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**Northern giant petrel *Macronectes halli* breeding population survey,
Auckland Islands**

December 2015 – February 2016

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Department of Conservation, Conservation Services Programme, Contract 4655-4



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Executive summary

Northern giant petrels *Macronectes halli* are a large, southern hemisphere fulmarine petrel that face conservation threats both in the terrestrial and marine environment. Introduced mammalian predators at breeding sites cause nesting failures and in some instances may also depredate adults. In the marine environment Northern giant petrels are threatened by capture in longline and trawl fisheries, oil pollution, shooting by fishers for bait stealing and the effects of climate change.

The contemporary size and the population trends of Northern giant petrels on New Zealand islands are not known. Records of their numbers in the Auckland Islands are based solely on anecdotal evidence, and the most recent summary dates to the 1980s. We estimated the size of the Northern giant petrel breeding population and describe their spatial distribution in the Auckland Islands.

Surveys counted 216 Northern giant petrel chicks on eight of the 15 islands visited in December 2015 and January 2016. Enderby Island had the largest breeding population, with 96 chicks counted. This represents a large increase in the population on Enderby Island compared to the only historic comprehensive count, in 1988, when just two Northern giant petrel chicks were counted. The second and third-largest populations were on Disappointment, (38) and Dundas Islands (32). No breeding Northern giant petrels were reported from Rose and Friday Islands, where the species has previously been recorded breeding. Chicks were counted at two locations previously not reported to support breeding Northern giant petrels, at French's Island and Crozier Point on the main Auckland Island.

Applying crude correction factors based on breeding success at the nearest Northern giant petrel colony where these data have been collected, Macquarie Island, we estimate the breeding population in the Auckland Islands 2015-2016 to be approximately 340 (range 310-390) breeding pairs. We recommend future monitoring of the Auckland Island Northern giant petrel breeding population. Ideally island-wide surveys would be repeated at regular 3-5 year intervals. Enderby Island would be the ideal location for regular, annual counts of breeding birds.

Keywords: Northern giant petrels, *Macronectes halli*, Auckland Islands, population estimate

Introduction

Northern giant petrels *Macronectes halli* are a large, southern hemisphere fulmarine petrel that forage between 30°S and 64°S. The species breeds on nine sub-antarctic island groups between 44°S and 54°S (ACAP 2009). Over one-third of the total estimated breeding population is on South Georgia Island, in the South Atlantic (ACAP 2009). In the southern Indian Ocean breeding takes place on the Prince Edward Islands (Ryan et al. 2003) and the Crozet and Kerguelen archipelagos (Shirihai 2007; Weimerskirch et al. 1989). In the southern Pacific region Northern giant petrels breed on the Chatham Islands group, Macquarie, Campbell, Auckland and Antipodes Islands (Heather and Robertson 2015).

Northern giant petrels exhibit strong site fidelity and pairs studied from 1966-80 at Île de la Possession generally showed long-term pair bonds (Voisin 1988). A colonial, or solitary, surface nesting species, the age at first breeding can be four years but averages approximately 10 years (Heather and Robertson 2015). A single egg is laid from mid-August to late September (Brooke 2003) and both male and females share incubation and chick provisioning (Cooper et al. 2001). Incubation is approximately 60 days, and chicks fledge at approximately 112 days of age (Heather and Robertson 2015). On both Marion and South Georgia Islands females fledged on average six and five days earlier, respectively, than males (Cooper et al. 2001; Hunter 1984). Breeding sabbaticals are common; at Île de la Possession 15- 40% of adults did not breed each year (Voisin 1988) and at South Georgia 47% took breeding sabbaticals (Hunter 1984).

Along with the closely related Southern giant petrel *M. giganteus*, Northern giant petrels are the most common scavengers in sub-antarctic and Antarctic waters (Brooke 2003). More recent evidence shows Northern giant petrels are also a capable predator of large birds such as great albatrosses and penguins (Dilley et al. 2013; Ryan et al. 2008; Hunter and Brooke 1992). Giant petrels are the most sexually dimorphic of all seabirds with males significantly larger than females (Brooke 2003). This difference in size has been used to explain contrasting foraging behaviours. Tracking data showed Northern giant petrel males at South Georgia forage both terrestrially and at sea whilst females are almost entirely marine foragers (González-Solís et al. 2000b). Similarly, female Northern giant petrels at Marion Island were shown to forage predominantly on fish and cephalopods compared to the seal and penguin dominated diet of males (Hunter and Brooke 1992). The smaller size of females may limit their ability to compete with males for terrestrial food resources (González-Solís et al. 2000a).

