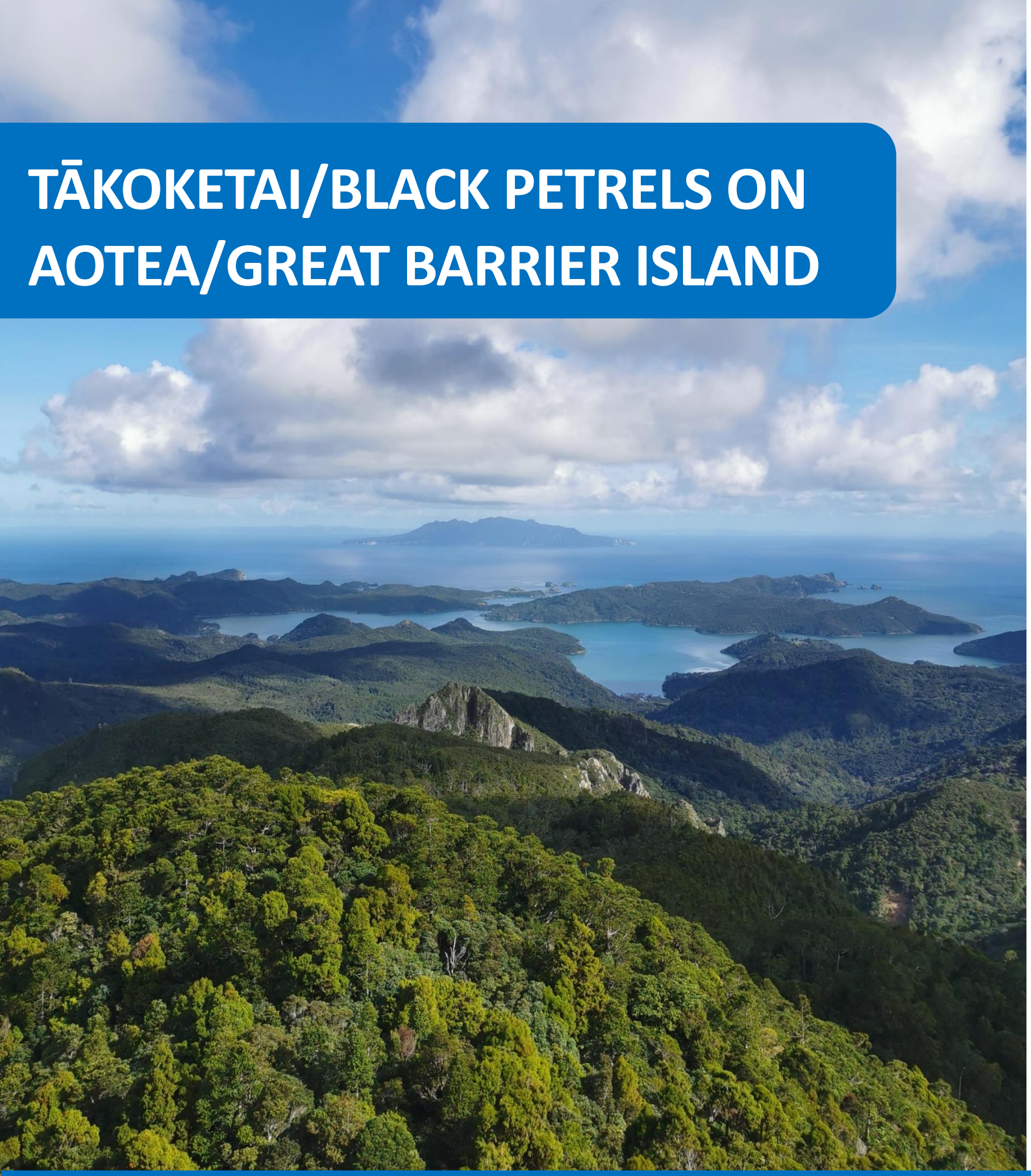
TĀKOKETAI/BLACK PETRELS ON AOTEA/GREAT BARRIER ISLAND



Key demographic parameters and population trends of black petrels (Procellaria parkinsoni) – 2021/2022

WMIL Wildlife Management International

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Key demographics parameters and population trends of tākoketai/black petrels (*Procellaria parkinsoni*) on Aotea/Great Barrier Island: 2021/2022

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This report was prepared by Wildlife Management International Limited for the Department of Conservation as fulfilment of the contract (DOC1086980: POP2021-01 Black petrel research – land based component) dated 21 August 2021.

20 June 2022

Version History:

Version	Date	Author	Reason for change
1	20 June 2022	WMIL: Bell & Welch	WMIL First Draft

Citation:

This report should be cited as:

Bell, E.A. & Welch, M. 2022. Key demographic parameters and population trends of tākoketai/black petrels (*Procellaria parkinsoni)* on Aotea/Great Barrier Island: 2021/2022. Unpublished Wildlife Management International Ltd. Technical Report to the Conservation Services Programme, Department of Conservation, Wellington.

Cover image: View of Te Hauturu-o-Toi/Little Barrier Island from Hirakimata/Mt Hobson Summit Aotea/Great Barrier Island (© Marcia Welch, WMIL, 2022)

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EXECUTIVE SUMMARY

This report is part of the ongoing study of the tākoketai/black petrel, *Procellaria parkinsoni*, on Great Barrier Island/Aotea that was begun in the 1995/1996 breeding season.

During the 2021/2022 breeding season 478 tākoketai/black petrel study burrows were intensively monitored within the Mt Hobson/Hirakimata study area on Aotea/Great Barrier Island.

There were 326 (68.2%) burrows occupied by breeding pairs, 92 (19.2%) occupied by non-breeding birds, and 60 (12.6%) were unoccupied. Overall, 239 chicks were produced from the study burrows representing a fledgling success rate of 73.3%.

Nine census grids were monitored within the study area and accounted for 196 of the inspected study burrows. Of these, 148 were occupied by breeding pairs (75.5%) and 102 chicks were produced representing a fledging success rate of 68.9%.

A total of 745 adults and 254 fledgling chicks were captured during the 2021/2022 field season with 107 adults banded this season (including 69 from study burrows). Of the 254 fledgling chicks banded during the 2021/2022 field season, 227 were banded in the study burrow and the remaining 12 had already fledged prior to the banding visit in May 2022.

There have been a total of 386 returned chicks recaptured at the colony since they were banded prior to fledging. Of these, 124 returned chicks identified during the 2021/2022 breeding season; 23 of which had been caught for the first time at the colony. The majority of returned chicks were from the 2013/2014 breeding season, followed by the 2010/2011 cohort). Not all cohorts were represented as no returned chicks from the 1995/1996 and 1996/1997 cohorts were recaptured this season. Understanding the factors affecting return rates of chicks into the population and whether it relates either to low juvenile survival and/or recruitment or is purely due to lack of effort to locate banded birds within the 35-ha study site is vital. Survival effort estimates, especially juvenile survival and recruitment are vital for accurate population estimates and risk assessment modelling, and it is highly recommended that effort to obtain data to fill this knowledge gap for black petrels is completed with urgency.

Key demographic parameters and population trends of tākoketai/black petrels (Procellaria parkinsoni) on Aotea/Great Barrier Island:

1. INTRODUCTION

1.1 Introduction

Black petrels (*Procellaria parkinsoni*) are a medium–sized endemic seabird that only breeds on Te Hauturu–o–Toi/Little Barrier Island and Great Barrier Island/Aotea in the Hauraki Gulf of New Zealand. Black petrels are known by the name of tākoketai by Ngāti Rehua Ngāti Wai ki Aotea, the tangata whenua and mana whenua of Great Barrier Island/Aotea. Black petrels are ranked as Nationally Vulnerable under the New Zealand Threat Classification System and Vulnerable on the IUCN Red List of Threatened Species (Robertson et al. 2021, BirdLife International 2020). They are recognised as the seabird species that is at greatest risk of being adversely impacted by high rates bycatch in commercial fisheries within New Zealand's Exclusive Economic Zone (Richard et al. 2020). Of the 171 observed captures of black petrel recorded between 2002 and 2019, 55.6% of captures occurred in bottom-longline fisheries, 26.3% in surface-longline fisheries and 18.1% in trawl fisheries (https://protectedspeciescaptures.nz/PSCv5a/; accessed 12/04/2021). Black petrels on Great Barrier Island/Aotea are also exposed to threats on land, principally depredation by cats (*Felis catus*), rats (*Rattus* spp.) and pigs (*Sus scrofa*) (Bell 2013).

To monitor the ongoing population-level impacts of commercial fisheries on black petrels, it is necessary to quantify population parameters such as annual burrow occupancy rates, annual adult reproductive success as well as both adult and juvenile annual survival rates to create accurate assessments of population trends. To this end, a long-term research project aimed at quantifying these population parameters was initiated in 1995/1996 (Bell & Sim 1998). During this first season, three 40 m x 40 m study grids were set up within the largest known breeding colony on Mt Hobson/Hirakimata on Great Barrier Island/Aotea, and all burrows within the grids were marked and monitored. Additional burrows located within 10 m of the public walking tracks were also monitored. In 1998/1999, the number of study grids was increased to six, and then to nine in 1999/2000 (Bell & Sim 2000a, Bell & Sim 2000b). Over the years, additional burrows situated near the public walking tracks have continued to be added (Bell et al. 2022), so that by the 2021/2022 season a total of 478 study burrows were being monitored.

This report provides a summary of the results of this monitoring work on Great Barrier Island/Aotea in the 2021/2022, with updates on the trends in several population parameters including both annual burrow occupancy and annual reproductive success.

1.2 Objectives

This project extends on demographic work funded by commercial fisheries levies and the department of Conservation (DOC) and Ministry for Primary Industries/Fisheries New Zealand (MPI/FNZ) since 1996. Black petrels are the species at highest risk from commercial fisheries in northern New Zealand. Continuing research on this species is necessary to gather current rates of adult mortality, breeding success, juvenile survival and recruitment until suitable mitigation methods significantly reduce the capture risk to this species.

The objectives are:

1. To monitor the key demographic parameters at the breeding colony of this threatened seabird to reduce uncertainty or bias in estimates of risk from commercial fishing.

