0029-4470

An estimate of numbers of grey-faced petrels (*Pterodroma macroptera gouldi*) breeding on Moutohora (Whale Island), Bay of Plenty, New Zealand, during 1998-2000

M.J. IMBER
MALCOLM HARRISON
Department of Conservation, P.O. Box 10-420, Wellington
mimber@doc.govt.nz

SASKIA E. WOOD
22 Sutherland Crescent, Melrose, Wellington

REG N. COTTER
1 Bolton Street, Petone, Wellington

Abstract Moutohora (Whale Island) holds the largest surveyed breeding colony of grey-faced petrels (*Pterodroma macroptera gouldi*). For our estimate of the breeding population, we divided the island into 16 sections within which burrow densities were approximately uniform; the surface areas of these sections were found by planimetry. Apparently completed burrows were counted in 1998-2000 within each section by plots of 2 m radius along linear transects, or by 10 × 10 m contiguous plots. The total estimate (± SE) for the island was 109,000 ± 10,000 burrows, which equates to about 95,000 pairs breeding annually, given an occupancy rate of about 87%. The population has apparently more than doubled since Norway rats (*Rattus norvegicus*) and rabbits (*Oryctolagus cuniculus*) were eradicated in 1985/87.

Imber, M.J.; Harrison, M.; Wood, S.E.; Cotter, R.N. 2003. An estimate of numbers of grey-faced petrels (*Pterodroma macroptera gouldi*) breeding on Moutohora (Whale Island), Bay of Plenty, New Zealand, during 1998-2000. *Notornis 50(1)*: 23-26.

Keywords grey-faced petrel; breeding population; estimate; Moutohora; Whale Island; post-predation population recovery

INTRODUCTION

Moutohora (Whale Island) in the Bay of Plenty, New Zealand (Fig. 1), 10 km north-east of the port of Whakatane, is a Wildlife Refuge (gazetted 1965) and a Government Purpose Wildlife Management Reserve (gazetted 1991). It holds probably the largest breeding colony of grey-faced petrels (*Pterodroma macroptera gouldi*) (Marchant & Higgins 1990; Heather & Robertson 1996). The eggs and chicks of this colony were intensely preyed upon by Norway rats (*Rattus norvegicus*), and rabbits (*Oryctolagus cuniculus*) chronically disturbed or usurped burrows, between 1972 and 1985 (Imber *et al.* 2000). Norway rats probably colonised Moutohora about 1920, and rabbits were introduced in 1967/68 (Imber *et al.* 2000).

During a study of grey-faced petrel breeding biology and ecology on the island between 1968 and 1972 (Imber 1976), a preliminary estimate of the size of the breeding population was made. The estimate was based on the numbers of fledglings banded during large-scale banding operations in 1969-71, on the proportions of fledglings found to be banded towards the end of those operations or among those recovered in and around Whakatane after being attracted to lights (Imber 1975), and on the percentage of burrows producing fledglings in the breeding biology study (Imber 1976). From these data MJI estimated that there were then 30,000 to 40,000 pairs of grey-faced petrels breeding on the island. With an occupancy rate by breeding pairs of 80-90% of burrows (Imber 1976), there were then estimated to be up to 50,000 burrows on the island.

The petrel population almost certainly declined between 1972 and 1987 because of the