The New Zealand Threat Classification System recognises Northern giant petrels as Naturally Uncommon, with the qualifiers Range Restricted and Secure Overseas (Robertson et al. 2012). The IUCN Red List of Threatened Species categorises Northern giant petrels as Least Concern (Birdlife 2012) (down-listed from Near Threatened in 2009) and the species is listed with the Agreement on the Conservation of Albatrosses and Petrels (ACAP 2016).

Northern giant petrels face conservation threats both in the terrestrial and marine environment. Introduced mammalian predators at breeding sites cause nesting failures and in some instances may also depredate adults. Cats *Felis catus* caused egg and chick failure on Macquarie Island (ACAP 2009), prior to their eradication in 2000 (Robinson and Copsin 2014), as did ship, or black rats *Rattus rattus*, eradicated in 2012 (Hunt 2014). Nest

trampling by livestock was not documented on Campbell Island (sheep) or Enderby Island (cattle) before their removal, but this seems entirely possible as large ground nesting birds such as Southern royal albatrosses were negatively impacted by stock on Enderby Island (Taylor 1971). Giant petrels are also prone to human disturbance (Brooke 2004) and secondary, non-target poisoning in operations to eradicate introduced mammals (Parks and Wildlife Service 2014).

In the marine environment Northern (and Southern) giant petrels are threatened by capture in longline and trawl fisheries (ACAP 2009), oil pollution (G. Parker unpublished data), competition with fisheries for resources, shooting by fishers for bait stealing (Szabo 2014) and the effects of climate change (Gremillet and Bouliner 2009). The differences in foraging strategies between male and female giant petrels may result in mortality in the marine environment being biased towards females (González-Solís 2000), but this is not always the case (Ryan and Boix-Hinzen 1999). Conversely, as a scavenging species giant petrels may benefit from the considerable food resources discarded from fishing vessels, such as fish heads, guts and tails and non-commercial bycatch species (Heather and Robertson 2015). In addition, both Northern and Southern giant petrels quickly mob and depredate Black-browed albatrosses *Thalassarche melanophris* injured by warp strike during bottom-trawl fishing operations in the Falkland Islands (Parker et al. 2012).

The world-wide Northern giant petrel breeding population is estimated to be c. 11,800 pairs (ACAP 2009). However, quantitative population estimates exist for only a few of the nine island groups where the species breeds so population trends need to be estimated (ACAP 2009). Local population trends, from the few islands where the species has been studied, show some Northern giant petrel populations have been increasing and others decreasing. Macquarie Island is the only population with trend data in the Australasian region. There the population has increased from approximately 200 breeding pairs to over 400 (ACAP 2009). At South Georgia the population increased by 60% between 1978 and 1996, apparently in relation to the dramatic increase in Antarctic fur seals *Arctocephalus gazella* and the increased availability of fisheries discards (González-Solís 2000). On Île de la Possession (Crozet Archipelago), the population increased between 1966 and 1980 (Voison 1988), declined during the 1980s, increased in the late 1990s and was reportedly decreasing in the late 1990s (De Lord et al. 2008). The Marion Island population has increased and decreased between 1985 and 2008, but overall the trend was for a slight decrease of 0.5% in the breeding population (ACAP 2009).

The contemporary size and the population trends of Northern giant petrels on New Zealand islands are not known. Single population estimates exist for the Antipodes (230 breeding pairs; Wiltshire and Hamilton 2003) and Campbell Islands (234 breeding pairs; Wiltshire and Scofield 2000). These provide a baseline population estimate for those islands, but no population estimates have been conducted since, preventing any insight into population trends there. The Chatham Islands is the stronghold of the species in the NZ region with an estimated 2000 breeding pairs in 1993 (Robertson and Sawyer 1994), but no population trend data exist there either. In the Auckland Islands, Northern giant petrels breed throughout the group, but no targeted, island-wide count of breeding birds has been conducted. Records of their numbers in the Auckland Islands are based solely on anecdotal evidence (see Patterson et al. 2008), and the most recent synthesis of known records dates to the 1980s (Taylor 1988).

Aim and objectives

We aim to estimate the size of the Northern giant petrel breeding population and describe their spatial distribution in the Auckland Islands. Specifically, our objectives were to count and to map Northern giant petrel chicks on all off-lying islands in the Auckland Islands group; and estimate the total number of breeding pairs.