1.3 Methods

1.3.1 Field methods

A network of 478 study burrows has been established within a 35-ha study area in the vicinity of Mt Hobson/Hirakimata on Great Barrier Island/Aotea (Figure 1). The colony residing around the Mt Hobson/Hirakimata summit represents the highest density of logistically accessible black petrels on Great Barrier Island/Aotea and one of was the reason underlying the establishment of the study site. Additionally, previous research programmes on black petrels that had taken place at Mt Hobson/Hirakimata before the establishment of WMIL's monitoring programme increases the importance of the site (Imber 1976, Imber 1987, Scofield 1989, Hunter et al. 2001, Imber et al 2003a). For instance, the first black petrel banded on Great Barrier Island/Aotea was banded in 1963 and the oldest bird currently resighted within the study is an estimated 34 years of age (i.e. banded as a chick) (WMIL, unpublished data). These study burrows have been progressively established over the past 27 years and to date, include 196 burrows located within nine 40 m x 40 m census grids, plus a further 282 arbitrarily selected burrows situated within 25 m of public walking tracks.

The locations of census grids were established over time in clusters of three at random locations in the vicinity of the public walking tracks (Figures 1 and 2). Census grid sizes at the start of the study were 10 m^2 in January 1996 and subsequently increased to 40 m^2 by April 1996 during the chick fledging period. Being within the vicinity of public walking tracks allows faster traversing of the study site. The average distance from the centre of the nine census grid ranges between 1 to 61.7 m (mean distance is 25 m ± 17.4 m SD) from walking tracks. At the establishment of a census grid, an exhaustive grid-like search was conducted on foot by researchers traversing together in a line at every 1 metre within the grid boundaries. All occupied, empty, and potential (burrows in the processes of being dug out) were recorded. On three separate occasions (December 2009, January 2010, and December 2015) further searches by a seabird detection dog was conducted in each census grid to identify any missed burrows. Burrow occupancy rates in the nine study grids likely provide the most consistent and representative measure of burrow occupancy across the study area, as they are unaffected by the occasional preferential addition of active breeding burrows to the study burrow network outside of the study grids that has occurred in previous years. For this reason, trends in burrow occupancy rates within the study grids provide the best measure of whether black petrel burrow occupancy is increasing or decreasing within the study area (Figure 2).

Up until the 2018/2019 season, when burrows are found outside of census grids, they are automatically added into the study if they are found within c. 10 m of the public walking tracks, or if the burrow when found, contained a breeding adult that was previously banded as a chick. Currently any new burrows that are found are only added into the study if they are within the census grids or contain a breeding adult that was previously banded as a chick. The additional 282 arbitrarily selected study burrows were found through a combination of haphazard searching and seabird detection dogs. Other random burrows that are found further than c. 10 m from public walking tracks are noted and are often returned to in order to increase the number of banded birds into the study but data on breeding status and occupancy is not collected.

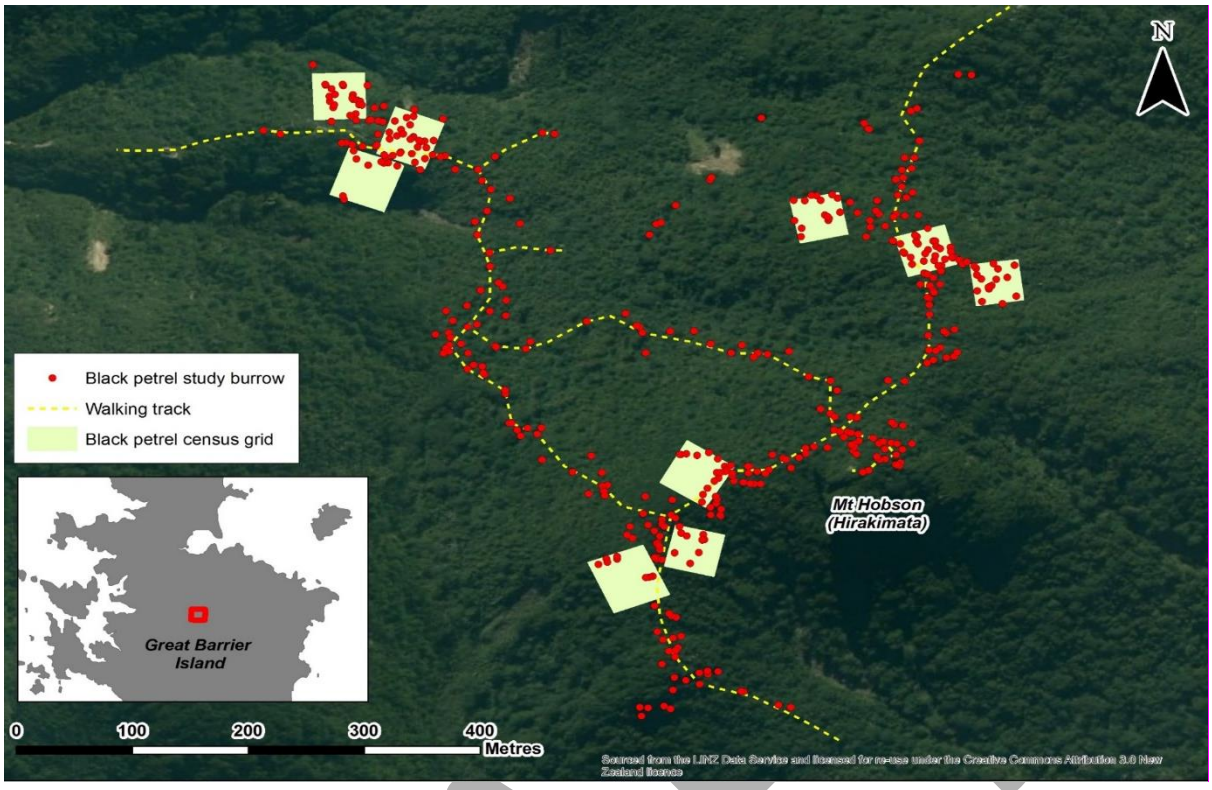

Figure 1. Map of the 478 tākoketai/black petrel study burrows (red points) that have been established in the vicinity of Mt Hobson/Hirakimata on Great Barrier Island/Aotea. Yellow dashed lines are public walking tracks and highlighted squares are census grids.

To facilitate accurate monitoring, 330 study burrows have had study hatches installed (69%), providing easier access to one or more chambers within the burrow and to reduce interaction time with the bird by the researchers. The effect of handler disturbances has not been investigated in black petrels, but it is hypothesised that black petrels are robust to handler disturbance, as offspring abandonment has not been observed following handling. Of these burrows with hatches installed, larger/internally complex burrows have had two (17 burrows, 5.2%) or three (10 burrows, 3%) hatches installed. While not formally quantified for this study, anecdotally, the time taken to retrieve the bird from the study burrow depends on several factors: the distance from the burrow entrance to the burrow chamber, the space within the chamber, the physical configuration/obstacles (e.g., tree roots) within the burrow, and the temperament of the bird. Depending on the internal complexity and accessibility of the bird within the burrow, retrieval of the bird may take between 1-30 min. The installation of hatches is aimed to reduce the time spent retrieving the bird by removing/ reducing the physical factors mentioned above.

During the 2021/2022 field season, study burrows were monitored during three visits to the Mt Hobson/Hirakimata study area. The first visit was a partial check (Trip 1: 19 December to 23 December) that coincided with the film crew, where only Kauri Dam was checked. The following visits coincided with the late incubation/hatching/early chick rearing (Trip 2: 19 January to 8 February 2022) and late chick rearing/fledging (Trip 3: 27 April to 3 May 2022). The number and timing of trips to the colony each breeding season vary from year to year depending on additional project goals, but at a minimum will contain two trips to cover the late incubation/hatching/early chick rearing and late chick rearing/fledging (Table 1).

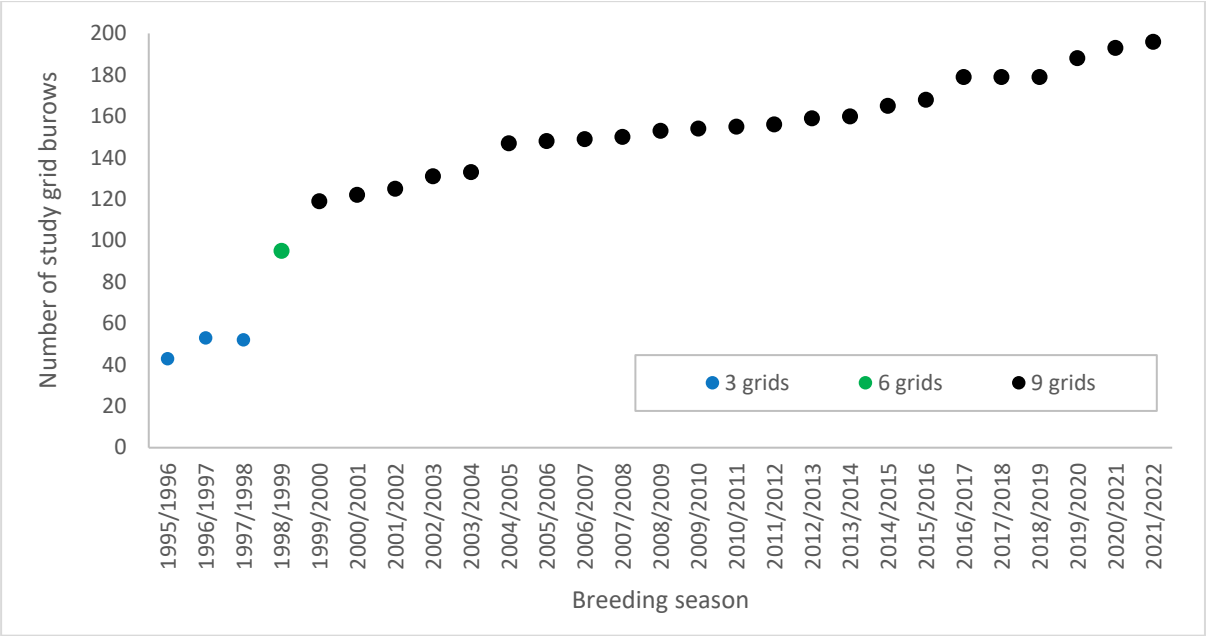

Figure 2. The total number of tākoketai/black petrel census grid burrows monitored each breeding season on Great Barrier Island/Aotea between 1995 to 2022.

