White-chinned petrel distribution, abundance and connectivity: NZ populations and their global context

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Summary

The white-chinned petrel *Procellaria aequinoctialis* is one of the most frequently observed seabird species captured in fisheries bycatch, yet some populations remain virtually unstudied. In the New Zealand region, the priority programmes to fill key information gaps included surveying, tracking and collecting demographic data from white-chinned petrels in the Auckland Islands. Survey of the Campbell Island population and clarification of taxonomic uncertainty in the New Zealand region were secondary aims. The scope of this report is to summarise research findings, with focus on New Zealand populations of white-chinned petrels.

An estimated 186,000 (95% CI: 131,000–248,000) white-chinned petrel pairs breed in the Auckland Islands, and the Campbell Island group supports around 22,000 (15,000–29,000) breeding pairs. The New Zealand region supports almost a third of white-chinned petrels globally, but population trends remain unknown. We establish population baselines that can be repeated for trend estimation.

A tracking programme in the Auckland Islands has retrieved 40 geolocators from white-chinned petrels, which were analysed together with tracking data from all major island populations. NZ populations do not overlap at sea with populations from South Atlantic or Indian Ocean islands. Antipodes and Auckland populations have some marine areas of overlap, but also have large areas specific to birds from a single island. Global density estimates for white-chinned petrels show key global density hotspots (off South America, New Zealand, and southern Africa). A study was initiated to collect demographic data from white-chinned petrels at Adams Island, Auckland Islands. Four years of data have since been collected.

Genomic data revealed genetic structure in white-chinned petrels at very fine scale (among islands) and at broad oceanic scales (between Atlantic and Indian Ocean regions) that was not detected previously. Three ocean-basin scale evolutionarily significant units, ESUs, were identified. The NZ ESU contains Antipodes, Auckland and Campbell island populations. Some NZ island populations are sufficiently unique from others in the region to link mortality in a specific fishery to a given island.

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Introduction

White-chinned petrels *Procellaria aequinoctialis* breed on islands around the Southern Ocean and remain a major component of commercial fisheries bycatch throughout their range. In the Pacific sector, they breed on the subantarctic Auckland, Antipodes and Campbell island groups, but very little is known about any aspect of these white-chinned petrel populations.

Priority gaps identified for this species included survey, tracking and collecting demographic data from white-chinned petrel s at the Auckland Islands (ACAP 2013). Census guidelines for the species were also identified as a priority. Regional prioritisation further highlighted the need for population data from Campbell Island (medium priority), and to revisit the taxonomic relationships among white-chinned petrel populations in the New Zealand region (Croxall and Wilson 2012; Wilson and Waugh 2013).

A research programme to fill these key information gaps was developed in 2013–14 by the University of Otago, in collaboration with New Zealand's National Institute of Water and Atmospheric Research (NIWA) and the NZ Department of Conservation's Conservation Services Programme (DOC CSP).

Three studies have since been completed that address key gaps in white-chinned petrel population data, two studies on the genetic relationships among populations have been finalised, and a tracking study is complete. Census guidelines for *Procellaria* petrels have been developed, and demographic studies were initiated and are in progress.

This work is detailed in a thesis which investigates global white-chinned petrel questions (Rexer-Huber 2017). The scope of this report is to summarise research findings, with focus on New Zealand populations of white-chinned petrels.

Population size estimates for NZ islands

Summary of methods

Robust population size estimates for white-chinned petrels were obtained for the Auckland Island and Campbell Island groups. Eleven islands were included. Burrow numbers were sampled widely to capture spatial variability (33–241 randomised sampling sites per island) and minimise variance in the final estimate (Parker and Rexer-Huber 2015). In brief, estimated burrow numbers accounted for burrow detection rates, and occupancy rates were estimated to correct burrow numbers for the proportion containing a breeding pair. For method details, please see Rexer-Huber (2017).