Methods

The Auckland Islands are located at 50°30'S 169°09'E, c.450 km south of the New Zealand mainland (Fig. 1). The total area of the island and islets is approximately 65,000 ha and the highest point is the 705-m Mount Dick, located on Adams Island. The main Auckland Island comprises the vast majority of the land area, at 55,990 h, but due to invasive pigs *Sus scrofa*, cats and mice *Mus musculus* the native vertebrate biodiversity on the main island is much lower than on islands free of introduced mammalian predators.

The vegetation of the Auckland Islands consists of Southern rata *Metrosideros umbellata* dominated forest at sheltered lower altitudes, interspersed with *Coprosma*, *Myrsine*, *Pseudopanax*, and *Dracophyllum*. The forest turns to *Coprosma*, *Hebe*, *Myrsine* and *Dracophyllum* shrubland at mid-elevations and then *Chionochloa antarctica*, *Poa litorosa* and *P. foliosa* tussock grasslands followed by herbfields at higher elevations.

Published and unpublished records were used prior to departure to ensure all areas with historic records of Northern giant petrel breeding were resurveyed. Survey data were supplemented by KRH and GP's unpublished counts of Northern giant petrel chicks from Disappointment Island January 2015 and Adams Island December 2013 and January 2015.

KRH and GP operated from a 15-m yacht 2 - 4 December 2015 to survey the islands in Port Ross in the north of the Auckland Islands. These were Rose, Friday, Shoe, Ocean, Ewing, French's, Yule, and Green Islands. Enderby Island was counted and recounted over many days during December by CM. KRH and GP visited the only apparently stable colony on Adams Island, at Fairchilds Garden, 13 December 2015. Northern giant petrel chicks on Disappointment (KRH and GP) and Dundas Islands (CM) were counted in January 2016.

On each island the number of pre-fledging chicks present and their spatial distribution was recorded. To achieve this two workers conducted parallel strip-transects spaced at approximately 30 m intervals to exhaustively survey the available Northern giant petrel nesting habitat. The exceptions were Enderby and Dundas where a single person conducted exhaustive searches of all available habitat. All vegetation classes were treated as available habitat (Marchant and Higgins 1990), with the exception of the interior of southern rata dominated forest interiors. The edges of thick rata forest were thoroughly searched. Hand-held GPS units (Garmin Map 62s) with topographical mapping software were used to record all line transect surveys and the locations of all chicks detected.

Nests that showed clear signs of having failed in the current breeding season were also counted. Recent evidence of breeding was considered to be a well-constructed nest with an accumulation of guano from incubation, down and contour feathers and broken egg shell or a dead chick. Recently used nests had a readily detectible giant petrel odour. Caution was used to avoid counting old nests and 'play' nests constructed by non-breeding birds.

In an attempt to correct for nesting failure during the egg and early chick stage (e.g. Wiltshire and Hamilton 2003), the total number of Northern giant petrels breeding was calculated by applying the average, lowest and highest records of breeding success from the past ten years on Macquarie Island to the number of nests we found. Macquarie Island, 350 nautical miles southwest of the Auckland Islands, is the nearest Northern giant petrel colony where these data have been collected.

Results

Surveys counted 216 Northern giant petrel chicks on eight of the 15 islands visited in December 2015 and January 2016 (Table 1). Enderby Island had the largest breeding population, with 96 chicks counted (45% of Auckland Island total; Figure 1). The second and third largest populations were on Disappointment (38, 18%) and Dundas Islands (32, 15%). Fourteen failed nests were recorded, eleven of which were on Enderby (Table 1). A brief description of each island visited is given in Appendix One.

No breeding Northern giant petrels were reported from Rose and Friday Islands, where the species has previously been recorded breeding (Table 1). Chicks were counted at two locations previously not reported to support breeding Northern giant petrels, at French's Island and Crozier Point on the main Auckland Island (Figure 1).

Nesting habitat was primarily partially wind-exposed sites in long grass bordering forest and shrub vegetation edges. All the counted chicks were in loose colonies ranging in size from two to tens of chicks.

