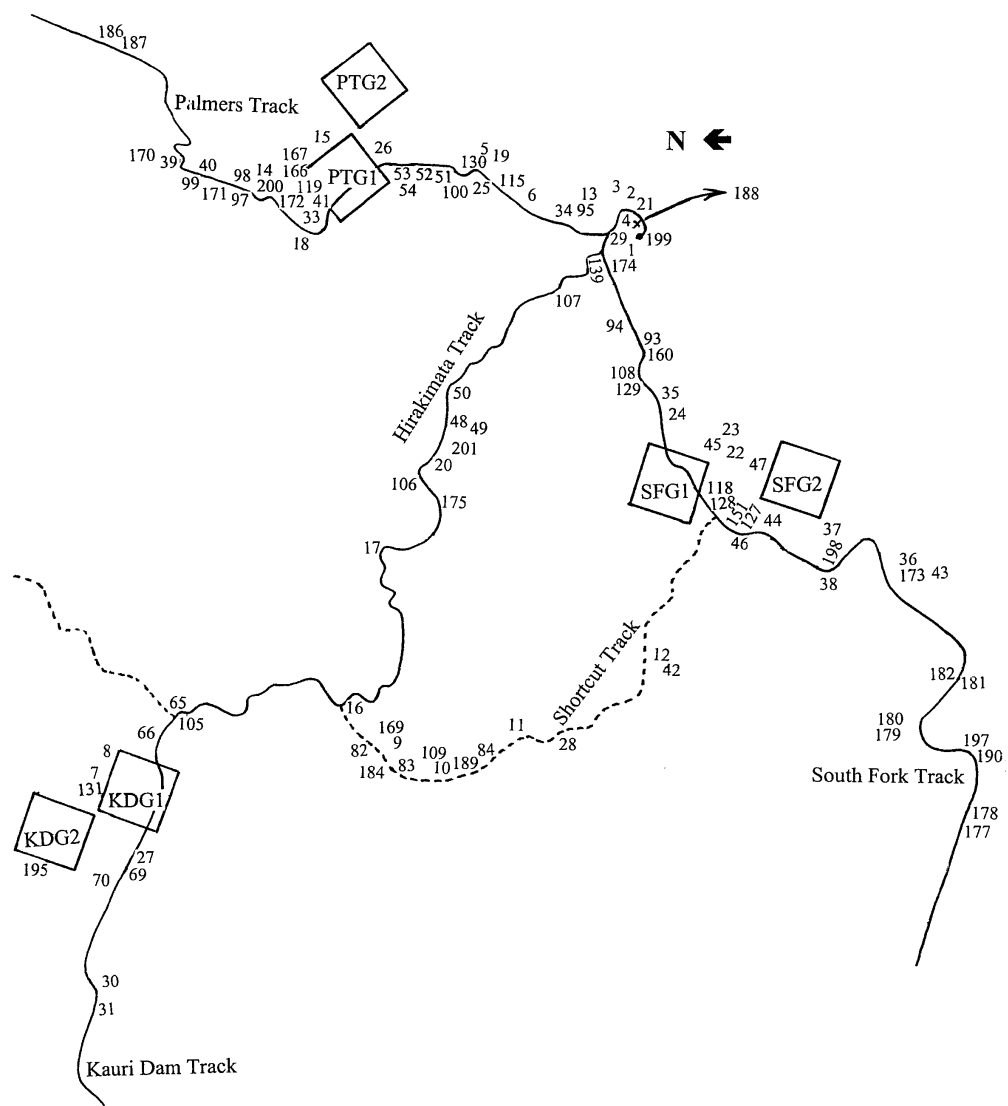


Figure 1. Location of the burrows and census grids around the summit area of Great Barrier Island. Note the numbers of the burrows found within the study grids are shown in Fig. 2.

Rat index lines were set up in February as directed in Cunningham & Moors (1993). A peanut butter and rolled oat mixture was used as bait. Index lines were set up in the same three areas as the census grids; Hirakimata Track, South Fork Track and Palmers Track. Rats were also trapped around the hut. Observations were also made on feral cat and rat predation and pig rooting.

4. Results

A total of 91 burrows were found in the 6 census grids (Table 1, Fig. 2). Of these, 65 were being used by breeding birds, 23 used by non-breeding birds, and 3 burrows were empty.

Breeding black petrels used 142 of the 197 study burrows, 42 burrows were being used by non-breeding birds, and 13 burrows were empty. There had been 33 failures, including an egg that was laid on the surface outside the burrow entrance. In April, 109 chicks were present and this corresponds to a breeding success of 77% (Table 2).