Table 1. Breeding cycle of tākoketai/black petrel on Great Barrier Island/Aotea (WMIL, unpublished data; also see Imber 1987).

Breeding stage	Time period
Return to colony	10 October to 15 November
Pre-egg-laying exodus ('honeymoon')	15 October to 15 November
Egg laying	15 November to 31 December (peak 1-15 December)
Incubation	15 November to 28 February
Guard phase	10 January to 15 March (peak 1-15 February)
Chick rearing	15 January to 30 June
Fledgling	10 April to 30 June (peak 1-20 May)

To determine the breeding status and breeding outcome for each burrow, and to record the adult occupants of each burrow, each study burrow was checked at least twice during Trip 2. During each burrow check, any resident adults were removed from the burrow, and checked for bands. If banded, the band number of each bird was recorded, otherwise the bird was banded with an individually numbered size H stainless steel band. Unbanded adult petrels (regardless of breeding status) are assumed to be at least five years of age and are given an age estimate of 5 years. Before being returned to the burrow, a small mark was made on each bird's forehead using white correction fluid to provide a means of visually checking whether the same bird was still occupying the burrow during subsequent checks, without having to remove the bird to read its band. The presence of an egg or chick was also recorded. After each check, a palisade of twigs was erected over the burrow entrance to provide a quick means of checking for recent activity (i.e. arrivals and departures of parents switching incubation/brooding duties) during subsequent checks of the same burrow. During the final trip of each season (Trip 3), fledgling chicks found in the study burrows were extracted and banded. There were several instances of chicks located in study burrows fledging before being banded. Fledged, but unbanded chicks were determined by the presence of down feathers and the dandruff-like substance produced by newly emerging flight feathers in the burrow and burrow entrances.

During each trip, the field team spent several nights walking the public track system within the 35-ha study area, capturing any black petrels found on the ground. These birds were checked for bands, and any band numbers were recorded. If unbanded, a band was applied to the bird's leg, before being

subsequently released. Before release, a small mark was made on each bird's forehead using white correction fluid to provide a means of visually checking whether a bird had already been captured, if encountered again on the same or another subsequent night.

1.3.2 Feral pig monitoring

Feral pigs pose an inherent risk for black petrels on Great Barrier Island/Aotea (Bell 2013). Not only do feral pigs destroy burrows, but they also predate eggs, chicks, and adults, causing major implications for island seabird colonies (Russell et al. 2020). In order to monitor the ecological interactions that pigs have with black petrels and the wider island ecosystem on Great Barrier Island/Aotea, pig surveys (for sign such as scats and wallows), camera monitoring of black petrel colonies to gather data on pig (and other predator) relative abundance and interaction with seabirds and interviews with Iwi, hunters and Great Barrier Island/Aotea community members was undertaken in collaboration with University of Auckland Masters student Christine Mansford.

In order to monitor feral pig disturbance and relative abundance eight LTL Acorn™ trail cameras were installed at various points along the Cooper's Castle track. Four trail cameras were placed on Trip 2 on 26 January 2022 (2 cameras) and 4 February 2022 (2 cameras). Four additional cameras were installed on 29 April 2022 during Trip 3. Placement was determined at areas where there were obvious signs of pig disturbance (i.e., scat, rooting or prints). The SD cards were replaced and reviewed by WMIL staff on 4 February 2022 and then again on 28 April 2022. The presence/absence of pigs (and other predators, specifically feral cats, and rats) was recorded. Further camera footage review will be undertaken by Christine on her subsequent visits to the island. This work will be reported in detail as part of her thesis.

1.3.3 Data entry and analysis

All mark–recapture and breeding status data were entered into a Microsoft Access™ database at the completion of each trip. Data analysis and visualisation has been performed using Microsoft Excel™.

1.4 Results

1.4.1 Burrow occupancy and breeding success

The number of census grid burrows has continued to increase over time since 1995 (Figure 2). From the 1995/1996 to 1997/1998 breeding season, there were 43 to 55 census grid burrows across the three census grids, respectively. The total number of census grid burrows increased to 96 in the 1998/1999 breeding season with the incorporation of three more census grids. Following the addition of three more census grids in 1999/2000, the total number of census grid burrows has steadily increased from 123 in 1999/2000 to 196 in 2021/2022, an increase of 4 burrows from the previous year (Figure 2). Some study burrows within the grids have been abandoned and are not used by breeding black petrels, but these burrows are still checked each season. Black petrel burrows are highly unlikely to be lost to other seabird species present on Great Barrier/Aotea. The only other burrow-nesting seabird that nests inland on Great Barrier Island/Aotea and overlaps with the habitat of black petrel is the Cook's petrel (*Pterodroma cookii*), approximately 65% smaller in size than the black petrel (Bell & Sim 1998, Imber et al. 2003b). However, due to sustained predation by mammalian predators, this species is at an extremely low density on Great Barrier Island/Aotea (Imber et al. 2003b), and within the study site only seven Cook's petrel breeding burrows have ever been found.

Of the 478 study burrows (196 census burrows and 282 non-census study burrows) monitored during the 2021/2022 breeding season, 326 (68.2%) were occupied by breeding birds, 92 (19.2%) were occupied by non-breeding birds and 60 (12.6%) were unoccupied. Of the 196 census grid burrows, there were 148 burrows occupied by breeding black petrels (75.5%), 21.8% more than the 27-year

average census grid burrow occupancy rate of 62.0% (Figure 3). Non-census study burrows breeding occupancy was 70.2% (198 burrows), 0.7% higher than the 27-year average of 69.7% (Figure 3).

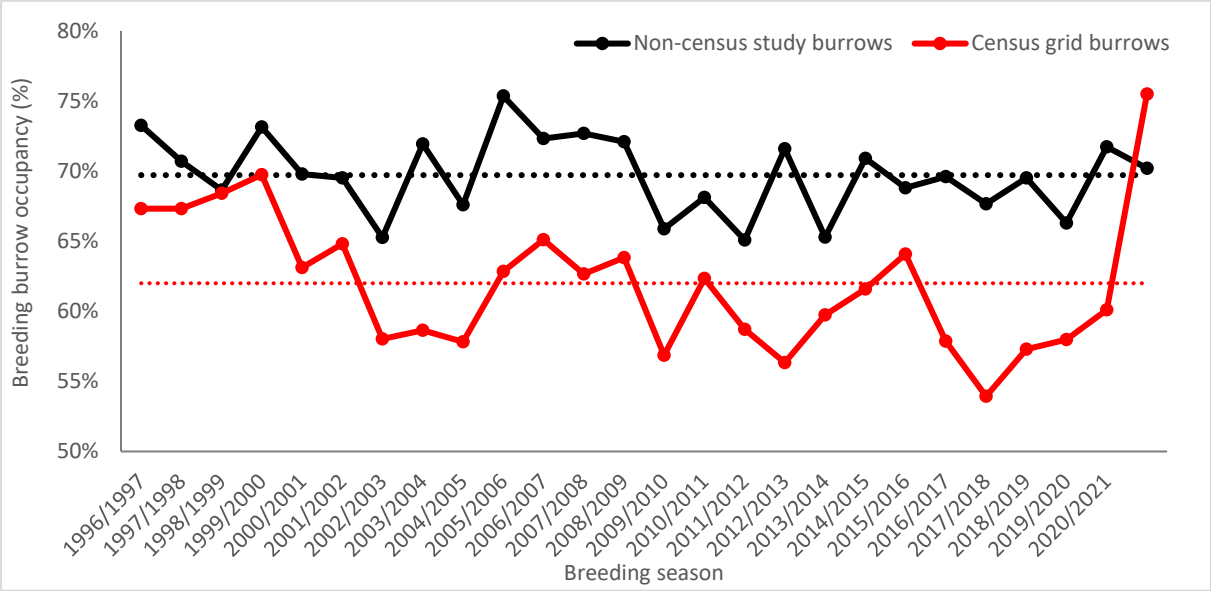

Figure 3. Percentage of census grid burrows (n=196, red) and non-census study burrows (n=282, black) occupied by breeding tākoketai/black petrels at Mt Hobson/Hirakimata on Great Barrier Island/Aotea between 1996 and 2022 (dotted line represents the mean occupation of census grid burrows (red) and non-census study burrows (black) over 27 years by breeding black petrels).

Of the 326 study burrows that were occupied by breeding birds during the 2021/2022 breeding season, 239 chicks were produced (73.3% breeding success) and there were 87 breeding failures (18.2%) (Table 2). Within the census grid burrows, there were 102 (68.9%) chicks produced during the 2021/2022 season from 148 burrows where a breeding attempt occurred (3.4% lower than the 27-year average of 71.3%) (Figure 4, Table 2).

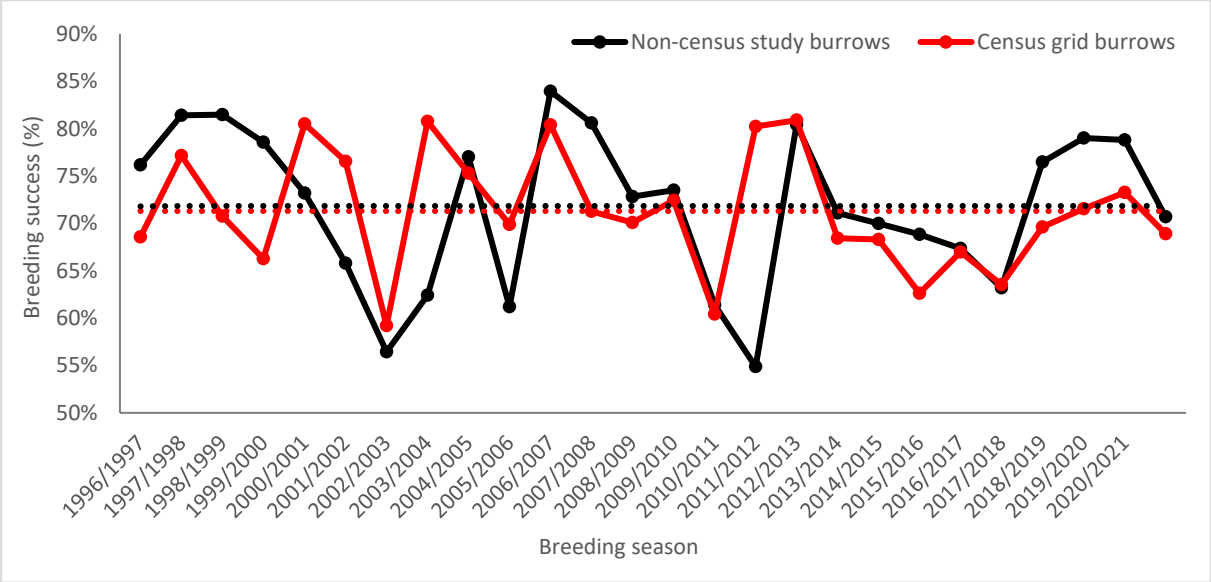

Figure 4. Breeding success (percentage of breeding burrows that fledge a chick) of all tākoketai/black petrel non-census study burrows (n=282, black) and census grid burrows (n=196, red) at Mt Hobson/Hirakimata on Great Barrier Island/Aotea between 1996 and 2022 (the dotted line represents the mean breeding success of census burrows (red) and all study burrows (black) over 27 years).