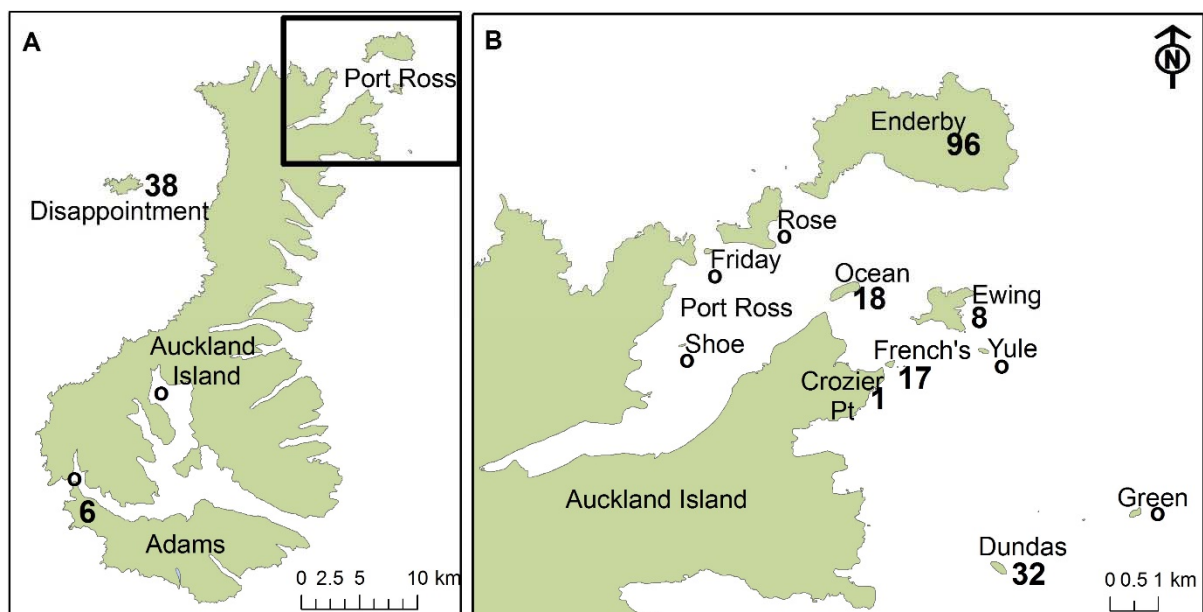


Figure 1. Location and number of Northern giant petrel chicks detected in surveys December 2015 and January 2016, Auckland Islands. A. The entire Auckland Islands group. B. Port Ross islands in detail. Small open circles mark islands surveyed where no Northern giant petrel breeding was recorded.

The 216 chicks we counted is a minimum breeding population due to the occurrence of breeding failure. By inspecting nests for signs of recent failure (i.e. the current breeding

season) we tried to include failed nests in our totals, but we assume the true number of failed nests is underestimated as nests without an adult or chick sitting on it are less conspicuous.

To correct for breeding failure we used Macquarie Island's most recent 10 year breeding success average of 63.8% and the range 55.7%– 69.8% (R. Alderman pers. comm.). If Auckland Island breeding success rates are similar to Macquarie then the large chicks counted (ignoring failed nests), represent approximately two thirds of the population that attempted to breed in the year of this study. Applying these crude correction factors to our estimates and assuming the number of large chicks we counted represent the number that fledged, we estimate the breeding population in 2015-2016 to be approximately 340 (range 310-390) breeding pairs.

Table 1. Northern giant petrel counts December 2015- January 2016 and historic counts

Location	Date counted	# large chicks	# failed nests	Previous breeding records B = breeding but no record of number of nests or chicks C = number of chicks counted	Increase / decrease # nests
Enderby Island	12/2015	96	11	'scattered colony' (1989) ^b ; 2C (1988) ^a , B (1972/73) ^l ; B (1944) ^d	increase
Rose Island	2/12/2015	0	0	18C [#] (1989) ^b , 0C (1988) ^a , B (1966) ^c ; B (1944) ^d	decrease
Friday Island	2/12/2015	0	0	B ^e	decrease
Shoe Island	2/12/2015	0	0	Visited regularly for sea-lion research and breeding NGPs never counted	na
Ocean Island	4/12/2015	18	1	18 C (1989) ^b ; 2C (1988) ^a ; B (1944) ^d	unclear
Ewing Island	3/12/2015	8	0	B (2013) ^m ; 30 (1989) ^b	decrease
French's Island	3/12/2015	17	0	none	unclear
Auckland; Crozier Point	4/12/2015	1	1	none	unclear
Yule Island	3/12/2015	0*	na	none	na
Green Island	4/12/2015	0*	na	none	na
Adams Island: Fairchilds Garden	12/12/2015	6	1	6C (2014) ^j ; 5C (2013) ^j ; 7C [#] (2006); 35C (2004) ^h ; 1C (1989) ^k , 13C (1978) ^k ; 'small colony' (1944) ^d ,	decrease
Dundas Island	18/01/2016	32	0	'Lots' (2015); 3C (1980) ⁿ ; 0 (1978) ^f ; B (1972-73) ^g ; B (1943) ^f	unclear
Disappointment Island	13/01/2016	38	0	53C (2015) ^j ; 44C (1993) ^h ; B (1976) ^o ; B (1972/33) ^l	decrease [^]
Monumental Island	na	na	na	0 (2015) ^j	na
Figure of Eight Island	9/01/2016	0	na	Visited regularly for sea-lion research and breeding NGPs never counted	na
Total		216	14		