There were 274 adults present in the study burrows with 151 already banded and 123 banded this season (Appendix 1). Eight other adults were caught around the summit area. The average weight of breeding adults was 759 g, of

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

AREA	BURROW TYPE	GRID 1				GRID 2
		1995/96	1996/97	1997/98	1998/99	1998/99
Kauri Dam	Empty*	3	0	0	1	0
	Breeding	8	10	9	12	15
	Non-breeding	2	6	6	6	4
	Total	13	16	15	19	19
Palmers Track	Empty	2	0	0	1	0
	Breeding	8	14	13	15	10
	Non-breeding	3	4	9	6	1
	Total	13	18	22	22	11
South Forks	Empty	1	1	0	0	1
	Breeding	5	12	11	11	2
	Non-breeding	3	1	3	5	1
	Total	9	14	14	16	4
Annual totals		35	48	51	57	34

* These burrows have been used in previous seasons for breeding, but have no activity this year. The data is included in breeding success estimates if the burrow corresponds to one of the 197 study burrows.

Kauri Dam grid one (KDG1)

↓ N	81	67	103 102	104 68
		80		71
	79	176	101	72
	77	76	75 74	78 73 185

Kauri Dam grid two (KDG2)

N ←	132		143 138 144
		134 133 149	
135	194	193	137
136			148 146
150		140	147

Palmers Track grid one (PTG1)

63 N ↗		126	32
	96		116
62	124	61 125	120
	123	60 154	55
122	59	58	168
64	121	57 56	

Palmers Track grid two (PTG2)

N ↗			161 164
163	162	159	158 202
	191		156
			155

South Fork Track grid one (SFG1)

↘ N			183 111
	192		88
	86		87
85 114	113	112	
117		110 92	91 89 90

South Fork Track grid two (SFG2)

→ N			141 142
		153	
		152	

Figure 2. Location of burrows found in each grid site.

TABLE 2. BREEDING SUCCESS AND CAUSES OF MORTALITY.

	1996/97	1997/98	1998/99
Number of study burrows*	118	137	197
Eggs			
—laid	92	95	142
—predation (rat)	6	1	2
—crushed/pushed out (fight)	5	0	1
—abandoned	2	1	5
—infertile	6	4	12
—dead embryo (various stages)	0	8	6
Chicks			
—hatched	73	81	116
—predation (rat)	0	0	2
—predation (cat)	0	0	2
—died (disease)	1	0	0
—died (starvation)	0	1	0
—died (unknown causes)	0	0	3
—fledged [†]	72	80	109
Overall breeding success (%)	78%	84%	77%

* As the aim of this study has changed since the first season (1995/96), more study burrows have been added each season. The final aim is to have at least 250 study burrows by 1999/2000.

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

non-breeding adults was 689.6 g and all adults combined was 744 g (Table 3). In April, 109 chicks were present in the study burrows and all were banded (Appendix 1).

Both parents were identified in 92 of the breeding study burrows, with 31 where only one parent was identified and 20 burrows where no parents were identified (Appendix 1). Of the non-breeding burrows, there were 23 burrows where two or more birds were identified, 10 where one was identified and 8 where no birds were present during the day, but the burrows were active at night (Appendix 1).

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 4781 birds (Table 4). This is made up of 2031 breeding pairs (i.e. 4062 birds) and 719 non-breeding birds.

TABLE 3. AVERAGE WEIGHT OF BREEDING AND NON-BREEDING ADULTS.

	1995/96	1996/97	1997/98	1998/99
Breeding adult	761.7	776.0	754.0	759.0
Non-breeding adult	710.0	680.2	679.0	689.6
All adults combined	728.3	755.2	734.1	744.0

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

YEAR	DENSITY (No./sq. ha)		TOTAL STUDY AREA SIZE (sq. ha)	POPULATION ESTIMATE	
	BREEDING PAIRS	NON-BREED- ING BIRDS		BREEDING PAIRS	NON-BREED- ING BIRDS
1995/96 Total	43.75	16.67	30	1312.5	500
1995/96 Grand total (Breeders and non-breeders)				3125 individuals	
1996/97 Total	75	22.92	30	2250	687.5
1996/97 Grand total (Breeders and non-breeders)				5188 individuals	
1997/98 Total	68.75	37.5	30	2062.5	1125
1997/98 Grand total (Breeders and non-breeders)				5250 individuals	
1998/99 POPULATION ESTIMATE					
Kauri Dam	84.375	31.25	30	843.75	312.5
Palmers Track	78.125	21.875		781.25	218.75
South Fork	40.625	18.75		406.25	187.5
1998/99 Total	67.7	23.96		2031.25	718.75
1998/99 Grand total (Breeders and non-breeders)				4781 individuals	

Also extrapolating from the census grids, the 'useable' burrow density was 95 burrows/ha. Of these, 68 burrows/ha are used for breeding, 24 burrows/ha for non-breeding and 3 burrows/ha were empty. This relates to a ratio of 1:3 for non-breeding to breeding burrows and 1:31 ratio of empty to occupied burrows. There were also 14 'potential' burrows within these six grids, which have not been included in any burrow estimate. We define 'potential' burrows as those which have been investigated and/or preliminarily dug out by a bird, but are not yet being used by breeding or non-breeding petrels.

Rat index lines were completed in February. The rat index figures are shown in Table 5. The rat index figures were calculated using the formulas devised by Cunningham & Moors (1993). Seventeen rats in total were caught; and both

TABLE 5. RAT INDEX LINE DATA.