Table 2. Summary of breeding success of tākoketai/black petrels (percentage of breeding burrows that fledged a chick; number (#) of successful fledglings followed in parentheses) at Mt Hobson/Hirakimata on Great Barrier Island/Aotea between 1995 and 2022 within census grid burrows, non-census study burrows and all burrows combined. The number of census grid, non-census and total number of study burrows are the number of burrows where a breeding attempt was observed.

Breeding season	Census grid burrows breeding success % (no. of chicks fledged)	Number of census grid burrows occupied by breeders (total census grid burrows)	Non-census study burrows breeding success % (no. of chicks fledged)	No. of non-census burrows occupied by breeders (total no. non-census burrows)	Breeding success % (No. of chicks fledge)	Total no. of study burrows occupied by breeders (total no. study burrows)
2021/2022	68.9% (102)	148 (196)	70.7% (140)	198 (282)	73.3% (239)	326 (478)
2020/2021	73.0% (85)	115 (192)	78.7% (160)	202 (282)	76.7% (244)	318 (475)
2019/2020	71.6% (78)	109 (188)	78.9% (142)	180 (272)	76.1% (220)	289 (460)
2018/2019	69.6% (71)	102 (178)	76.3% (142)	186 (268)	74.0% (213)	288 (446)
2017/2018	63.5% (61)	96 (178)	63.0% (114)	181 (268)	63.2% (175)	277 (446)
2016/2017	67.0% (69)	103 (178)	67.2% (127)	189 (272)	67.1% (196)	292 (450)
2015/2016	62.6% (67)	107 (167)	68.7% (125)	182 (265)	66.4% (192)	289 (432)
2014/2015	68.3% (69)	101 (164)	69.8% (132)	189 (267)	69.3% (201)	290 (431)
2013/2014	68.4% (65)	95 (159)	70.9% (122)	172 (264)	70.0% (187)	267 (423)
2012/2013	80.9% (72)	89 (158)	80.3% (151)	188 (263)	80.5% (223)	277 (421)
2011/2012	80.2% (73)	91 (155)	54.6% (89)	163 (251)	63.8% (162)	254 (406)
2010/2011	60.4% (58)	96 (154)	61.4% (105)	171 (250)	61.0% (163)	267 (423)
2009/2010	72.4% (63)	87 (153)	73.3% (121)	165 (251)	73.1% (184)	252 (404)
2008/2009	70.1% (68)	97 (152)	72.8% (126)	173 (239)	71.9% (194)	270 (391)
2007/2008	71.3% (67)	94 (150)	80.6% (133)	165 (251)	77.2% (200)	259 (377)
2006/2007	80.4% (78)	97 (149)	84.0% (136)	162 (224)	82.6% (214)	259 (373)
2005/2006	69.9% (65)	93 (148)	61.2% (101)	165 (219)	64.3% (166)	258 (367)
2004/2005	75.3% (64)	85 (147)	77.0% (114)	148 (219)	76.4% (178)	233 (366)
2003/2004	80.8% (63)	78 (133)	62.4% (88)	141 (196)	68.9% (151)	219 (329)
2002/2003	59.2% (45)	76 (131)	56.5% (70)	124 190	57.5% (115)	200 (321)
2001/2002	76.5% (62)	81 (125)	65.8% (75)	114 (164)	70.3% (137)	195 (289)
2000/2001	80.5% (62)	77 (122)	73.2% (71)	97 (139)	76.4% (133)	174 (261)
1999/2000	66.3% (55)	83 (119)	78.6% (77)	98 (134)	72.9% (132)	181 (253)
1998/1999	70.8% (46)	65 (95)	81.5% (66)	81 (118)	76.7% (112)	146 (213)
1997/1998	77.1% (27)	35 (52)	81.4% (57)	70 (99)	80.0% (84)	105 (151)
1996/1997	68.6% (24)	35 (52)	76.2% (48)	63 (86)	73.5% (72)	98 (138)
1995/1996	87.0% (20)	23 (43)	92.3% (36)	39 (45)	90.3% (56)	62 (88)

1.4.2 Survival and status of returned chicks

A total of 745 adults and 254 fledgling chicks were captured during the 2021/2022 field season (Table 3). A total of 107 adults were banded during the 2021/2022 field season, of which 69 were captured in the study burrows (Table 3). Of the 254 fledgling chicks banded during the 2021/2022 field season, 227 were banded in the study burrows (Table 3). Twelve chicks from study burrows fledged prior to banding (i.e., evidence of down, pin feathers and droppings were obvious in the now-unoccupied burrow during the Trip 3 check). The adults and fledgling chicks not banded in study burrows were located in either non-study burrows or were located on the forest floor during nocturnal field work.

Of the 652 parents occupying the 326 breeding study burrows during the 2021/2022 breeding season, a total of 570 (87.4%) were captured and identified. Additionally, the percentage of parents captured

within census grids was also high at 88.1% (a total of 208 of 236 parents were identified and captured within 118 census grid burrows where a breeding attempt took place). The majority of individuals that were not identified were adults whose breeding attempts had failed either prior to, or during the first fieldtrip of the season, and were therefore unlikely to be spending much time in their burrows during our fieldtrips.

The cumulative number of birds banded as chicks identified returning to the colony (as either breeding or non-breeding adults) has steadily increased over time (Figure 3). In the 2021/2022 breeding season the cumulative number of returned adults recorded to date was 386. This includes 23 returned adults that had not been previously recorded since being banded as fledglings. Of those 23 returnees, most were found in study burrows (60.9%). The rest were found walking along on the forest floor during nocturnal monitoring (34.8%) or in non-monitored burrows (4.3%).

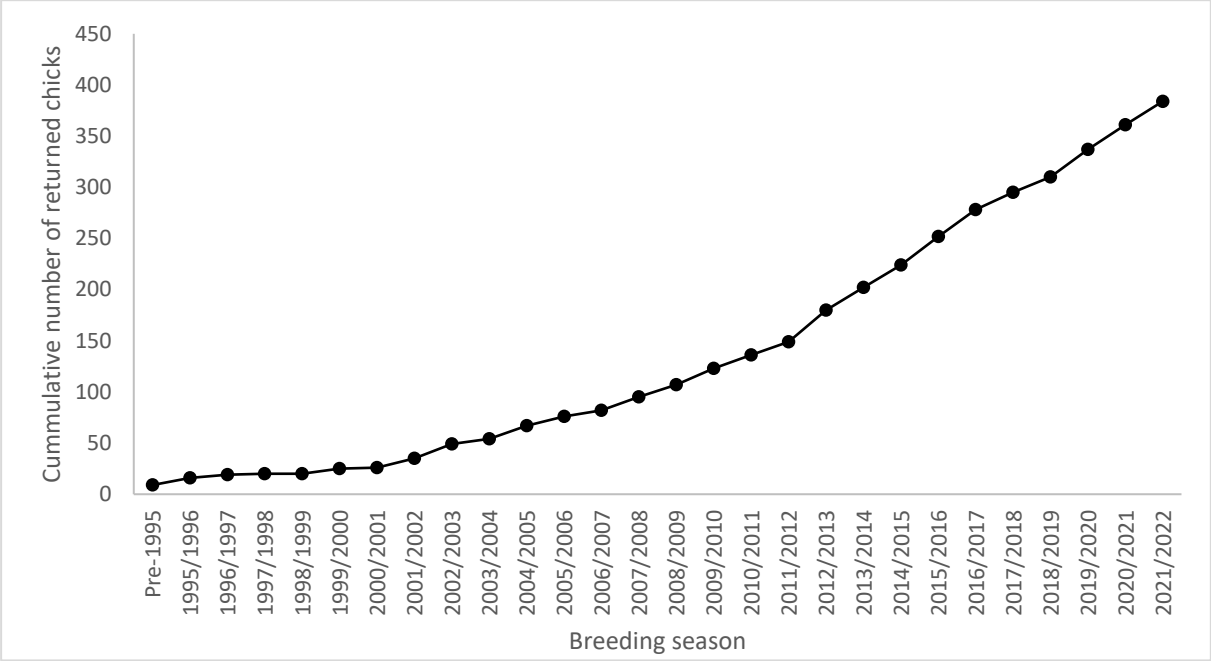

Figure 3. The cumulative number of tākoketai/black petrel adults banded as chicks that have returned to the colony as adults at Mt Hobson/Hirakimata on Great Barrier Island/Aotea. Note: the time period before 1995 encompasses approximately 20 years of chicks banding records (1972-1992; e.g., the first returned chick was banded in 1972 and recaptured again in 1977).