Source: a. Taylor 1988; b. Moore and McClelland 1989; c. Taylor 1971; d. Turbott 2002; e. S. Childerhouse pers.com; f. Falla et al. 1979; g. Atkinson 1986; h. Kath Walker pers.com 1994; i. Parker and Rexer-Huber unpublished data, 1-11/01/2015; j. Parker and Rexer-Huber unpublished data 17/01/2015; k. Buckingham et al. 1991; l. Bell *in* Yaldwyn 1975; m. Kerry-Jayne Wilson pers.obs.; n. Jenkins 1981; o. Bartle and Paulin 1986.

a-o sources of historical records.

*Surveyed from boat; no suitable nesting habitat for Northern giant petrels available

'at least' this number of chicks

^ The 2015 count was possibly not complete due to time restrictions

na = not applicable

Discussion

Our aim was to estimate the breeding population of Northern giant petrels in the Auckland Islands. A total of 216 large Northern giant petrel chicks were counted during December and January. Using breeding success data from Macquarie Island, we estimate the Northern giant petrel breeding population in the Auckland Islands to be approximately 340 (range 310-390) breeding pairs. Our quantitative estimate is higher than the four historical, non-quantitative records of breeding pairs. The population has been documented as 50 breeding pairs three times (Taylor 2000; Taylor 1988; Bell 1975) and once as 200 breeding pairs (CJ Robertson *in* Hunter 1986).

Our work was based on counts of chicks, due to temporal constraints, so does not accurately estimate breeding numbers due to error associated with nest failure during incubation and the early chick phase. Because no monitoring of Northern giant petrel breeding has occurred in the New Zealand sub-antarctic, we cannot apply local nest-failure rates to our chick counts, so assume that breeding success is similar on Macquarie. This may not be the case because Macquarie has vastly greater colonial penguin populations which are key prey and scavenged species for Northern giant petrels (Hunter and Brooke 1992). We also cannot account for the fact that egg- and chick-failures can show high inter-annual variability, or that the size of the breeding population may change substantially inter-annually due to breeding sabbaticals (Voisin 1988; Hunter 1984). For example we note that in the 2014-2015 year, our counts of Northern giant petrel chicks on Disappointment Island were approximately 25% higher than the following year (53 vs. 38).

Using historical records and a thorough survey design we minimised non-detection of breeding birds as a source of error. However, breeding Northern giant petrels can be difficult to count because single nests can be isolated or a few nests occur in loose groups over 1 km inland, making comprehensive coverage challenging and potentially decreasing detection rates (Ryan et al. 2009). The small islands in this study made us confident to have achieved an exhaustive search effort of all potential habitat.

The spatial distribution of the species has changed in the Auckland Islands, but this is not a recent phenomenon there nor is it rare for the species. Moore and McClelland (1990) visited Ewing, Enderby, Rose and Ocean and wrote that 'the Northern giant petrel population may have expanded or changed its distribution, as several colonies were found that were not

present in 1972-73'. This has also been found on other island groups. Wiltshire and Scofield (2000) suggest a perceived population decline in Northern giant petrels on Campbell Island was instead just a change in local breeding locations.

In the past, declines in Northern giant petrel populations in NZ have been attributed to declines in prey species such as elephant seals *Mirounga leonina* and rockhopper penguins *Eudyptes chrysocome* (Heather and Robertson 1996), but more recently the authors consider the species to be 'moderately stable' (Heather and Robertson 2015). Very little is known about the diet of Northern giant petrels breeding on NZ islands, so documenting population fluctuations relative to the abundance of key prey species is not possible. Nor are we able to estimate the potential for incidental mortality of Northern giant petrels in commercial fisheries in international waters.

Giant petrels can be vulnerable to human disturbance around nesting areas and are known to abandon breeding sites (Brooke 2004). Enderby Island is the most tourist and researcher visited island in the Auckland Island group, so it is encouraging that the breeding population there has clearly expanded significantly compared to the only previous comprehensive survey, when just two Northern giant petrel chicks were recorded on the island (Taylor 1988). However, given Northern giant petrels are prone to human disturbance, future monitoring of the Enderby Island Northern giant petrel breeding population is important.