	NO. OF RATS CAUGHT	NO. OF TRAPS SPRUNG	TOTAL TRAP NIGHTS	'LOST' TRAP NIGHTS	CORRECTED TRAP NIGHTS	RAT INDEX
1997/98 (total)	39	64	600	51.5	548.5	7.1 rats/100 trap nights
South Fork, Feb. 1998/99	2	7	150	4.5	145.5	1.4 rats/100 trap nights
Palmers Track, Feb. 1998/99	2	7	148	4.5	143.5	1.4 rats/100 trap nights
Hirakimata Track, Feb. 1998/99	13	17	150	15	135	9.6 rats/100 trap nights
Feb. 1998/99 (total)	17	31	448	24	424	4.0 rats/100 trap nights

Rattus rattus (all three colour morphs were caught) and *R. exulans* were caught (Table 5, Appendix 2).

This season was the first occasion that a feral cat (or cats) predated black petrel chicks. Chicks from two study burrows were predated. Another black petrel chick corpse was found on the Shortcut Track (also inside the study area), but this chick was not from one of the study burrows in the area. There was also several feral cat predated corpses of Cook's petrel (*Pterodroma cookii*) found around the summit area (two being directly adjacent to black petrel burrow entrances). A ginger feral cat was seen near the lower Kauri Dam, but trapping was not successful. Other cat trapping around the summit area was also not successful. Further cat predation sign was found along the Coopers Castle Track. Pig sign was also found along this track as well as along the lower sections of the South Fork Track.

The general public visit Mount Hobson over the black petrel breeding season and approximately 500 visited during January and February and at least 200 over March and April. Two school groups (the local Okiwi School and a visiting school from Tamaranui) were given introductory talks about the black petrel project during the first monitoring period. As usual, even those petrels with burrows directly adjacent to the track, did not appear to be disturbed by the high numbers of visitors.

5. Discussion

Monitoring of the three census grids established in the 1995/96 season (Bell & Sim 1998a) continued in the 1998/99 season (Table 1) along with the three additional census grids (one in each of the three distinct environmental areas). In the 1998/99 season, there were 91 burrows within the six grids (65 breeding, 23 non-breeding and three empty burrows). The previously established grids are resurveyed each season and as a result 4 new burrows were located in Kauri Dam grid one, and 2 new burrows were also found in South Forks grid one. As this study continues the number of burrows within the grids will only change slightly as new birds return to their natal area and start to excavate new burrows, or burrows collapse and become unusable.

In the 1998/99 season there were 14 potential burrows (burrows that have been investigated, or preliminarily dug out by black petrels) identified within the six grids. Two were first identified in the 1997/98 season and were still not being used this year. The remaining 12 burrows were newly identified this season.

Comparing the 'old' and 'new' grids shows distinctly different numbers of burrows in some areas. Both Kauri Dam grids one and two had 19 burrows, but Palmers Track grid one had 22 while the new Palmer Track grid two only had 11 and South Fork grid one has 16 burrows and the new South Fork grid two only had 4. Both Palmers Track grid two and South Fork grid two are in areas of more steep terrain with tangled vegetation. These areas may be less optimal environment for digging burrows or may be difficult for the black petrels to get through.

Extrapolating from the 6 census grids to the Mount Hobson summit area (30 ha) gives the population estimate of the Great Barrier Island black petrels to be 4781 birds (2031 breeding pairs (4062 birds) and 719 non-breeding birds). This estimate is less than previous years (5188 in 1996/97 and 5250 in 1997/98) and this is likely to be the result of increasing the number of study grids from 3 to 6. Three more grids will be set up again during the next season, and so the population estimate is likely to lower again. Replicating the grids will give a better idea of burrow density within each distinct area and as a result give a more statistically sound population estimate for the entire study area.

As this population estimate is only for the area directly around Mount Hobson it does not give an accurate estimate for the entire black petrel population on Great Barrier. 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). Also the status of the population present in the Northern Block (Tataweka) should be checked and possibly monitored regularly. This population has not been monitored since Scofield (1989) visited the area.

As in all the previous years, the burrows were occupied at a much higher ratio than found in previous studies. Imber (1987) and Scofield (1989) both had ratios of about 1:1 empty to occupied burrows. For this season the ratio is 1:31, which is also higher than the previous years (1995/96 was 1:1, 1996/97 was 1:7, and 1997/98 was 1:25). This is because of the low number of empty burrows this year, and also a feature of the higher number of burrows in the six grids. This occupation rate is probably due to a higher number of returning birds during the 1998/99 breeding season.

The ratio of non-breeding burrows to breeding burrows was 1:3. This is higher than the 1:1 from both Imber (1987) and Scofield (1989), and higher than the two previous seasons of 1995/96 (1:2) and 1997/98 (1:2). However, it is identical to 1996/97 (1:3). This is probably due to more breeding birds this season compared to 1995/96, 1997/98, and the Imber and Scofield seasons, and similar numbers to the 1996/97 season (see Table 1).