Key population size findings

In the Auckland Islands, most white-chinned petrels breed on Disappointment Island (155,500 pairs, 95% CI: 125,600–192,500 in January 2015, during mid incubation) (Rexer-Huber et al. 2017). White-chinned petrel breeding sites on Adams Island are much more dispersed (Fig. 1). Adams Island supported 28,300 (10,400–44,800) white-chinned petrel pairs in December 2015 (early incubation). Monumental Island, off the northwestern tip of Adams Island (Fig. 1) had an estimated 60 pairs of white-chinned petrels breeding, and Ewing Island (Port Ross) supported an estimated 30 breeding pairs. White-chinned petrels were not found on other islands in the Port Ross area, with extensive survey of Rose, Friday, Shoe, Ocean, French's, Yule and Green Islands. Taken together, these estimates suggest that the Auckland Islands supported a breeding population of 184,000 (136,000–237,000) white-chinned petrels in 2015-16 (Rexer-Huber 2017).

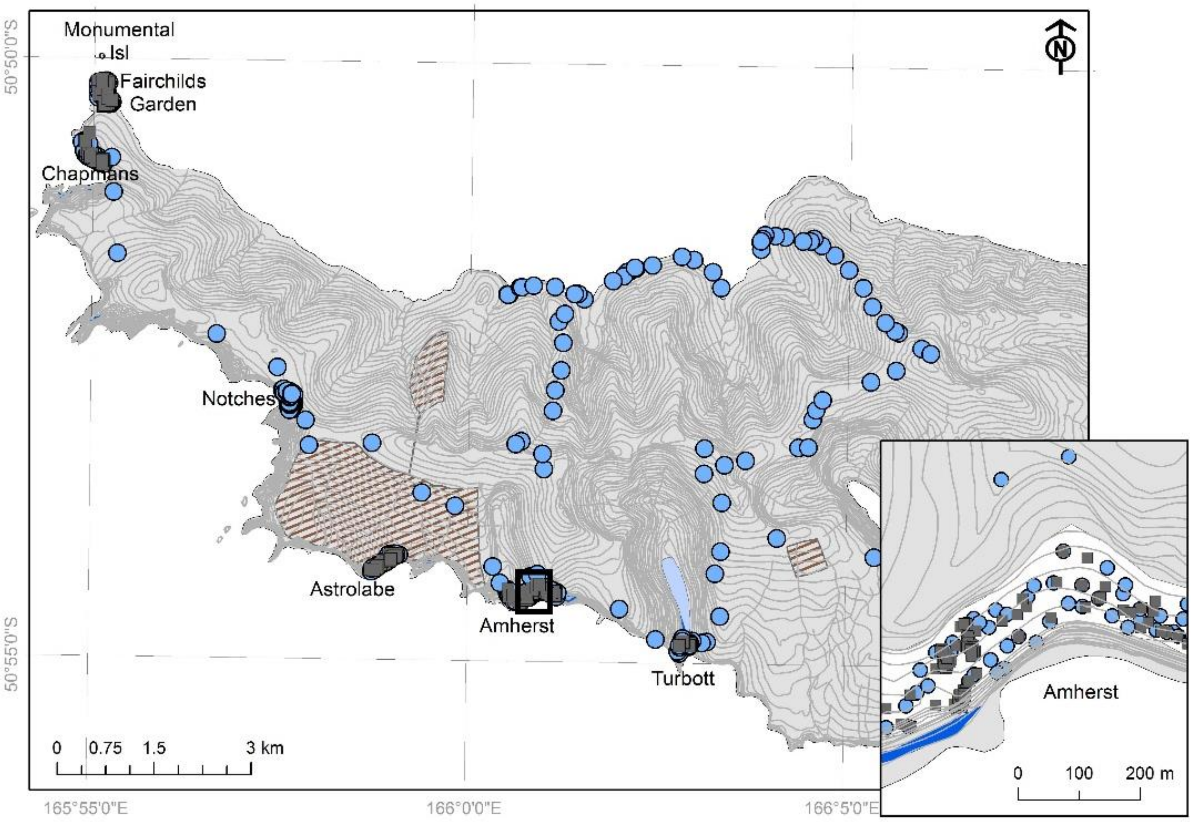

Figure 1. White-chinned petrel burrow distribution on Adams Island, Auckland Islands. White-chinned petrel burrows (grey squares) are shown relative to sampling effort (burrow sampling plots, blue circles) and search effort (exhaustive search blocks, brown hatched polygons). Inset: burrow distribution at the Amherst shelf site, showing the extent of sampled habitat (white polygon) and of unsampled habitat (dark blue polygon).