The discovery of breeding Northern giant petrels on the mainland was surprising. We assumed the species would be excluded due to depredation by pigs, as White-capped albatrosses are from pig-accessible areas at Southwest Cape (Peat 2003). The single live chick and single dead, recently killed chick found at Crozier Point on the main island, with pig faeces, prints and rooting throughout the area, confirms that the main Auckland Island is not viable habitat for Northern giant petrels, nor for many native seabird species.

Recommendations

This work illustrates the importance of long term monitoring of seabird populations on remote islands. We recommend future monitoring of the Auckland Island Northern giant petrel breeding population. Ideally island-wide surveys would be repeated regularly, for example every three to five years.

Enderby Island would be the ideal location for regular, annual counts of breeding birds. This already happens for Southern royal albatrosses *Diomedea epomophora* and could perhaps become a part of that survey, depending on the timing. Disturbance from tourism may negatively impact upon breeding Northern giant petrels on Enderby Island, and should be monitored given that the island supports such a large proportion of the Auckland Island Northern giant petrel breeding population. To gain insight into inter-annual changes in the number and spatial distribution of the breeding population on Enderby Island, Chris Muller aims to map and count nests there for a further two years.

Because there are no trend data for Northern giant petrels anywhere in the NZ region, we strongly advise that the Antipodes and Campbell Islands populations are re-counted in the near future and the results related to previous counts (Wiltshire and Scofield 2000; Wiltshire and Hamilton 2003).

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References

Bartle JA, Paulin CD 1986. Bird observations, Auckland Islands, December 1976. Pp 51-61 in Penniket A, Garrick A, Breese E. Preliminary reports of expeditions to the Auckland Islands Nature Reserve 1973-1984. Department of Lands and Survey, Wellington.

ACAP 2009. ACAP Species assessments: Northern giant petrel *Macronectes halli*. Agreement on the Conservation of Albatrosses and Petrels. Available at: <http://www.acap.aq>, accessed 10 March 2016.

Bell BD 1975. Report on the birds of the Auckland Islands Expedition 1972-73. Pp 136-142 in Yaldwyn, J.C. editor, Preliminary Results of the Auckland Islands Expedition 1972-73. Department of Lands and Survey, Wellington.

BirdLife International. 2012. *Macronectes halli*. The IUCN Red List of Threatened Species 2012. www.iucnredlist.org Accessed on March 12, 2016.

Brooke M 2004. Albatrosses and Petrels Across the World. Oxford University Press, Oxford.

Buckingham R, Elliot G, Walker K 1991. Bird and Mammal Observations on Adams Island and Southern Auckland Island 1989. Department of Conservation Science and Research Internal Report No. 105, Department of Conservation, Wellington.

Cooper J, Brooke M, Burger AE, Crawford RJM, Hunter S, Williams AJ 2001. Aspects of the breeding biology of the Northern giant petrel (*Macronectes halli*) and the Southern giant petrel (*M giganteus*) at sub-Antarctic Marion Island. *International Journal of Ornithology* 4: 53-68.

Dilley BJ, Davies D, Connan MI, Cooper J, Villiers M, Swart L, Vandenabeele S, Ropert-Coudert Y, Ryan PG 2013. Giant petrels as predators of albatross chicks. *Polar Biology* 36:761–766.

Falla RA, Taylor RH, Black C 1979. Survey of Dundas Island, Auckland Islands, with particular reference to Hooker's sea lion (*Phocarctos hookeri*), New Zealand. *Journal of Zoology* 6:347-355.

González-Solís J, Croxall JP, Wood AG 2000a. Sexual dimorphism and sexual segregation in foraging strategies of Northern giant petrels, *Macronectes halli*, during incubation. *Oikos*

González-Solís J, Croxall, JP, and Wood AG 2000b. Foraging partitioning between giant petrels *Macronectes* spp. and its relationship with breeding population changes at Bird Island, South Georgia. *Marine Ecology-Progress Series* 204: 279-288.

Heather B, Robertson H 2015. *The Field Guide to the Birds of New Zealand*. Penguin, Auckland.

Hunt G 2014. Macquarie Island is declared officially pest-free. <http://www.environment.gov.au/minister/hunt/2014/mr20140407.html>. Accessed 11 February 2015.

Hunter S, de L Brooke M 1992. The diet of giant petrels *Macronectes* spp at Marion Island, Southern Indian Ocean. *Colonial Waterbirds* 15: 56-65.

Hunter S 1984. Breeding biology and population dynamics of giant petrels *Macronectes* at South Georgia (Aves: Procellariiformes). *Journal of Zoology (London)* 203: 441-460.