In addition to the 100 long-term study burrows selected during the 1996/97 season (Bell & Sim 1998a) a further 97 burrows were established. All 197 study burrows were intensively monitored this season. Of these, 142 were used for breeding, 42 were used by non-breeding birds and 13 burrows were empty. Two eggs were predated by rats (1.5%), 5 eggs were abandoned (3.5%), 12 eggs were infertile (8.5%), 6 embryos died at various stages within the egg (4%) and 1 egg was crushed during a fight between adults. Two chicks were predated by rats (1.5%), another 2 chicks were predated by a feral cat(s) (1%), and 3 chicks died of unknown causes (2%). This equates to an overall breeding success rate of 77% compared to 50% in 1977, 60% in 1978 (Imber 1987), or 62% in 1988/89 (Scofield 1989). This breeding success rate is lower than the rates for both the preceding seasons of this study—1996/97 was 78% (Bell & Sim 1998a) and 1997/98 was 84% (Bell & Sim 1998b). This is the result of more egg failures and chick deaths than in the previous years.

Each breeding season has had very different mortality factors. The 1996/97 season was predominately effected by rat predation (6.5%), but that has not been such an important factor in the last two years (1% in 1997/98 and 1.4% in 1998/99). The percentage of infertile and abandoned eggs was higher this

season than in previous years (infertile eggs: 8.5% compared to 6.5% in 1996/97 and 4% in 1997/98; abandoned eggs: 3.5% compared to 2% in 1996/97 and 1% in 1997/98). Several of the infertile eggs were located in burrows with 'new' partnerships (after an adult death, disappearance or divorce event, Appendix 1) and therefore may be due to one of the birds being not ready for breeding yet, or both birds 'practising' breeding. The number of embryos dying within the egg was less than last season (4% compared to 8%). Chicks are very vulnerable at the pipping stage to changes in humidity and temperature and are affected by loss of water (Warham 1990). In 1997/98 the weather was very hot and dry whereas this season the weather was cooler and had more frequent periods of rain (or drizzle). There were similar percentages of chicks hatched both in 1997/98 (85%) and 1998/99 (82%), but more chicks were predated or died of unknown causes in 1998/99. This resulted in a lower breeding success for this season (77%) compared to last year (84%). Despite the range of mortality factors, this year appears to be a good breeding season with a large number of chicks surviving to fledging.

This season a total of 283 adult black petrels were found around the summit area this season and 274 of these were found in the study burrows with 151 already banded. Most adults were weighed. The average adult weight (of all adults combined) was 744 g (compared to 770 g from Scofield 1989). The average weight for a breeding adult was 759 g compared to 690 g for a non-breeding adult and this difference is due to differing physical requirements needed for incubation, and chick feeding. Over the past 4 seasons this weight difference has been between 50 g and 100 g. The 1998/99 weights of the breeding adults were lighter than the weights in 1995/96 and 1996/97, but heavier than 1997/98 (Table 3). The weights of non-breeding adults were lighter than those from 1995/96, but heavier than 1996/97 and 1997/98 (Table 3). However there is not much difference in both the breeder and non-breeder weights (22 g spread between the breeders weights and 31 g spread for non-breeders). This may relate to the availability of food and overall condition of the birds.

In April, 109 chicks were present in the study burrows and together with the eight chicks found in other non-study burrows around Mount Hobson, were banded. Chicks present in two study burrows were very small (375 g and 390 g). One chick was not very well developed and was still downy, with barely any feather development (only the wing feathers were beginning to pin), but was very healthy (large amounts of body fat could be felt) and active (study burrow 57, Appendix 1). The other was very thin (no body fat), balding in some areas (belly and rear) and was very lethargic. This chick had clear, feathered wings (study burrow 87, Appendix 1). Both chicks were banded and were still alive at the end of the April visit, however the chick in burrow 87 was not very healthy and gave the appearance of being 'at death's door'. It will be interesting to see if there are any remains of this chick next season.

Trapping and observation during the 1995/96 and 1996/97 breeding seasons suggested high numbers of rats in the Mount Hobson study area. Rat predation occurred again this season (3%) and this was higher than last year (1%) and 1995/96 (2%) but lower than 1996/97 (6.5%). It was also the first season that rats had predated small (newly hatched) chicks. Two chicks and two eggs were predated. Both Imber (1987) and Scofield (1989) also recorded rat predation

during their studies. Although the percentage of rat predation varies annually, it is still a major mortality factor. As such it is important to monitor the density of rats in the study area and so the rat index lines set up during the 1997/98 season were repeated in 1998/99 (Palmer's Track, Hirakimata Track, and South Fork). Both *Rattus rattus* (all three colour morphs) and *R. exulans* were caught. The results from the index line was 6.2 rats/100 trap nights. This gave much higher rat densities than Scofield (1 capture/98 trap nights, 1989). Note that previously, in the earlier breeding seasons, rat predation was generally in Palmer's Track grid one, in study burrows along Palmer's Track, or around the summit (pers. obs.; Bell & Sim 1998, 1998a). However this year there was a rat predation in each of the two Palmer's Track census grids, in the South Forks area and in Kauri Dam grid one. It is also interesting to note that where the highest density of rats were caught, the breeding burrows in the area all produced chicks that fledged safely. However, it must be stressed that this does not mean rats did not predate eggs and/or chicks in other (non-study) burrows in this area.