Received 17 January 2002; accepted 24 October 2002

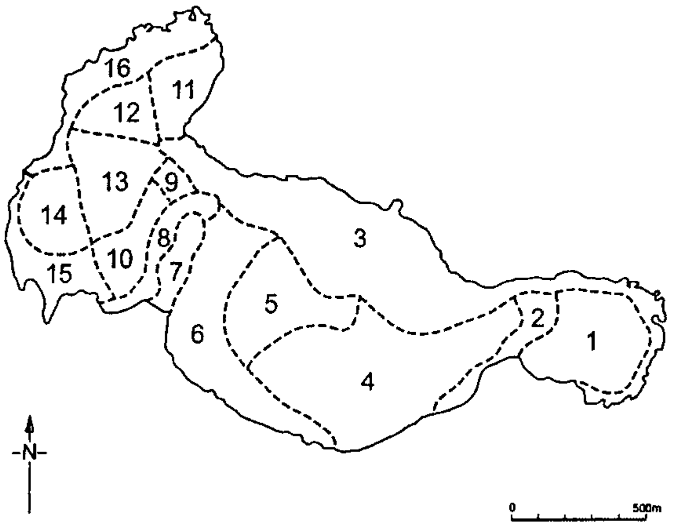

Fig. 1 Outline map of Moutohora (Whale Island), Bay of Plenty, New Zealand (37°52'S, 176°58'E), showing the sections into which the surface area of the island was divided for counting petrel burrows.

heavy losses of eggs and chicks – up to 100% of all eggs laid in several years (Imber *et al.* 2000). However, no estimation was made of the size of the petrels' breeding population at its lowest point. The estimated number of fledglings reared in a 1.4 ha study area increased between 1986 and 1994 (Harrison 1992; Imber *et al.* 2000), from 550±110 to 1050±130, indicating that the breeding population was then increasing.

With a need to obtain accurate information on the size of Moutohora's grey-faced petrel population for conservation information and management purposes, an estimate of the numbers breeding was made between 1998 and 2000.

METHODS

The surface area of Moutohora was divided into 16 sections, each comprising an area with uniform topography and similar vegetation throughout (Fig. 1). Within these sections petrel burrow densities appeared to be relatively uniform. Some sections were almost or entirely devoid of burrows. The surface area of each section was determined by planimetry off an aerial photograph, and then corrected for slope by factors between 1.0 (dunes/swamp section 15) and 1.7 (western cliffs section 16).

We calculated the number of burrows in each section mainly by counts of burrows within 2 m radius (= 12.5664 m^2) plots along transects. These transects were made on compass bearings across the widest axis of the section, and plots were spaced at 20 m intervals. At each interval a plot was surveyed both left and right of the transect line, at centres 5 m off the line.

All burrows found within each plot were examined carefully and probed with a stick if there was any doubt about their suitability for breeding: that is, having a nest chamber. Only completed burrows deemed suitable for breeding were counted. Often an accumulation of nest material at the entrance indicated a burrow's use for breeding. Occasionally there were 2 or more entrances to the same nest chamber; these were counted as only 1 burrow. Rarely, 1 entrance led to 2 nest chambers; if both were clearly in use, 2 burrows were counted.

Very few burrows (<50) were also occupied by sooty shearwaters (*Puffinus griseus*) but nearly all, if not all, of these were also occupied by grey-faced petrels in the alternate season. Thus we counted burrows regardless of the present occupants.

Burrows were counted from 30 Apr to 6 May 1998 (sections 1,4,8), from 18 Jun to 26 Jun 1999 (sections 4,5,6,9,10,12,13,14,15), and 23 Nov to 5 Dec 2000 (section 6). The later time of the last count was of no consequence, we believe, as this was only a check of the count in this section by another method (see below). The numbers of plots counted per section ranged from 78 to 172, except that only 40 were counted in the small section 9, and a token burrow count was allowed for the largely empty section 15. The counts in 2000 in section 6 were of 78 contiguous 10 × 10 m plots in Harrison's (1992) study area (so 56% of his 1.4 ha area was surveyed). The purpose of these more intensive counts was to compare the results of these with those from the transect of 2 m radius plots in the same section.

We estimated the number of burrows (N) in each section from the following equation:

$$N = (\text{area of section (ha)} \times 10{,}000 \times \text{total number of burrows in all plots}) / (12.5664 \times \text{number of plots counted})$$

where 12.5664 is the area (m^2) of a 2 m radius circular plot. For each estimate (N), the standard error (SE) was also calculated, and the results were rounded to the nearest 100.