Jenkins J 1981. Dundas Island, Auckland Islands. *Notornis* 28: 139-140.

Marchant S, Higgins PJ 1990. *Handbook of Australian, New Zealand & Antarctic Birds*. Vol. 1: Ratites to Petrels. Oxford University Press, Melbourne.

Moore PJ, McClelland PJ 1991. Notes on birds of the Auckland Islands, November – December 1989. Department of Conservation Science and Research Internal Report No. 93, Department of Conservation, Wellington.

Parker G, Brickle P, Crofts S, Pompert J, Wolfaardt A 2013. Research into undetected seabird mortality in a demersal trawl fishery: Agreement on the Conservation of Albatrosses and Petrels (ACAP). Seabird Bycatch Working Group 5. Document 07. www.acap.aq.

Parks and Wildlife Service 2014. Evaluation Report: Macquarie Island Pest Eradication Project, August 2014, Department of Primary Industries, Parks, Water and Environment. Hobart Tasmania.

Patterson DL, Woehler EJ, Croxall JP, Cooper J, Poncet S, Peter HU, Hunter S, Fraser WR 2008 Breeding distribution and population status of the Northern giant petrel *Macronectes halli* and the Southern giant petrel *M. giganteus*. *Marine Ornithology* 36:115-124

Peat N 2003. Subantarctic New Zealand. A Rare Heritage. Department of Conservation, Wellington.

Robertson H.A, Dowding J.E, Elliott GP, Hitchmough RA, Miskelly CM,; O'Donnell CFJ Powlesland RG, Sagar PM, Scofield RP, Taylor GA 2013. Conservation status of New Zealand birds, 2012. *New Zealand Threat Classification Series* 4. Department of Conservation, Wellington. 22 p.

Robinson SA, Copson GR 2014. Eradication of cats (*Felis catus*) from subantarctic Macquarie Island. *Ecological Management and Restoration* 15:34-40

Robertson C, Sawyer S 1994. Albatross research on (Motuhara) Forty-Fours Islands: 6-15 December 1993. *Conservation Advisory Science Notes* DOC. 70. Wellington.

Ryan PJ, Cooper J, Dyer B., Underhill L Crawford R 2003. Counts of surface-nesting seabirds breeding at sub-Antarctic Prince Edward Island, summer 2001/02. *African Journal of Marine Science* 25: 441-451.

Ryan PJ, Sommer E, Breytenbach E 2008. Giant petrels *Macronectes* hunting Northern Rockhopper Penguins *Eudyptes moseleyi* at sea. *Ardea* 96: 129-134.

Ryan PG, Boix-Hinzen C 1999. Consistent male-biased seabird mortality in the Patagonian toothfish longline fishery. *The Auk* 116: 851-854.

Ryan PG, Jones MGW, Dyer BM, Upfold L, Crawford RJM 2009. Recent population estimates and trends in numbers of albatrosses and giant petrels breeding at the sub-Antarctic Prince Edward Islands. *African Journal of Marine Science* 31:3, 409-417

Shirihai H 2007. *A Complete Guide to Antarctic Wildlife*. A and C Black. London.

Szabo MJ 2013. Northern giant petrel. In Miskelly, CM (ed.) *New Zealand Birds Online*. www.nzbirdsonline.org.nz

Taylor GA 1988. Report to the Department of Conservation on an expedition to the Auckland Islands National Reserve, February 1988. Department of Conservation, Auckland.

Taylor GA 2000. Action Plan for Seabird Conservation in New Zealand. Part B: Non-Threatened Seabirds. Threatened Species Occasional Publication No. 17. Biodiversity Recovery Unit. Department of Conservation, Wellington.

Taylor RH 1971. Influence of Man on Vegetation and Wildlife of Enderby and Rose Islands. *New Zealand Journal of Botany*. Volume 9, Number 2, 225 – 268.

Voisin JF 1988. Breeding biology of the Northern giant petrel *Macronectes halli* and the Southern giant petrel *M. giganteus* at Ile de la Possession, Iles Crozet, 1966-1980. *Cormorant* 16: 65-97.

Weimerskirch H, Zotier R, Jouventin P 1989. The avifauna of the Kerguelen Islands. *Emu* 89: 15-29.

Wiltshire A, Hamilton S 2003. Population estimate for Northern giant petrels (*Macronectes halli*) on Antipodes Island, New Zealand. *Notornis* 50:128-132.

Wiltshire AJ, Scofield RP 2000. Population estimate of breeding Northern giant petrels *Macronectes halli* on Campbell Island, New Zealand. *Emu* 100:186-191.