This season was the first year that chicks were predated by a feral cat(s). Two chicks were predated. Only one corpse was recovered (in the entrance to the burrow). This corpse had crushed bones and the skull was missing which are classic indicators of a cat feeding. A feral cat could have fitted into the burrow to reach the chick (the entrance has now been reduced). The adult black petrels were both very stressed and had dug another entrance after this predation. The second burrow had an entrance which would have been too small for the feral cat and so the chick must have been predated when it was outside. As most of the black petrel burrow entrances are too small (or passages too narrow and long to reach the chamber), juvenile petrels are vulnerable to feral cat predation as soon as they leave the burrows to strengthen wings and practise flying (Warham 1996).

Another back petrel chick corpse was found along the Shortcut Track. The whole chick had been swallowed and then regurgitated by a feral cat. No chicks were missing from any of the adjacent burrows, so it must have been from another nearby non-study burrow. Trapping in the area (and further trapping at the lower Kauri Dam by Te Ngahere Native Forest Management) did not result in any captures. A ginger feral cat was seen near the lower Kauri Dam on two occasions (pers. obs.; W. Scarlett pers. comm.). A black petrel with suspected avian pox was also found near the lower Kauri Dam by Te Ngahere Native Forest Management staff, but before it could be collected, the bird was predated by a feral cat (W. Scarlett pers. comm.). Further feral cat sign and predation evidence (of both Cook's petrels and black petrels) were located along the Cooper's Castle walk. Three black petrel chick remains and four Cook's petrel corpse were counted. Two Cook's petrel corpses were also found in April, directly adjacent to black petrel burrows. The trapping completed this season should be extended and constant trapping over the breeding season (especially during fledging, May-June) should continue throughout this study.

As in all the other breeding seasons, high numbers of the public visited the Mount Hobson black petrel breeding area. This had little-to-no impact on the breeding success. The construction of raised walkways around the summit has decreased damage to the environment and consequently, to the burrows. This

season, Te Ngahere Native Forest Management was completing construction of several of the DOC structures on and around the summit area. The team was informed of all burrow locations near the building sites and structures to reduce disturbance or prevent destruction of any burrows. None of the building disturbed any of the breeding birds. Extra walkway construction is recommended, particularly on Palmers (Windy Canyon) and Kauri Dam Tracks where erosion has increased down the tracks. This should be done with full consultation, to prevent the destruction of burrows as certain areas have high burrow densities. Another important development for Great Barrier Island would be if more interpretative material could be placed around the summit area (perhaps sited on the summit platform). This would educate the visitors about the unique habitat and the black petrels, and deter them from littering or fouling the area.

It was noted last season (Bell & Sim 2000) that a parent went 'missing' from study burrow 15 resulting in the starvation of the chick. This season the burrow was empty and the female had moved to another burrow (96), got another partner and laid an egg (that was later predated). This means it is likely that its former male partner died during the 1998 season. It is very important to continue to monitor for this 'missing' bird (in case he returns) and to monitor the female's progress with the new partner over the next few seasons.

The domestic long-line industry operates during the black petrel breeding season and despite observer data being limited, black petrel by-catch has been recorded in previous breeding seasons (Ian West pers. comm.). Over recent years approximately 15 black petrels have been caught by the fishing industry (Ian West pers. comm.). Adult black petrels caught on long lines from February to June could easily be foraging food for chicks and this would result in the starvation of the chick. Overall this will effect the entire population by reducing recruitment and productivity. Like most procellariiforms, black petrels have delayed maturity, low reproduction rates, and high adult survivorship. Any change, however small, in adult survivorship will effect the population greatly (Murray et al. 1993). If large numbers of breeding adults continue to get caught on long-lines, this species could be drastically effected. It is important to continue to study the black petrel population especially in relation to adult survivorship, mortality, productivity and breeding success. The development of an accurate population model to determine these factor and their effects is very important. A good population model will assess the various factors affecting the black petrel population and help to determine the overall effects of by-catch in the long-line fishing industry.