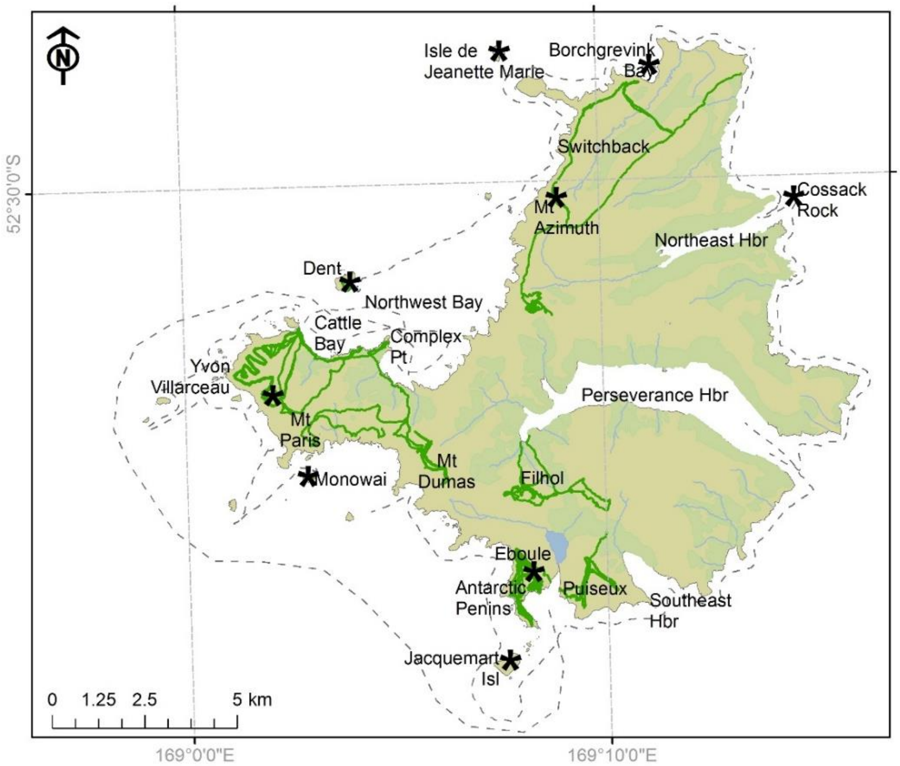

Figure 2. White-chinned petrel breeding sites (black stars) in the Campbell Island group, indicating survey transects (solid green lines) and boat-based coastal surveys (thin dashed grey lines).

At Campbell Island, most white-chinned petrels breed on Monowai Island (estimated 8,100 breeding pairs, 95% CI: 5,800–10,300) and Dent Island (8,800 breeding pairs, 5,300–12,300) (Fig. 2) (Rexer-Huber 2017). Monowai Island supports a strikingly high density of white-chinned petrels at 3,877±541 burrows/ha (mean±SE; 33 sampling plots). By comparison, nearby Dent Island has 1,150±228 burrows/ha (60 plots). On the main Campbell Island, white-chinned petrels were found in three different areas on main Campbell (Fig. 2) (Rexer-Huber 2017). Forty-four burrows were counted, but an exhaustive count was not possible so an unknown proportion of burrows will have been missed.