The proportions of burrows occupied by fledglings in late 2000 was found by screening with twigs the entrances of 367 burrows during 23-28 Nov and counting the disturbed screens on 29 Nov and 4 Dec. At that time of year only adults feeding fledglings were visiting the colony, and most (but not all) fledglings would have been fed within this 6- to 11-day period. This method was more accurate than probing for fledglings with a stick, because of the length of burrows and acute turns in some burrows. As expected, the entrance screening revealed 7% higher fledgling occupancy than probing with a stick. Although fledglings preparing to depart may wander into nearby burrows, our screening survey was done 1-2 weeks before they begin to leave and a month before the peak of leaving (Imber 1976), and there was little evidence (such as down) of emergence. Burrow density is low (0.1 m^{-2}) in this area and fledglings wander little during early emergences, both of which lessened the risk of them disturbing other screens at that time. Offsetting any positive bias was the probability that some chicks were not fed over the 6-11 days of screening (not an exceptionally long interval between feeds at this stage).

The occupancy rate of burrows by breeders was considered to be the proportion of burrows in which an egg was laid. Neither we nor Harrison (1992) have recent data on this. In 1970 it was 87% of 93 burrows (MJI pers. obs.), and in 1987 it was 73% of 81 burrows (Johnstone & Davis 1990). The latter was probably near the population's lowest point, and we expect it to have recovered to about the former level by 1998. An occupancy rate of above 90% is unlikely because, with about 5% annual mortality (MJI pers. obs.), almost 10% of pairs are disrupted each year and survivors usually take a year, sometimes more, to breed again. With known losses of eggs to infertility (5.6%), embryonic death (5.8%), and desertions, competition, and breakages (>10%) (MJI pers. obs. 1969-71 data), and possibly 5% chick mortality in the absence of rats, the observed occupancy rate of fledglings in 2000 equates well with an 87% occupancy by breeding pairs.

RESULTS

The calculated areas of the 16 sections, totalling 230 ha, and the estimated burrow counts, totalling 109,000 ± 10,000 burrows, are given in Table 1. Of the 16 sections, 5 (2,3,7,11,16) held no burrows, or so few that they would probably not have been encountered on transects. These were areas of cliffs (3,16), or steep, shallow soil over bedrock (11), or sand dunes (2), or volcanic activity, with fumaroles and hot springs (7). The most densely burrowed areas were on the main cone of the island, especially on the warmer north-west to south-west facing slopes (sections 5, 6).

The counts duplicated by square plots in section 6 agreed well with the circular plot counts. The 12.5664 m^2 circles indicated 0.1146 burrows m^{-2}; the 100 m^2 squares indicated 0.1167 burrows m^{-2}. We took the mean (0.116) as the burrow density in this section (Table 1).

At occupancy of 87% of burrows by breeding pairs, Moutohora held 95,000 ± 9000 breeding pairs in 1998-2000. The proportion of 176 burrows occupied by fledglings on 29 Nov 2000 was >62.5%, and (after 5 more days of screening) 65.4% of 367 burrows were occupied by fledglings on 4 Dec 2000. Thus, about 70,000 fledglings should have flown from Moutohora at the end of that breeding season. From the 1.4 ha study area B (Harrison 1992; Imber *et al.* 2000) in section 6, about 1060 fledglings would have departed that same season.

Table 1 Estimated number of burrows apparently suitable for breeding of grey-faced petrels (*Pterodroma macroptera gouldi*) on Moutohora (Whale Island), Bay of Plenty, New Zealand, in 1998-2000. For the counts the island was partitioned into 16 sections (areas in ha), ithin each of which burrow density was apparently uniform. See Fig. 1 for map of sections.

Section		Burrows	
No.	Area	Density (m^{-2})	Total (n ± SE)
1	14.98	0.034	5100 ± 900
2	4.43	0	0
3	57.60	0	0
4	37.39	0.090	33,500 ± 2800
5	14.24	0.224	31,900 ± 2400
6	19.96	0.116	23,100 ± 1700
7	4.56	0	0
8	4.68	0.040	1900 ± 300
9	1.44	0.058	800 ± 200
10	6.63	0.021	1400 ± 300
11	11.17	0	0
12	6.29	0.036	2300 ± 400
13	11.28	0.047	5300 ± 900
14	7.09	0.043	3100 ± 500
15	8.50	0.001	100
16	19.69	0	0
Total	229.93		108,500± 10,400

DISCUSSION

During the 1969 to 1971 breeding seasons an estimated 30,000-40,000 pairs of grey-faced petrels nested on Moutohora (Imber 1976). However, <2000 pairs were estimated in the western end of the island — the low-density area (Imber 1976) — and we have reason to believe that this estimate was too low. The western end produced no fledglings then unless rats were poisoned. In 1998-2000 about 11,000 pairs nested in sections 9-16, the western end (given 87% occupancy of burrows by breeding pairs). Therefore, it seems likely that there were nearer 5000 pairs nesting at the western end in 1969-71, and that the island total may have been 35,000-45,000 breeding pairs.