6. Recommendations

The authors recommend:

- Continued monitoring of the black petrel population (using the long-term study burrows) at Great Barrier Island for at least a further five breeding seasons. This will ensure enough data will be collected for determining the population dynamics of black petrels, in particular survivorship, mortality and breeding success, and to determine the effects of predation, long-line fishing and other environmental factors.
- A check of the Northern Block (Tataweka) for the black petrel population recorded by Imber and studied by Scofield, to determine whether black petrels still inhabit the area.
- Setting up census grids on other high points around the Mount Hobson area (Mount Heale, Mount Matawhero, Hogs Back) to get a better estimate of the black petrel population on Great Barrier Island. These sites should be monitored for as long as the study continues.
- Visit the Great Barrier Island breeding population for two weeks during October/November to monitor pair bonding and pre-breeding behaviour. A large number of adults could easily be banded (hence identifiable) as they are generally outside the burrows at this time. This could be established as a mark-recapture programme to determine a better population estimate.
- The January/February study session should remain five weeks long, as this gives a clearer picture of breeding behaviour and results; the April period should remain as one week.
- Rat index lines continue to be run in the study area. This will ensure data on species present, total rat densities, and densities within distinct areas will be collected and can be related to effects on petrel mortality.
- Constant cat trapping over the black petrel breeding season, November–June, especially during pre-laying (November) and the fledging period (May–June) should continue.
- Continuation of the walkway system down Palmers (Windy Canyon) and Kauri Dam Track Construction should be completed between July and October when the chicks have fledged and before the adults return. Known petrel burrows could be identified for the construction team to avoid.

7. Acknowledgements

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Appendix 1

RESULTS FROM THE BURROWS

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
1	-	-	Empty
2	H25408 H25438	760 g -	Chick H31503
3	H31267 H31109	650 g 905 g	Chick H31504
4	H27542 H25481	800 g 800 g	Infertile egg
5	H31020 -	- -	Chick H31533
6	-	-	Non-breeder
7	H31272 H30854	935 g 885 g	Chick H31471
8	H31103 H31273	710 g 840 g	Chick H31472
9	-	-	Non-breeder
10	-	-	Empty
11	-	-	Empty
12	-	-	Empty
13	H31281 H25418	745 g 625 g	Non-breeder
14	H31284 H31202	780 g 815 g	Infertile egg
15	-	-	Empty
16	H31004 H31296	760 g 755 g	Chick H31476
17	H31108	750 g	Non-breeder
18	H31204 H25434	675 g 690 g	Non-breeder
19	H31162 H30859 H25468	735 g 580 g -	Non-breeder
20	H31134 H25420	715 g -	Chick H31490
21	H31235 H31019	905 g 800 g	Chick H31502
22	H31214 H25492	- 735 g	Chick H31483
23	-	-	Empty

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
24	H31242	-	Infertile egg
25	H25487 H31217	- 760 g	Chick H31531
26	H23014 H31218	- 770 g	Chick H31528
27	-	-	Empty
28	H31231 H31114	780 g 935 g	Infertile egg
29	-	-	Empty
30	H25412 H25445 H25446	670 g 790 g 710 g	Non-breeder
31	H31101 H31237	795 g 710 g	Chick H25521
32 (PTG1)	H25480 H31466	680 g 605 g	Non-breeder
33	H31123 H31244	715 g -	Chick H31526
34	H31248 H31121	- 730 g	Dead embryo
35	H31249 H13641	730 g 870 g	Chick H31486
36	H31129 H25414 H25520	680 g 680 g 635 g	Abandoned egg
37	H31107 -	610 g -	Chick H25548
38	-	-	Empty
39	H31039 H25426	640 g -	Chick H31517
40	H31111 -	610 g -	Chick H31518
41	H31029 H31112	835 g 680 g	Chick H31525
42	H31115 H31140	900 g 670 g	Chick H31481
43	H31016	710 g	Non-breeder
44	H31130 H25424	- -	Non-breeder

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
45	H31117	805 g	Predation (rat, chick)
	H31157	725 g	
46	H28813	660 g	Non-breeder
	H31002	-	
47	H31005	630 g	Chick H31482
	H31018	645 g	
48	H31003	790 g	Chick H31492
	H26991	720 g	
49	H31243	700 g	Chick H31491
	H31010	790 g	
50	H25466	-	Non-breeder
	H25476	680 g	
51	H31454	640 g	Non-breeder
52	H31289	-	Chick H31530
	H31255	695 g	
53	H31021	-	Chick H31529
	H30884	-	
54	H31022	-	Non-breeder
55 (PTG1)	-	-	Empty
56 (PTG1)	H31151	765 g	Infertile egg
	H31152	700 g	
57 (PTG1)	H31136	860 g	Chick H31541
	H31153	820 g	
58 (PTG1)	H31205	660 g	Dead chick
59 (PTG1)	H31125	790 g	Chick H31543
	H31220	840 g	
60 (PTG1)	H25456	-	Non-breeder
61 (PTG1)	H31113	800 g	Chick H31553
	H30878	770 g	
62 (PTG1)	H31257	-	Infertile egg
	H31288	-	
63 (PTG1)	H31247	910 g	Chick H31536
	H31206	-	
64 (PTG1)	H31286	-	Chick H31544
	H30861	-	
65	H31460	680 g	Non-breeder
	H27548	700 g	
66	H25406	690 g	Non-breeder
	H25407	615 g	
67 (KDG1)	H31270	820 g	Predation (cat, chick)
	H31271	670 g	
68 (KDG1)	H31154	790 g	Chick H25536
	H31172	825 g	
69	H31240	850 g	Chick H31467
	H27604	765 g	