Boat-based surveys were conducted around Campbell Island to locate other possible breeding colonies (54 nautical miles of coastline within 0.5–2.5 nm of the shore, 19–28 January during late incubation) (Fig. 2). White-chinned petrel burrows were documented on three islands: Isle de Jeanette Marie, Cossack Rock, and an unnamed islet in Borchgrevink Bay (Fig. 2). Jacquemart Island is inaccessible from a boat and habitat is ~ 200 m above sea-level so white-chinned petrel presence could not be confirmed, but they have been recorded breeding there (Taylor 2000). The number of breeding pairs on these unsampled islands was estimated coarsely using habitat areas estimated from photographs, topographic maps and satellite images; mean burrow density from Monowai and Dent; and mean burrow corrections from the Auckland Isl in the same breeding season. For detail please see Rexer-Huber (2017). An estimated 600 (95% CI: 450–750) white-chinned petrel pairs breed on Isle de Jeanette Marie, 240 (200–300) on Cossack Rock, 50 (40–70) on the Borchgrevink Bay islet. Assuming white-chinned petrels have persisted on Jacquemart Island, a further 4,100 (3,000–5,100) pairs may breed on Jacquemart Island. Taken together, the Campbell Island group supports ~ 22,000 (15,000–29,000) breeding pairs of white-chinned petrels (Rexer-Huber 2017).

The Auckland Island group has an estimated 186,000 (95% CI: 136,000–237,000) white-chinned petrel breeding pairs, and the breeding population of the Campbell group is estimated ~ 22,000 (15,000–29,000) pairs (Rexer-Huber 2017). The Antipodes Island breeding population may be between 59,000 and 91,000 pairs (summary figures from (Sommer et al. 2010; Sommer et al. 2011). Taken together, NZ subantarctic islands support an estimated 280,000 (210,000–357,000) breeding white-chinned petrels. The region supports almost a third of white-chinned petrels globally, substantially more than suspected.

Estimates have been incorporated into global and regional updates of white-chinned petrel conservation status (BirdLife International 2017; Robertson et al. 2017). The NZ regional threat status was recently changed from At Risk-Declining to Not Threatened (stable or increasing) (Robertson et al. 2013; Robertson et al. 2017). This acknowledges that white-chinned petrels are abundant, but involves the assumption that trends are stable or increasing. Since trends remain entirely unknown (with no repeat estimates available for any site), the precautionary principle would suggest that the NZ populations should continue to be treated as At Risk until trend estimates are available. This work provides repeatable baselines to build on for future trend calculations. Estimates of the Antipodes population should be repeated, and the Campbell and Auckland populations revisited in 5–10 years (between 2021 and 2026).

Global distribution patterns of white-chinned petrels

Summary of tracking methods

Tracking data from all major island populations (except Campbell Island) were analysed together, giving a global picture of the at-sea distribution of adult white-chinned petrels. The movements of 150 adult petrels (9–33 petrels per island group, including 33 from Adams in the Auckland Islands) were tracked for an average of 369 days with light-level geolocation GLS loggers (Table 1).

Methods are detailed in Rexer-Huber (2017). In brief, positions were validated and filtered to exclude locations with light-level interference in the data file, proximity to equinoxes, or unrealistic flight speeds. Validated positions, accurate to ~ 190 km (Phillips et al. 2004), were pooled by population. Key stages in the annual cycle were defined as pre-lay 1 October–30 November; breeding 1 December–15 April; and nonbreeding or wintering 16 April–30 September (Jouventin et al. 1985; Hall 1987; Phillips et al. 2006; Perón et al. 2010).

Table 1. Tracking of adult white-chinned petrels from seven island populations by geolocator (GLS), showing tracking statistics, timing that breeding starts, and home range areas at different times of year. Breeding islands are MAR Marion; CRZ Crozet; KER Kerguelen; AKL Auckland; ANT Antipodes; FI Falkland; SG South Georgia.

						home range area (million km²) [b]		
island [source]	retrieved (deployed)	n final [a]	tracking period	mean d tracked	validated locations	pre-lay	breed	nonbreed
MAR [1]	12 (21)	12	2009-13	870	14,127	1.50	2.25	1.38
CRZ [2]	14 (20)	10	2007-08	355	3,725	4.02	3.77	1.12
KER [3]	27 (30)	13	2006-08	337	4,707	5.16	2.77	1.25
AKL [4]	40 (62)	33	2013-15	289	11,401	4.30	3.85	1.92
ANT [5]	30 (34)	22	2008-10	329	8,126	3.69	4.32	1.43
FI [6]	15 (27)	14	2014-15	340	6,075	1.11	1.07	2.14
SG [7]	10 (15)	9	2013	250	2,282	2.76	3.12	1.34
Overall	150 (209)	113		369	50,443	3.14	2.81	1.52