The median age of black petrels when first re-observed returning to the Hirakimata/Mt Hobson colony (regardless of breeding status) has fluctuated between 4.8 and 6.6 years since the 2002/2003 breeding season (Bell et al. 2022). Between the 1995/1996 and 2021/2022 breeding seasons the mean age of first return was 6.6 ± 0.2 years, the mean age of first breeding attempt was 8.0 ± 0.2 years and the mean age of first successful breeding attempt was 8.3 ± 0.2 years. Figure 4 shows the range of ages that black petrels have been when recaptured for the first time at the colony, as well as age of first time breeders and first-time successful breeders. The minimum and maximum first recapture age varies between each breeding season, with the oldest black petrel recaptured for the first time since being banded as a chick occurred during the 2011/2012 breeding season at 26.6 years (Bell et al. 2022). The youngest returnee detected was observed at 2.6 years in the 2011/2012 breeding season (Bell et al, 2022). During the 2021/2022 breeding season, the median return age was 6 years (min and max range 4-15 years), which was similar to the previous 2020/2021 breeding season (median 5.8, min and max range 4.7-13.1 years; Figure 4).

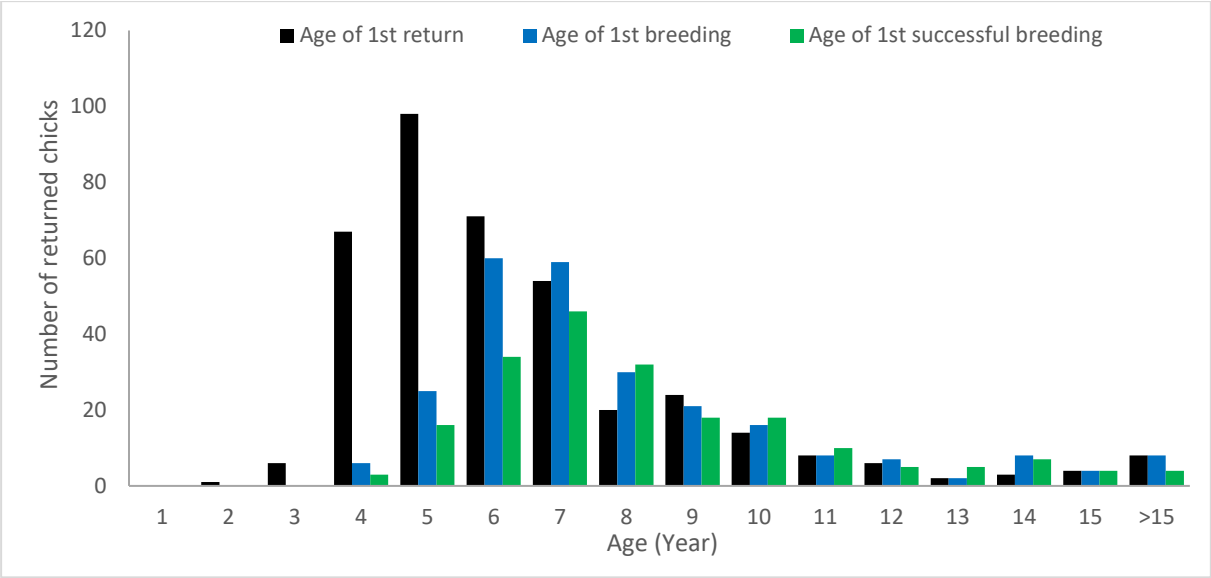

Figure 4. The age of tākoketai/black petrel adults banded as chicks that have returned to the colony as adults when first returned (black bars), when first recorded breeding (blue bars) and first recorded successfully breeding (breed bars) at Mt Hobson/Hirakimata on Great Barrier Island/Aotea.

The composition of each breeding seasons' cohort (i.e. the breeding season the chick hatched in) continues to vary each breeding season (Figure 5, Table 3). Of the 124 returned chicks identified during the 2021/2022 breeding season, the majority (n=16) of returned chicks were from the 2013/2014 breeding season, followed by the 2010/2011 cohort (n=9). Not all cohorts were represented as no returned chicks from the 1995/1996 and 1996/1997 cohorts were recaptured this season (Figure 5). There were six returned chicks from the 2017/2018 cohort (all 4 years of age) recaptured this season (Figure 5). All cohorts from the 2018/2019 breeding season onwards are still expected to be at sea until 4 years of age.

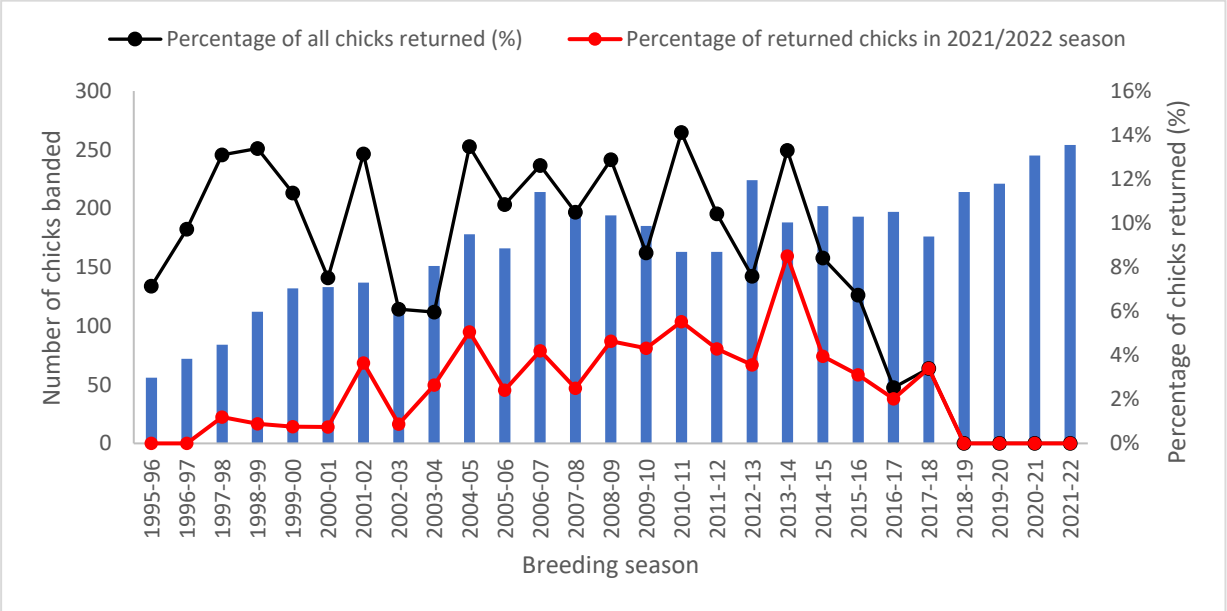

Figure 5. The number of banded tākoketai/black petrel chicks per year (blue bars) overlayed with the percentage of banded chicks (black points and lines) from a particular breeding season cohort returning to the colony at Mt Hobson/Hirakimata on Great Barrier Island/Aotea as adults. Note: the number of chicks banded, and percentage returned before 1995 was intentionally not plotted. There were 589 chicks banded before 1995 and of these 4.9% have been re-observed as adults.

Despite a similar number of chicks banded each breeding season, the percentage of chicks returning to the colony at Mt Hobson/Hirakimata on Great Barrier Island/Aotea fluctuates between 2.5-14.1% of chicks (Figure 5, Table 3).

Table 3. Summary of the number of tākoketai/black petrels captured, banded, re-captured adults and chicks (i.e., returned to the colony to breed) at Mt Hobson/Hirakimata on Great Barrier Island/Aotea between 1995 and 2022. Several fledglings located in study burrows had fledged before being banded, thus the number of fledglings banded may be less than the number fledged shown in Table 1. The total number of fledglings banded includes birds found either on the surface or in burrows not located within the study site (see Figure 1).

Breeding season	Number of captures	Number of all adult recaptures	Number of adults banded	Number of fledglings banded in study burrows	Total number fledglings banded
2021/2022	999	638	107	227	254
2020/2021	1103	703	136	233	264
2019/2020	960	636	154	155	170
2018/2019	898	562	122	201	214
2017/2018	800	541	84	154	175
2016/2017	1121	476	244	173	401
2015/2016	978	617	177	171	184
2014/2015	918	536	167	200	215
2013/2014	860	539	120	185	201
2012/2013	1021	546	249	212	226
2011/2012	551	340	48	161	163
2010/2011	685	457	83	139	145
2009/2010	789	510	107	160	172
2008/2009	875	489	183	191	203
2007/2008	594	347	56	191	191
2006/2007	672	371	85	210	216
2005/2006	632	332	155	141	145
2004/2005	650	330	135	177	185
2003/2004	536	358	67	108	111
2002/2003	637	392	182	60	63
2001/2002	621	346	115	136	160
2000/2001	555	320	98	128	137
1999/2000	542	257	150	130	135
1998/1999	404	158	130	111	116
1997/1998	296	151	59	81	86
1996/1997	300	51	180	67	69
1995/1996	129	30	40	48	59

2. DISCUSSION

The 2021/2022 black petrel fledgling success rate on Great Barrier Island/Aotea was 73.3%, 1.2% higher than the 27-year average (Figure 4), which was 4.6% lower than last season's success rate (76.8%; Table 1). The fledgling success was lower within census grids (68.9%). The success rate was also lower than the previous 2020/2021 season (73.5%; Table 1). The 2021/2022 season saw a decrease in breeding success, following the slight negative trend from last year's breeding season (Figure 4). Bell et al. (2022) hypothesised that age structure of the black petrel population might be contributing to an overall negative trend or difference between the census grid burrows and overall study burrows on Great Barrier Island/Aotea. Breeding success and reproductive performance in long-lived seabirds is affected by age, age at first reproduction, senescence, and experience (Aubry et al.

2009, Limmer & Becker 2010). The age distribution between burrows within and outside the census grids were similar, but there was some disparity between birds of known and estimated age (i.e., known ages were more uniformly distributed where estimated ages peaked towards younger birds (Bell et al. 2022). The oldest known aged bird still being caught at the colony is 34 (banded in 1988 by Dr. Mike Imber; in 2021/2022 this bird was breeding, but failed to fledge a chick). During the 2021/2022 season four returned chicks were re-captured from the 2017/2018 breeding season, at age 4, a year earlier than the typical return age (Figure 5). Future, in-depth modelling on the effect of age, age difference in pairs, experience on breeding success will be needed to understand this relationship in black petrels.

There was one recorded instance of feral cat predation within the study colony this season. Live cage traps targeting feral cats are located around the Mt Hobson/Hirakimata summit and run prior to, and throughout the black petrel breeding season. There was one recorded instance of rat predation on an egg during the 2021/2022 which was the same as the previous 2020/2021. Despite the low number of recorded rat predation incidences, rats remain a common sight within the area. A trial of Good Nature A-24 traps is currently underway at Mt Hobson/Hirakimata (S. Dwyer, DOC, pers. comm.).