Between 1972 and 1987 the petrel breeding population presumably declined because of the intense predation by rats and burrow competition by rabbits. We have no data on the size of the population at its lowest point. However, it may have been < 35,000 breeding pairs.

Given the 1998-2000 estimate of *c.* 95,000 breeding pairs, the population has apparently more than doubled since 1987. This is supported by data from study area B, where the numbers of fledglings almost doubled between 1986 and 1994

(Imber *et al.* 2000). As the number reared there in 1994 was estimated to be 1050 ± 130 (Imber *et al.* 2000), and in 2000 it was about 1060, it is likely that the period of major growth was in the 1st 10 years after pest eradication began in 1985. The evidence points at little further increase in numbers in study area B over the next 5 years to 2000.

Study area B is in one of the sections (5,6) containing optimal habitat for these petrels, as indicated by burrow densities. These sections (on the western sides of the central volcanic cone) probably recovered soonest because they retained most of the burrows and breeding pairs at the population's lowest point. Also, these sections produced most fledglings burrow^{-1} whilst pests were present on the island, because detrimental effects of rats and rabbits were least there (MJI, pers. obs.).

Petrel numbers on other areas of the island may have been slower to recover. The western end (sections 9-16) was affected most heavily by both rats and rabbits. The same may apply to eastern sections 1,2, and 4, but these were less well studied, being farthest from the operational bases (tents, huts) in section 10. Within these peripheral sections the population is probably still increasing. Here, the numbers of breeding pairs may have increased proportionately much more than in sections 5 and 6.

Over all, the breeding population should continue to increase, though probably at a lesser rate, because there still appears to be ample ground space for more burrows on the island. We recommend another survey in 10-15 years' time, using the 2 m circular plots method in the same sections.

ACKNOWLEDGEMENTS

We are very grateful to Mike Vanstone and Dave Beaching for assistance in surveying plots. For logistical support, and providing transport by MV *Moutohora*, we thank Wayne Price, Matt Cook, and David Paine of the Whakatane Field Centre and Rotorua District Office, Department of Conservation. We thank Mala Nesaratnam for word-processing, and Chris Edkins for doing the planimetry and drawing the figure. For comments on drafts of this paper we thank Jaap Jasperse, Keith Owen, Paul Sagar, and an anonymous referee.

LITERATURE CITED

Harrison, M. 1992. Changes in the grey-faced petrel population on Moutohora (Whale Island) 1982-1991. *Department of Conservation Science & Research series 48*. Wellington, New Zealand Department of Conservation.

Heather, B.D.; Robertson, H.A. 1996. *The field guide to the birds of New Zealand*. Auckland, Viking.

Imber, M.J. 1975. Behaviour of petrels in relation to the moon and artificial lights. *Notornis 22*: 302-306.

Imber, M.J. 1976. Breeding biology of the grey-faced petrel *Pterodroma macroptera gouldi*. *Ibis 118*: 51-64.

Imber, M.J.; Harrison, M.; Harrison, J. 2000. Interactions between petrels, rats and rabbits on Whale Island, and effects of rat and rabbit eradication. *New Zealand journal of ecology 24*: 153-160.

Johnstone, R.M.; Davis, L.S. 1990. Incubation routines and foraging-trip regulation in the grey-faced petrel *Pterodroma macroptera gouldi*. *Ibis 132*: 14-20.

Marchant, S.; Higgins, P.J. (Co-ordinators) 1990. *Handbook of Australian, New Zealand and Antarctic birds. Vol. 1. Part A. Ratites to petrels*. Melbourne, Oxford University Press.