[a] *n final* is the number of individuals for which usable data files were available

[b] *home range* is taken as the area within the 50% kernel contour

Data *source*: [1] P. Ryan unpub. data; [2] H. Weimerskirch; published in Delord et al. (2010); [3] H. Weimerskirch, published in Perón et al. (2010); [4] K. Rexer-Huber this study; [5] D. Thompson unpub. data; [6] P. Catry and A. Stanworth this study; [7] R. Phillips this study

Key foraging areas were identified for each population at each annual stage via kernel utilization distributions (kernel UD) following Calenge (2006), at three different levels of utilisation: 30% kernel contour (core areas, high intensity of use), 50% (home range, intermediate intensity of use) and 70% (almost entire range extent). Overlap among populations at sea was quantified using the UD overlap index, UDOI (Fieberg and Kochanny 2005). Range areas were calculated in an equal-area Mollweide projection. Global density patterns (adult white-chinned petrels, from any population, with positions weighted by population size and sampling effort) were also calculated from pooled data at 2° grid square resolution (customised from unpublished R script by R. Ramos 2016). For detail of analyses, please see Rexer-Huber (2017).

Key petrel distribution findings

In the pre-laying period October-November, white-chinned petrel adults foraged mainly in temperate waters between latitudes ~ 20 °S and ~ 60°S (Fig 3A). There was substantial space sharing between Auckland and Antipodes populations' home ranges (50% contour UDOI 0.09), but very little of their core foraging areas are shared (30% contour 0.008) (red and blue polygons, Fig. 3A) (Rexer-Huber 2017). While incubating and raising a chick, however, Auckland and Antipodes white-chinned petrel populations show some space-use sharing in the core areas (UDOI 0.04, Fig. 3B), primarily off the east coast of the NZ South Island.

Adult white-chinned petrels from the Auckland Islands wintered furthest north, mainly off Peru but ranging into Ecuadorean waters to the north and Chilean waters in the south (Fig. 3C). Antipodes adults wintered off the northern half of Chile (Fig. 3C). Antipodes and Auckland adults overlap in an area off northern Chile (UDOI 0.11) (Fig. 3C), and with white-chinned petrels from the Falkland Islands in the Humboldt upwelling region between 25° and 40°S (Rexer-Huber 2017). Although most core wintering areas mostly fell within national EEZs, adults from the Auckland Islands were among those which had more than a third of the core area in international waters (Fig. 3C) (Rexer-Huber 2017).

Year-round, there are important areas where only adults from a given island population occur at a given time of year (Fig. 3). For example, adult white-chinned petrels in the Peruvian EEZ May–September are highly likely to be from the Auckland Islands (Rexer-Huber 2017).