Cohorts of returned chicks appear to be mixed each breeding season, with no apparent dominating year group (Figure 5). The number of chicks banded each breeding season ranges from 59 (in 1995/96, when there were three census grids) to 254 (in 2021/2022, when there are nine census grids; Table 3). However to date, less than 8% of the black petrel chicks banded at the Great Barrier Island/Aotea study colony have been re-captured in subsequent field seasons. There is a real lack of understanding whether the low return rates relates either to low juvenile survival and/or recruitment or is purely due to lack of effort to locate banded birds within the 35-ha study site. Survival effort estimates, especially juvenile survival and recruitment are vital for accurate population estimates and risk assessment modelling, and it is highly recommended that effort to obtain data to fill this knowledge gap for black petrels is completed with urgency.

In order to fill this urgent gap, it is recommended that additional methods (night banding team, at-sea captures, conservation (seabird detection) dogs, and additional transect surveys within core areas) should be employed in unison with on the ground study burrow monitoring. Firstly, a dedicated night banding team in addition to the day-time study burrow monitoring team would help to expand the capacity to locate and identify returned black petrel chicks outside the current 35-ha study area. Black petrels are nocturnal and are highly vocal in the late evening. During the breeding season, un-paired males ‘clack’ (perform attraction calls) from or near their burrows to attract an un-paired female (Warham 1988). In addition, returning birds are easily located by the crashing sounds made through the forest canopy as they land to return to their burrows.

Another recommended method is the employment of seabird detection dogs to locate burrows occupied by breeding and non-breeding birds. Seabird detection dogs have been used successfully in the past within localised areas on Great Barrier Island/Aotea and Te Hauturu-o-Toi/Little Barrier Island (Bell et al. 2016a, Bell et al. 2016b). Expanding this effort into untapped and/or core breeding areas will help to identify black petrel hotspots and increase the probability of detecting returning birds. Previous experience with seabird detection dogs has found detection ability via scent of occupied or recently occupied burrows was up to 10 metres on either side of the track on calm days, with greater distances on the windward side of the track (up to 30 metres; Bell et al. 2016a). Black petrels carry a distinctive smell that is immediately apparent when handling, but because burrow entrances can often be cryptic and hidden within dense vegetation the scenting ability of trained seabird detection dogs confers a unique advantage over other methods (e.g., transect surveys) and makes their use as a highly effective tool to complement current methods.

At-sea captures is another highly effective method to catch large numbers of birds within short time periods; rafting birds can be caught by throwing a 1.8 m cast net and quickly pulled up onto the boat to be processed (Bugoni et al. 2008, Roconi et al. 2010). In early January and March of 2022, Wildlife

Management International Ltd. (WMIL) staff conducted at-sea capture work within the Hauraki Gulf (locations off the coasts of Chicken/Marotere and Mokohinau Islands; Burgin 2022). Over a total of 4 days, WMIL staff caught and banded 139 black petrels, of which 5 birds were re-captures (Burgin 2022). As this pilot trial was conducted near the tail end of the breeding season (when chicks are likely to be fledging), the use of at-sea captures during the peak breeding season will likely result in a higher volume of banded black petrels identified and incorporated into the study. There is possibility that at-sea captures are also likely to target birds that might not be able to be caught during burrow monitoring e.g., pre- or non-breeders (immature individuals or those that have failed to attract/find a mate) or birds that have a failed breeding attempt and have subsequently returned to sea. Like other Procellaria, black petrels are highly philopatric (Warham 1996), and are suspected to exhibit sexed biased dispersal within the colony site. Males are suspected of returning closer to their natal areas whereas females are suspected of dispersing farther afield. Some males have been documented usurping their father and occupying their natal burrow (unpublished WMIL data). Because of this, we suspect that the identified returned chicks are predominantly male, however genetic confirmation of sex identity is needed to establish this trend, which is lacking for most individuals. At-sea captures would therefore likely reduce the likelihood of sex-biased detection.

3. ACKNOWLEDGMENTS

This project was funded by the Conservation Services Programme, Department of Conservation (DOC, POP2021/01, partially funded through a levy on the quota owners of relevant commercial fish stocks). Special thanks to:

- Sarah Dwyer, Louise Mack, and colleagues from the Department of Conservation Okiwi Office on Great Barrier Island/Aotea for providing crucial logistical support for our field teams during the 2021/2022 field season.
- Participants in the advocacy visits to the study site: Imogen Mahon and Adam Jones (My Big Blue Backyard Filming), Melanie Young and Jordan Scarlett (DOC), and Ben Richards, Ben Wilden and Jack Fifield (High Country Contracting) for their interest in black petrels, and assistance and enthusiasm in the field.
- Fellow WMIL colleagues: Paul Garner-Richards, Sara Larcombe, and Baylee Connor-McClean for their hard work and companionship in the field.
- Gaia Dell'Ariccia, Auckland Council, and Christine Mansford, Auckland University, for their collaboration, support, hard work and companionship in the field.
- Ngāti Rehua Ngāti Wai ki Aotea for their ongoing support and permission to carry out this work.

4. REFERENCES

Aubry, L.M.; Koons, D.N.; Monnat, J.Y. & Cam, E. (2009). Consequences of recruitment decisions and heterogeneity on age-specific breeding success in a long-lived seabird. *Ecology* 90: 2491–2502.

Bell, E.A. (2013). Black petrel In: Miskelly, C.M. (ed.) *New Zealand Birds Online*. www.nzbirdsonline.org.nz (Accessed 6 May 2022).

Bell, E.A. & Sim, J.L. (1998). Survey and monitoring of black petrels on Great Barrier Island 1996. *Science for Conservation 77*. Department of Conservation, Wellington. 17p.

Bell, E.A. & Sim, J.L. (2000a). *Surveying and monitoring of black petrels on Great Barrier Island, 1998/99.* Published client report on contract 3089, funded by Conservation Services Levy. Department of Conservation, Wellington. 23p.

Bell, E.A. & Sim, J.L. (2000b). *Survey and monitoring of black petrels on Great Barrier Island, 1999/2000*. Published client report on contract 3018, funded by Conservation Services Levy. Department of

Conservation, Wellington. 30 p. https://dxcprod.doc.govt.nz/globalassets/documents/science-and-technical/csl3018.pdf

Bell, E.; Lamb, S. & Ray, S. (2022). Population trends and breeding population size of black petrels (Procellaria parkinsoni) — 2020/2021 operational report. *New Zealand Aquatic Environment and Biodiversity Report No. 280*. 43 p.

Bell, E.A.; Mischler, C.P.; MacArthur, N. & Sim, J.L. (2016a). *Black petrel (Procellaria parkinsoni) population study on Te Hauturu-o-Toi/Little Barrier Island, 2015/16*. (Unpublished report to the Conservation Services Programme, Department of Conservation, Wellington.) https://www.doc.govt.nz/Documents/conservation/marine-and-coastal/marine-conservation-services/reports/pop2015-01-black-petrel-lbi-final.pdf

Bell, E.A.; Mischler, C.P.; MacArthur, N.; Sim, J.L. & Scofield, P. (2016b). *Population parameters of the black petrels (Procellaria parkinsoni) on Great Barrier Island (Aotea Island), 2015/16*. (Unpublished report to the Conservation Services Programme, Department of Conservation, Wellington.) https://www.doc.govt.nz/Documents/conservation/marine-and-coastal/marine-conservation-services/reports/pop2015-01-black-petrel-gbi-final.pdf

Birdlife International (2020). *Species factsheet: Procellaria parkinsoni*. IUCN Red list for birds. Accessed from www.birdlife.org on 4 April 2020.

Bugoni, L.; Neves, T.S.; Peppes, F.V. & Furness, R.W. (2008). An effective method for trapping scavenging seabirds at sea. *Journal of Field Ornithology* 79: 308-313.

Burgin, D. 2022. *At-sea capture work for tākoketai/black petrels 2022*. Unpublished Wildlife Management International Technical Report to the Department of Conservation, Wellington. 18p.

Hunter, C.; Fletcher, D. & Scofield. P. 2001. Preliminary modelling of black petrels (Procellaria parkinsoni) to assess population status. *DOC Science Internal Series 2*. Department of Conservation, Wellington, New Zealand. 42p.

Imber, M.J. (1976). Comparison of prey of the black Procellaria petrels of New Zealand. New Zealand *Journal of Marine and Freshwater Research* 10: 119–130.

Imber, M.J. (1987). Breeding ecology and conservation of the black petrel (Procellaria parkinsoni). *Notornis* 34: 19–39.

Imber, M.J.; McFadden, I; Bell, E.A. & Scofield, R.P. (2003a) Post-fledging migration, age of first return and recruitment, and results of inter-colony translocation of black petrels (*Procellaria parkinsoni*). *Notornis* 50, 183–190.

Imber, M.J.; West, J.A. & Cooper, W.J. (2003b). Cook's petrel (*Pterodroma cookii*): historic distribution, breeding biology, and effects of predators. *Notornis* 50, 221–230.

Limmer, B. & Becker, P.H. (2010). Improvement of reproductive performance with age and breeding experience depends on recruitment age in a long-lived seabird. *Oikos* 119: 500–507.

Richard, Y.; Abraham, E. & Berkenbusch, K. (2020). Assessment of the risk of commercial fisheries to New Zealand seabirds, 2006–07 to 2016–17. *New Zealand Aquatic Environment and Biodiversity Report 237*. 57 p.

Robertson, H.A.; Baird, K.A.; Elliott, G.P.; Hitchmough, R.A.; McArthur, N.J.; Makan, T.D.; Miskelly, C.M.; O'Donnell, C.F.J.; Sagar, P.M.; Scofield, R.P.; Taylor, G.A. & Michel, P. (2021). Conservation status of birds in Aotearoa New Zealand, 2021. *New Zealand Threat Classification Series 36*. Department of Conservation, Wellington. 43 p.

Russell, J.C.; Horn, S.R.; Miskelly, C.M.; Sagar, R.L. & Taylor, R.H. (2020). Introduced land mammals and their impacts on the birds of the subantarctic Auckland Islands. *Notornis* 67(1): 247–268.