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
70	H25401	830 g	Chick H25522
	H27665	-	
71 (KDG1)	H31242	705 g	Chick H25550
	H31023	710 g	
72 (KDG1)	H31293	900 g	Chick H31468
	H31155	820 g	
73 (KDG1)	H28572	865 g	Chick H31469
	H31300	815 g	
74 (KDG1)	H25429	-	Abandoned egg
75 (KDG1)	H30867	800 g	Non-breeder
	H31147	710 g	
76 (KDG1)	H25402	845 g	Chick H31473
	H31001	660 g	
77 (KDG1)	H31274	680 g	Predation (rat, chick)
	H30870	710 g	
78 (KDG1)	H31141	650 g	Non-breeder
	H31102	780 g	
79 (KDG1)	H25403	645 g	Non-breeder
80 (KDG1)	H31104	820 g	Chick H31475
	H25404	860 g	
81 (KDG1)	-	-	Abandoned egg
82	H31253	825 g	Chick H31477
	H30889	675 g	
83	H25413	660 g	Non-breeder
	H25496	630 g	
84	H31179	-	Chick H31480
	H28551	730 g	
85 (SFG1)	H25478	715 g	Non-breeder
	H31118	750 g	
86 (SFG1)	H27678	880 g	Chick H31499
	H31259	710 g	
87 (SFG1)	H31211	740 g	Chick H31496
	H31158	760 g	
88 (SFG1)	-	-	Abandoned egg
89 (SFG1)	H31233	790 g	Chick H31495
	H30910	750 g	
90 (SFG1)	H25409	-	Non-breeder
	H25432	770 g	
91 (SFG1)	-	-	Non-breeder
92 (SFG1)	H31261	710 g	Predation (cat, chick)
	H31119	745 g	
93	H30856	-	Chick H31488
	H27552	720 g	

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
94	H23018 H31028	- -	Infertile egg
95	H30880 H25425	825 g -	Chick H31513
96 (PTG1)	H31011 H31287	810 g 640 g	Predation (rat, egg)
97	H30872 H31263	650 g 700 g	Chick H31522
98	H31283 H30890	815 g 680 g	Chick H31521
99	H31262 H31201	655 g 670 g	Chick H31518
100	H25485 H31268	655 g -	Non-breeder
101 (KDG1)	-	-	Non-breeder
102 (KDG1)	H25511	-	Non-breeder
103 (KDG1)	-	-	Non-breeder
104 (KDG1)	-	-	Empty
105	H14018 H25444	680 g 795 g	Infertile egg
106	H31038 H25458 H25451	770 g 680 g 690 g	Crushed egg
107	-	-	Empty
108	H25452 H25477	750 g 760 g	Chick H31487
109	H31052 H25428	670 g -	Chick H31470
110 (SFG1)	H31007	670 g	Chick H31494
111 (SFG1)	H31026 H25431	810 g -	Chick H31497
112 (SFG1)	-	-	Non-breeder
113 (SFG1)	H25410 -	725 g -	Chick H31500
114 (SFG1)	H31025 H25453	1000 g 750 g	Chick H31485
115	H31031 H25433	- 620 g	Non-breeder
116 (PTG1)	H25411 H25435	920 g 920 g	Chick H31537
117 (SFG1)	H28804	610 g	Chick H31501
118	H25467 H25486	- 650 g	Chick H31484
119	H31055 H25454	680 g 740 g	Chick H31527

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
120 (PTG1)	H23635 H25436	750 g 785 g	Non-breeder
121 (PTG1)	H25455	750 g	Chick H31542
122 (PTG1)	H31050	720 g	Non-breeder
123 (PTG1)	H31053 H31246	750 g -	Chick H31554
124 (PTG1)	-	-	Non-breeder
125 (PTG1)	-	-	Non-breeder
126 (PTG1)	-	-	Infertile egg
127	H25415 H31128	785 g 830 g	Infertile egg
128	H31054 H25495	700 g 790 g	Dead embryo
129	H25417	760 g	Dead chick
130	H28212 H25457	765 g 830 g	Chick H31532
131	H25421	980 g	Chick H31470
132 (KDG2)	H25465	730 g	Dead embryo
133 (KDG2)	H25430	830 g	Chick H25525
134 (KDG2)	-	-	Non-breeder
135 (KDG2)	H25463 H25447	790 g 865 g	Chick H25527
136 (KDG2)	H25464 H25470	720 g 895 g	Chick H25528
137 (KDG2)	H25475 H25494	655 g 695 g	Non-breeder
138 (KDG2)	H25448	700 g	Chick H25535
139	H14012 H23035	625 g 820 g	Chick H31493
140 (KDG2)	H25482	595 g	Chick H25532
141 (SFG2)	-	-	Chick (out of reach)
142 (SFG2)	-	-	Empty
143 (KDG2)	H25469	650 g	Chick H25523
144 (KDG2)	H25459	800 g	Dead embryo
145 (KDG2)	H25474 H25504	655 g 705 g	Chick H25534
146 (KDG2)	H25460 H25473	710 g 910 g	Chick H25533
147 (KDG2)	H25461 H25472	735 g 770 g	Dead embryo
148 (KDG2)	H27534 H25483	830 g 710 g	Chick H25531