Appendix 1. A brief description of each island surveyed and planar map area from GIS

Enderby Island (695 h)

More breeding Northern giant petrels were on Enderby Island than expected. Taylor (1988) conducted a comprehensive survey of the island and counted just two chicks. The few other records we could find suggested much smaller numbers than the 96 large chicks recorded in this survey (Moore and McClelland 1989; Bell in Yaldwyn 1975). Enderby may be the location for almost half of the breeding population due to factors such as an abundance of resources available during the sea lion breeding season, the comparatively sheltered habitat available and a greater availability of open nesting habitat as a result of land clearing and historic rabbit and cattle modification to the flora.

Rose Island (80 h)

Breeding Northern giant petrels were reported from Rose Island in 1944 and 1966, the only previous count was 28 chicks in 1989 (Moore and McClelland 1989). Despite this, we recorded no nests and no loafing adults during a seven hour survey of the island in what appeared to be very good breeding habitat.

Friday Island (1.6 h)

Members of the sea lion team reported seeing breeding Northern giant petrels on Friday Island in previous years (S. Childerhouse pers. comm.). We did not detect any birds during a survey of the very small island.

Shoe Island (0.4 h)

Shoe was surveyed but no nests found. The small island offers very little breeding habitat that appears suitable for Northern giant petrels.

Ocean Island (12 h)

The south west end of Ocean Island provided very good habitat for nesting Northern giant petrels. Eighteen chicks were counted, the same number of chicks as recorded here in the only previous count, in 1989 (Moore and McClelland 1989).

Ewing Island (58 h)

We recorded just eight Northern giant petrel chicks on Ewing Island. In 1989 30 were counted; 25 chicks amongst herbs on the south-west point and five on the south-east point (Moore and McClelland 1989). The island is almost completely dominated by the invasive tree *Olearia lyallii*, which forms a thick vegetative tangle not suitable to Northern giant petrel nesting.

French's Island (1.8 h)

No Northern giant petrel breeding has previously been recorded here. Adults were clearly visible flying over the island and Crozier Point on the mainland opposite. Despite the small size of the island, 17 nests were located in the southwest corner.

Crozier Point, Auckland Island

We observed adults displaying in flight above Crozier Point so investigated the mainland site for possible breeding activity. No breeding has previously been recorded here. A recently depredated, large, Northern giant petrel chick was found beside a single live chick. Pig prints, rooting and faeces were abundant in the area.

Yule and Green Islands (1.6 h and 3.0 h)

Both of these islands are very low and offer no suitable nesting habitat for Northern giant petrels so landings were not considered necessary.

Dundas Island (4.9 h)

Breeding Northern giant petrels on Dundas were recorded in four of five visits between 1943 and 2015 (Jenkins 1981; Atkinson 1986; Falla et. al. 1979). The single year when no breeding was recorded was 1978, despite having been recorded five years prior in 1972/73. Previous records don't state exactly how many chicks were present. Thirty two chicks were counted in January 2016. As with Enderby it is possible the presence of breeding NZ sea lions is a reason a comparatively large population of Northern giant petrels breeds there.

Adams Island (9,700 h)

Breeding has been recorded from three locations on Adams Island; Fairchilds Garden, south of Chapmans Pinnacle and at Grafton Ridge (Turbott 2002; Buckingham et al. 1991; K. Walker pers.comm.). Of the three sites Fairchilds Garden has consistently had breeding Northern giant petrels and the other two sites breeding has been recorded on just one occasion. We recorded no breeding birds south of Chapman's Pinnacle and were unable to survey Grafton ridge, where breeding was reported in 1991 (6 chicks) but not in 2004 (K. Walker and J. Kemp pers.comm.). Records suggest Fairchilds Garden has been a consistently small population, but in 2004 35 chicks were counted there, three to six times the number of chicks counted in the other six occasions 1978 – 2015 (J. Kemp pers.comm.). We counted five chicks in 2013, and six in both January 2015 and December 2015.

Monumental Island (4.0 h)

Monumental Island was visited in January 2015 and no breeding Northern giant petrels were recorded.

Figure of Eight Island (5.3 h)

Sea-lion researchers have visited Figure of eight Island and never recorded breeding Northern giant petrels (S. Childerhouse pers.comm.).

Disappointment Island (284 h)

Breeding Northern giant petrels have been recorded from Disappointment Island in four visits 1972 – 2015. The 1993, 2015 and 2016 count data of 44, 53 and 38 chicks, respectively, may suggest a stable population.