Scofield, R.P. (1989). *Breeding biology and conservation of the black petrel (Procellaria parkinsoni) on Great Barrier Island.* Unpublished MSc (Zoology) thesis. Auckland University, Auckland, New Zealand. 69 p.

Warham, J. (1988). Vocalisations of Procellaria petrels. *Notornis* 35: 169–183.

Warham, J. (1996). *The behaviour, population biology and physiology of the petrels*. Academic Press, London. 613 pp.

5. APPENDICES

5.1.1 Summary of returned chick captures

Table 4. Number of captures, age at first recapture, age at first breeding and age at first successful breeding for tākoketai/black petrels (*Procellaria parkinsoni*) banded as chicks and recaptured in the study site on Great Barrier Island/Aotea since the 1995/96 breeding season.

Band	Sex	Date banded	No. of captures	Age of 1st recapture	Age of 1st breeding	Age of 1st successful breeding
27604	M	27-Apr-89	27	7	7	8
31366	U	01-Apr-98	20	5	6	6
33052	M	22-Apr-02	15	6	6	6
25661	M	15-Apr-00	14	9	9	13
34903	M	28-Apr-05	13	5	7	7
34580	U	25-Apr-07	11	5	6	6
23635	M	12-May-88	22	10	10	14
33375	U	09-May-04	13	5	5	5
34320	U	27-Apr-05	12	5	8	8
34338	U	27-Apr-05	12	5	6	6
34820	U	28-Apr-05	11	6	6	10
33540	F	02-May-06	11	4	7	7
34527	M	24-Apr-07	10	6	6	13
32980	M	21-Apr-02	11	4	11	11
34304	U	27-Apr-05	10	8	8	8
32985	U	21-Apr-02	10	11	11	11
32995	M	21-Apr-02	10	11	11	13
35360	U	22-Apr-09	9	5	6	6
36139	M	11-Apr-08	9	6	7	
34836	U	28-Apr-05	10	6	7	10
29047	U	21-Apr-09	8	6	7	7
34317	U	27-Apr-05	9	8	8	8
35313	U	06-May-10	7	6	6	9
35315	M	06-May-10	7	6	7	7
33244	M	16-May-03	10	6	10	10
35188	M	24-Apr-09	7	6	6	7
36925	M	27-Apr-12	6	5	5	7
36957	U	29-Apr-12	6	5	8	9
36419	M	08-May-11	6	6	7	7
36440	U	08-May-11	6	6	7	7
36213	U	11-Apr-08	6	9	9	10
34713	M	10-May-04	6	13	13	13
33035	U	22-Apr-02	13	6	7	7
29927	M	02-Apr-01	10	9	12	12
36290	U	13-Apr-08	9	5	6	7
33508	U	02-May-06	9	7	7	7

Band	Sex	Date banded	No. of captures	Age of 1st recapture	Age of 1st breeding	Age of 1st successful breeding
33528	U	02-May-06	9	7	7	7
35574	U	08-May-10	7	5	6	10
36495	U	08-May-10	6	6	6	8
34837	U	28-Apr-05	6	9	14	14
38760	U	28-Apr-13	5	5	6	6
37615	F	28-Apr-12	5	6	6	8
35460	M	06-May-11	5	7	7	7
36411	M	07-May-11	5	7	7	7
35597	M	08-May-10	5	9	9	9
35516	M	09-May-10	5	8	9	10
29008	M	21-Apr-09	5	9	9	9
35459	F	06-May-11	6	5	8	10
36930	U	27-Apr-12	5	5	7	8
35399	M	23-Apr-09	5	8	10	10
34535	U	24-Apr-07	5	9	9	9
39311	U	25-Apr-14	4	5	5	5
39460	U	27-Apr-14	4	5	5	5
38609	U	29-Apr-13	4	6	6	7
35485	U	07-May-11	4	8	9	9
34528	U	24-Apr-07	4	12	12	12
33276	U	08-May-04	10	7	7	7
33369	U	09-May-04	9	9	8	8
35101	U	21-Apr-09	6	6	6	7
35521	U	09-May-10	5	6	6	9
36904	U	27-Apr-12	4	6	8	8
38661	U	27-Apr-13	4	4	4	4
34621	M	25-Apr-07	5	4	9	9
34645	U	26-Apr-07	4	10	15	15
36994	U	28-Apr-12	4	4	8	8
34612	U	25-Apr-07	4	9	14	14
41343	U	25-Apr-15	3	5	7	7
38899	U	25-Apr-14	3	6	6	8
39310	U	25-Apr-14	3	6	6	6
39318	U	25-Apr-14	3	6	6	6
39323	U	25-Apr-14	3	6	6	6
39343	U	25-Apr-14	3	6	6	
38983	U	26-Apr-14	3	6	7	7
39063	U	27-Apr-14	3	6	6	6
39481	U	28-Apr-14	3	6	7	7
36112	M	10-Apr-08	4	5	10	10
37659	U	29-Apr-12	3	8	8	8
36247	U	11-Apr-08	3	12	14	14
34895	U	27-Apr-05	3	14	15	15
35311	U	6-May-10	1	6	6	6

Band	Sex	Date banded	No. of captures	Age of 1st recapture	Age of 1st breeding	Age of 1st successful breeding
31494	U	18-Apr-99	15	6	9	10
25673	M	15-Apr-00	16	5	7	7
33737	U	16-May-03	11	7	7	7
33246	U	16-May-03	9	10	10	10
35361	U	22-Apr-09	8	5	6	6
34615	M	25-Apr-07	8	7	9	10
34843	M	28-Apr-05	10	5	6	6
36441	U	08-May-11	6	4	9	9
36426	U	08-May-11	5	5	6	8
31324	U	03-May-06	8	7	7	7
35187	M	24-Apr-09	7	5	6	6
35419	F	06-May-11	5	5	7	7
36431	U	08-May-11	4	7	7	9
36209	M	11-Apr-08	4	10	10	10
35193	U	24-Apr-09	7	5	6	6
34278	U	27-Apr-05	4	12	12	12
37605	U	28-Apr-12	3	7	7	8
34901	U	28-Apr-05	11	5	7	7
34273	U	27-Apr-05	9	7	7	7
31495	M	18-Apr-99	17	4	5	5
31542	U	19-Apr-99	17	4	6	7
42037	M	07-May-16	2	4	6	
39691	U	23-Apr-15	2	5	5	5
39022	U	27-Apr-13	2	7	8	8
38780	U	28-Apr-13	2	7	7	7
34687	U	26-Apr-07	8	7	8	8
35131	M	22-Apr-09	7	5	10	11
29023	U	21-Apr-09	3	10	10	10
41316	U	25-Apr-15	2	5	7	7
32099	U	02-Apr-01	13	5	8	8
35151	M	23-Apr-09	5	7	7	8
34520	U	24-Apr-07	5	5	12	12
38574	U	26-Apr-13	3	5	5	5
35345	M	07-May-10	3	7	9	
39683	U	23-Apr-15	2	4		
39340	U	25-Apr-14	2	5		
35421	U	06-May-11	2	8	8	
42050	U	07-May-16	1	4	4	
41923	U	08-May-16	1	4		
41902	U	10-May-16	1	4		
41357	U	25-Apr-15	1	5		
38979	M	26-Apr-14	1	6		
38592	U	26-Apr-13	1	7	7	7
39011	U	27-Apr-13	1	7		

Band	Sex	Date banded	No. of captures	Age of 1st recapture	Age of 1st breeding	Age of 1st successful breeding
36968	U	29-Apr-12	1	8		
35166	U	24-Apr-09	1	11	11	11
32073	U	05-Apr-01	2	6	19	
34891	U	27-Apr-05	1	15		
33575	U	03-May-06	11	5	5	5
25536	U	15-Apr-99	12	6	6	11
39044	U	27-Apr-13	5	4	6	9
35450	M	06-May-11	3	7	10	
35481	U	06-May-11	3	5	10	11
41992	U	08-May-16	2	5	6	6
39692	U	23-Apr-15	2	6	7	7
39735	U	23-Apr-15	2	6	6	6
39714	M	25-Apr-15	2	6		
41342	U	25-Apr-15	2	6	6	6
39059	U	27-Apr-14	2	7	7	7
39065	U	27-Apr-14	2	7	7	
39478	U	27-Apr-14	2	7	8	8
36430	U	08-May-11	2	10	11	11
29095	U	21-Apr-09	2	12	13	13
39078	U	27-Apr-14	2	5	7	
25651	U	15-Apr-00	14	5	6	6
39465	U	27-Apr-14	2	4		
42624	U	13-May-17	1	4		
41691	U	07-May-16	1	5		
41912	U	08-May-16	1	4		
42000	U	08-May-16	1	5		
39654	U	23-Apr-15	1	6		
39721	U	23-Apr-15	1	6		
41313	U	25-Apr-15	1	6		
41399	U	26-Apr-15	1	6		
38994	U	26-Apr-14	1	7		
39067	U	27-Apr-14	1	7		
38847	U	26-Apr-13	1	8	8	8
37648	U	28-Apr-12	1	9	9	
36401	U	07-May-11	1	10		
36270	U	12-Apr-08	1	13		
38969	U	26-Apr-14	2	4		
38844	U	27-Apr-13	2	5		
40235	U	02-May-18	1	4		
40237	U	02-May-18	1	4	4	
40239	U	03-May-18	1	4		
40320	U	08-May-18	1	4		
43352	U	08-May-18	1	4		
43382	U	16-May-18	1	4		