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
149 (KDG2)	H25462	860 g	Chick H25524
	H25507	750 g	
150 (KDG2)	H25471	735 g	Chick H25524
	H25493	780 g	
151	H31040	690 g	Non-breeder
152 (SFG2)	H25498	825 g	Chick H25549
	H31453	540 g	
153 (SFG2)	H25479	645 g	Non-breeder
154 (PTG1)	H25484	870 g	Abandoned egg
	H25499	740 g	
155 (PTG2)	H25497	650 g	Predation (rat, egg)
156 (PTG2)	H25439	770 g	Dead embryo
	H25454	900 g	
157 (PTG2)	-	-	Chick H31546
158 (PTG2)	H25440	830 g	Chick H31550
	H31451	800 g	
159 (PTG2)	H25441	660 g	Dead chick
160	H25422	-	Non-breeder
	H25506	700 g	
161 (PTG2)	H25488	750 g	Chick H31545
	H25500	615 g	
162 (PTG2)	H25442	785 g	Chick H31549
	H25489	745 g	
163 (PTG2)	H25490	740 g	Non-breeder
	H25491	625 g	
164 (PTG2)	H25443	670 g	Chick H31551
	H25505	870 g	
165 (KDG2)	-	-	Non-breeder
166	H25437	745 g	Chick H31538
167	-	-	Chick H31539
168 (PTG1)	H25449	745 g	Chick H31540
169	-	-	Non-breeder
170	H25501	785 g	Chick H31516
171	H31110	820 g	Chick H31520
172	H25502	750 g	Chick H31523
	H31048	770 g	
173	-	-	Chick H25546

BURROW	ADULT		OUTCOME
	BAND	WEIGHT	
174	H27728	720 g	Chick H31489
175	H25503	-	Infertile egg
176 (KDG1)	-	-	Chick H31474
177	H31459	-	Chick H25537
	H31462	760 g	
178	H31168	-	Chick H25538
	H25508	700 g	
179	H31058	660 g	Chick H25541
180	-	-	Chick H25542
181	H31463	690 g	Chick H25544
182	H31464	650 g	Chick H25545
	H25514	-	
183 (SFG1)	H31465	740 g	Chick H31498
	H25515	610 g	
184	-	-	Chick H31478
185 (KDG1)	H25509	680 g	Infertile egg
186	H31046	825 g	Chick H31514
187	H31047	-	Chick H31515
	H31452	825 g	
188	-	-	Chick H31505
189	H25516	700 g	Non-breeder
	H25517	680 g	
190	H25518	670 g	Non-breeder
	H25519	690 g	
191 (PTG2)	-	-	Chick H31547
192 (SFG1)	-	-	Non-breeder
193 (KDG2)	-	-	Non-breeder
194 (KDG2)	-	-	Chick H25526
195	-	-	Chick H25530
196	-	-	Chick H25539
197	-	-	Chick H25540
198	-	-	Chick H25547
199	-	-	Chick H31506
200	-	-	Chick H31524
201	-	-	Chick H31535
202 (PTG2)	-	-	Chick H31548

Appendix 2

RESULTS FROM THE RAT INDEX LINES

DATE (night of)	LOCATION	TRAP NO.	SPECIES	WEIGHT (g)	NOTES
3/2/99	Hirakimata	14a	<i>R. rattus alexandrinus</i>	53	female
3/2/99	Hirakimata	20b	<i>R. rattus frugivorous</i>	144	male
3/2/99	Hirakimata	23b	<i>R. rattus frugivorous</i>	45	male
3/2/99	Hirakimata	24b	<i>R. r. rattus</i>	41	male
3/2/99	Hirakimata	25a	<i>R. r. rattus</i>	46	male
3/2/99	Hirakimata	25b	<i>R. rattus alexandrinus</i>	47	male
4/2/99	Hirakimata	8a	<i>R. rattus frugivorous</i>	176	male
4/2/99	Hirakimata	8b	<i>R. exulans</i>	74	female
4/2/99	Hirakimata	23a	<i>R. exulans</i>	42	female
4/2/99	Hirakimata	25b	<i>R. rattus alexandrinus</i>	47	female
5/2/99	Hirakimata	15b	<i>R. rattus frugivorous</i>	166	female
5/2/99	Hirakimata	21b	<i>R. r. rattus</i>	56	male (juvenile)
5/2/99	Hirakimata	24b	<i>R. rattus alexandrinus</i>	52	male (juvenile)
15/2/99	Hut	-	<i>Rattus exulans</i>	-	Female, eaten
18/2/99	South Forks	5a	<i>R. rattus alexandrinus</i>	116	female
19/2/99	South Forks	5b	<i>R. exulans</i>	87	female
21/2/99	Palmers	4b	<i>R. rattus alexandrinus</i>	30	
21/2/99	Palmers	4b	<i>R. rattus alexandrinus</i>	183	female (lactating)