Band	Sex	Date banded	No. of captures	Age of 1st recapture	Age of 1st breeding	Age of 1st successful breeding
42962	U	05-May-17	1	5		
42965	U	05-May-17	1	5		
41732	U	07-May-17	1	5		
42724	U	07-May-17	1	5	5	
41490	U	05-May-16	1	5		
41654	U	06-May-16	1	6		
41656	U	06-May-16	1	6		
42042	U	07-May-16	1	6		
41932	U	08-May-16	1	6		
41303	U	25-Apr-15	1	7		
41334	U	25-Apr-15	1	7	7	7
39480	U	27-Apr-14	1	8		
39491	U	28-Apr-14	1	8		
38654	U	27-Apr-13	1	9	9	9
38668	U	27-Apr-13	1	9		
38795	U	28-Apr-13	1	9		
34445	U	24-Apr-07	1	15	15	15
30930	M	14-Apr-96	20	4	5	5
33389	M	09-May-04	10	6	6	6
34299	U	27-Apr-05	6	7	7	7
33581	U	03-May-06	7	5	6	15
29018	U	21-Apr-09	3	7	7	7
36455	U	07-May-10	3	6	9	9
26955	U	07-May-86	6	24	24	24
36918	U	27-Apr-12	2	5		
35444	U	06-May-11	2	5	7	
39674	U	23-Apr-15	1	4		
41317	U	25-Apr-15	1	4		
39053	U	27-Apr-14	1	5		
39484	U	28-Apr-14	1	5		
28572	U	06-Mar-92	23	4	4	4
34660	U	26-Apr-07	7	4	5	5
33248	U	16-May-03	10	6	8	8
35493	U	07-May-11	3	5	5	5
34349	U	27-Apr-05	5	7		
38777	U	28-Apr-13	2	4		
34610	U	25-Apr-07	4	7	11	
39088	U	27-Apr-14	1	4	4	
37606	U	28-Apr-12	1	6		
25525	M	15-Apr-99	10	7	8	10
33530	U	02-May-06	7	5	6	6
29978	U	14-Apr-00	6	9	14	14
34505	U	24-Apr-07	5	6	6	6
35160	U	23-Apr-09	4	5	6	6

Band	Sex	Date banded	No. of captures	Age of 1st recapture	Age of 1st breeding	Age of 1st successful breeding
35392	U	23-Apr-09	3	6	7	
36124	U	10-Apr-08	3	8	8	8
29098	U	21-Apr-09	3	4	7	7
36147	U	11-Apr-08	3	5		
38655	U	27-Apr-13	2	3		
35466	U	06-May-11	2	5		
35316	U	06-May-10	2	6	7	7
35180	U	24-Apr-09	2	7	7	7
35439	U	06-May-11	2	4	6	
34550	U	24-Apr-07	2	8	10	
33071	U	22-Apr-02	2	11	14	
38672	U	27-Apr-13	1	4		
37616	U	28-Apr-12	1	5		
37636	U	28-Apr-12	1	5		
36953	U	29-Apr-12	1	5		
35436	U	06-May-11	1	5	5	
33015	U	22-Apr-02	4	6	14	
35130	U	22-Apr-09	1	8	8	
34525	U	24-Apr-07	1	10	10	10
34607	U	25-Apr-07	1	10	10	
28089	U	02-Apr-01	1	15	15	
41507	U	11-May-88	17	11	12	12
32957	F	21-Apr-02	10	5	6	7
32927	U	21-Apr-02	8	6	6	6
33003	U	22-Apr-02	6	7	7	7
34886	U	26-Apr-05	5	7	7	8
35489	U	07-May-11	2	4		
35490	U	07-May-11	2	4	5	
36115	U	10-Apr-08	2	7	8	8
36277	U	12-Apr-08	2	7		
33589	F	03-May-06	5	5	5	5
36911	U	27-Apr-12	1	4		
37638	U	28-Apr-12	1	4		
34574	U	25-Apr-07	2	4		
36470	U	07-May-10	1	6		
35584	U	08-May-10	1	6		
25635	M	15-Apr-00	6	5	5	6
36248	U	11-Apr-08	1	7		
34513	U	24-Apr-07	1	9	9	
34626	U	25-Apr-07	1	9		
34655	U	26-Apr-07	1	9	9	
34994	U	02-May-06	1	10	10	
32960	U	21-Apr-02	1	14	14	14
36118	M	10-Apr-08	4	5	7	

Band	Sex	Date banded	No. of captures	Age of 1st recapture	Age of 1st breeding	Age of 1st successful breeding
35186	U	24-Apr-09	3	4	6	
35518	U	09-May-10	2	4	6	6
36233	U	11-Apr-08	2	6	7	
34553	U	24-Apr-07	2	7	8	8
36427	U	08-May-11	1	4		
36476	U	07-May-10	1	5		
36271	U	12-Apr-08	1	7		
33584	U	03-May-06	1	9		
31340	U	04-May-06	1	9	9	9
34308	U	27-Apr-05	1	10	10	10
33226	U	16-May-03	1	12	12	
31389	U	02-Apr-98	1	17	17	17
31089	U	31-Mar-98	9	5	6	9
25664	U	15-Apr-00	9	3	6	10
34276	U	27-Apr-05	4	5	8	8
34600	U	25-Apr-07	3	5	7	
25546	M	16-Apr-99	10	5	5	11
31537	U	19-Apr-99	6	8	8	8
34698	U	26-Apr-07	2	7		
36474	U	07-May-10	1	4		
29027	U	21-Apr-09	1	5		
35380	U	22-Apr-09	1	5		
30175	U	12-Apr-08	1	5		
36294	U	13-Apr-08	1	6	6	
34435	U	24-Apr-07	1	7	7	7
34916	U	28-Apr-05	1	9	9	
30934	U	15-Apr-96	1	18		
31370	U	01-Apr-98	5	5	8	
33376	U	09-May-04	2	8	8	
27702	F	29-Apr-90	13	6	6	6
33550	U	02-May-06	3	4	5	5
31478	U	17-Apr-99	3	10	10	
29912	U	02-Apr-01	5	5	5	6
35571	U	08-May-10	1	3		
35397	U	23-Apr-09	1	4	4	4
35189	U	24-Apr-09	1	4		
36140	U	11-Apr-08	1	5		
36241	U	11-Apr-08	1	5		
30167	U	12-Apr-08	1	4		
27614	U	27-Apr-89	5	5		
34599	U	25-Apr-07	1	6		
34624	U	25-Apr-07	1	6		
25659	U	15-Apr-00	2	6	6	6
33546	U	02-May-06	1	7	7	

Band	Sex	Date banded	No. of captures	Age of 1st recapture	Age of 1st breeding	Age of 1st successful breeding
34808	U	28-Apr-05	1	8		
32921	U	21-Apr-02	1	11	11	11
32100	U	02-Apr-01	1	12	12	
31422	U	05-Apr-97	1	16	16	
36216	U	11-Apr-08	1	4		
31345	U	04-May-06	1	6		
34867	U	22-Feb-05	1	7	7	7
30924	U	12-Apr-96	9	6	6	6
33596	U	03-May-06	2	5	6	
33335	U	08-May-04	2	5	7	
33543	U	02-May-06	1	5		
33591	U	03-May-06	1	5		
32915	U	21-Apr-02	3	6	6	6
34804	U	27-Apr-05	2	4	5	5
33068	U	22-Apr-02	2	7	8	
33518	U	02-May-06	1	4		
34828	U	28-Apr-05	1	5		
33055	U	22-Apr-02	1	8	8	8
33067	U	22-Apr-02	1	8		
25663	U	15-Apr-00	6	4	7	8
13638	U	11-May-88	4	18	16	17
31498	U	18-Apr-99	4	6	6	6
25648	U	15-Apr-00	4	4	5	8
27058	U	30-Apr-87	7	14	14	14
33218	U	16-May-03	2	5	6	
31956	U	02-Apr-01	2	7		
31382	U	02-Apr-98	5	4	5	5
31424	U	05-Apr-97	5	6	8	8
33397	U	09-May-04	1	5		
13614	U	10-May-88	1	11		
33380	U	09-May-04	1	4		
32091	U	02-Apr-01	1	7		
31546	U	19-Apr-99	1	9		
33225	U	16-May-03	1	4		
27568	U	27-Apr-89	4	11	11	11
32979	U	21-Apr-02	1	5		
25677	U	15-Apr-00	1	7	7	7
27665	M	29-Apr-90	11	6	6	6
25630	M	15-Apr-00	2	5		
25669	U	15-Apr-00	2	5	5	5
26991	U	09-May-86	9	17	18	18
28085	U	02-Apr-01	1	5		
32063	U	05-Apr-01	1	5		
13618	U	10-May-88	5	10	6	6

Band	Sex	Date banded	No. of captures	Age of 1st recapture	Age of 1st breeding	Age of 1st successful breeding
31491	U	18-Apr-99	1	7		
31405	U	03-Apr-97	3	6	7	7
31415	U	05-Apr-97	2	7		
31476	U	17-Apr-99	2	4	6	
33088	U	22-Apr-02	1	3		
25637	U	15-Apr-00	1	5		
25658	M	15-Apr-00	1	5	5	5
31413	U	05-Apr-97	1	8	8	8
25631	M	15-Apr-00	1	4		
31383	U	02-Apr-98	1	6		
31081	U	31-Mar-98	2	4		
31474	U	17-Apr-99	1	4		
31490	U	18-Apr-99	1	4		
31527	U	18-Apr-99	1	4		
31076	U	31-Mar-98	1	5		
30908	U	08-Apr-96	1	7		
31080	U	31-Mar-98	1	4		
31082	U	31-Mar-98	1	4		
31377	U	02-Apr-98	1	4		
31194	M	03-Apr-97	1	5	5	
31406	U	03-Apr-97	1	5		
26980	U	09-May-86	1	16	16	
29644	U	01-May-86	1	15		
27728	U	29-Apr-90	4	7	8	9
27032	U	29-Apr-87	2	7		
27708	U	29-Apr-90	1	10		
27678	U	29-Apr-90	4	4	7	
27666	U	29-Apr-90	4	4	7	7
27512	U	06-May-88	2	6		
27689	U	29-Apr-90	1	7	7	7
22564	U	09-Apr-78	1	18	18	
21185	M	29-Apr-87	1	9		
27726	U	29-Apr-90	1	4		
27637	F	02-May-89	1	5		
26924	U	04-May-86	1	6		
22473	U	14-Mar-72	1	5		
30161	U	12/04/2008	1	2		
31322	U	3/05/2006	1	3		
30177	U	12/04/2008	1	3		
33208	M	15/05/2003	4	5	7	
30807	F	29/04/1997	5	9	9	9
29960	M	13/04/2000	8	9	9	9
Mean (±SEM)			3.96 ± 0.21	6.55 ± 0.15	7.97 ± 0.19	8.34 ± 0.20