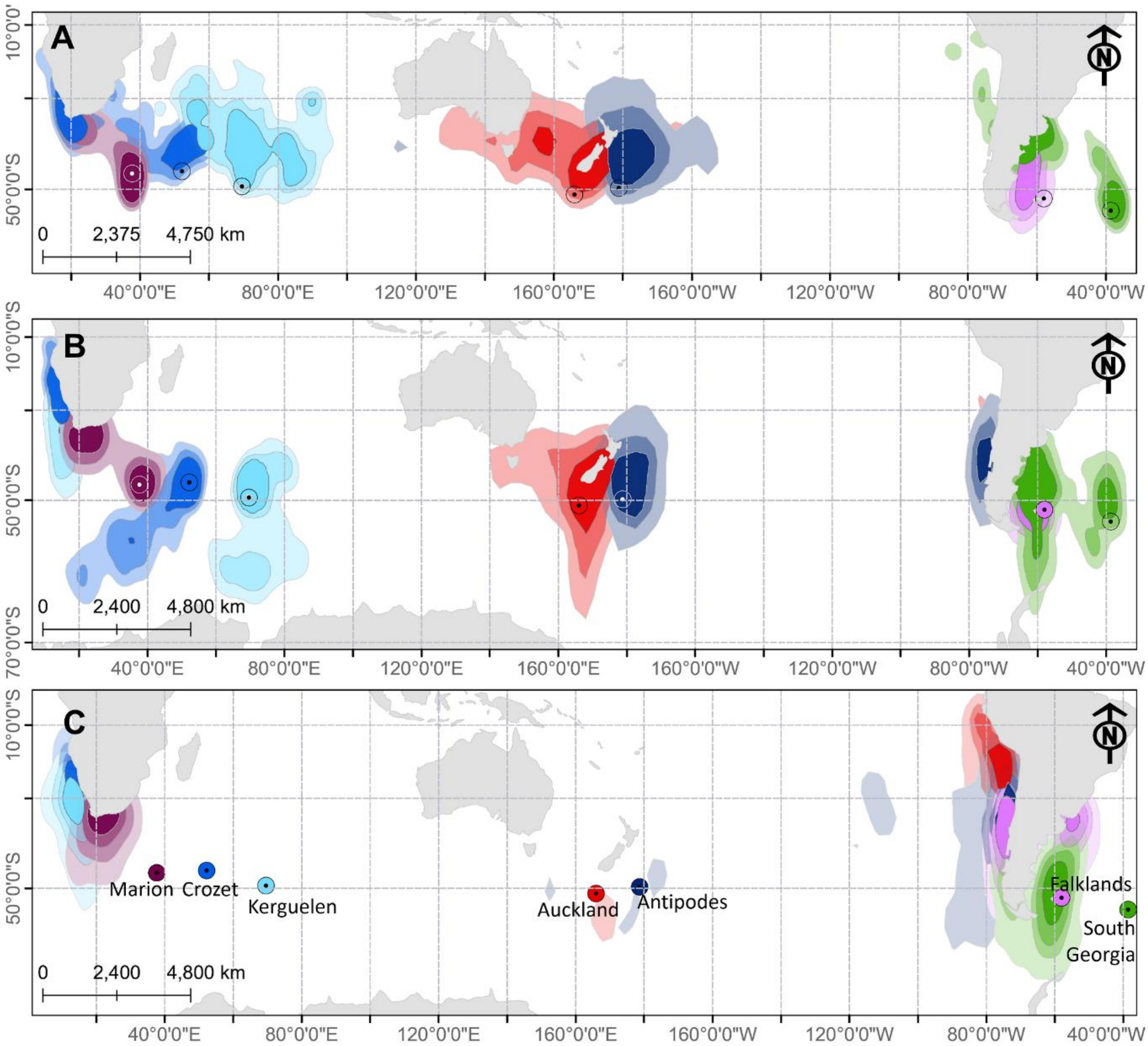

Figure 3. Global distributions of white-chinned petrel island populations over the annual cycle. Kernel contours for adults from each island population are shown during A pre-lay (October–November); B breeding (December–April); and C nonbreeding (May–September) stages. Kernel contours are coloured by breeding island (coloured circles named in C), and 30%, 50%, 70% and 90% kernel contours shown as progressively lighter shades. Kernel contours based on h=2°. Map projection mercator and datum WGS-1984.

Quantitative density estimates for white-chinned petrels show key global density hotspots. In October–November, white-chinned petrel adults reach numbers of 30,000–35,000 birds per 2° grid square in four general density hotspots (Fig. 4A), including areas off Australia and New Zealand (Great Australian Bight and in the western Tasman Sea, Chatham Rise, Bounty Plateau) (Fig. 4A) (Rexer-Huber 2017). During the breeding season December-April, areas in the NZ region with high white-chinned petrel densities are to the south and east of New Zealand (Auckland Escarpment, Campbell Plateau, Stewart-Snares Shelf, Chatham Rise) (Fig. 4B). Wintering hotspots are more diffuse; for example, small areas of high white-chinned petrel densities occur along South America's Pacific coast, from waters off Peru (running west off Nazca Ridge) and Chile (the Chile Rise region) down to Tierra del Fuego (Fig. 4C) (Rexer-Huber 2017). These global density patterns remain to be overlapped with fishing effort; the scale of 2° grid square was used to facilitate the comparison.

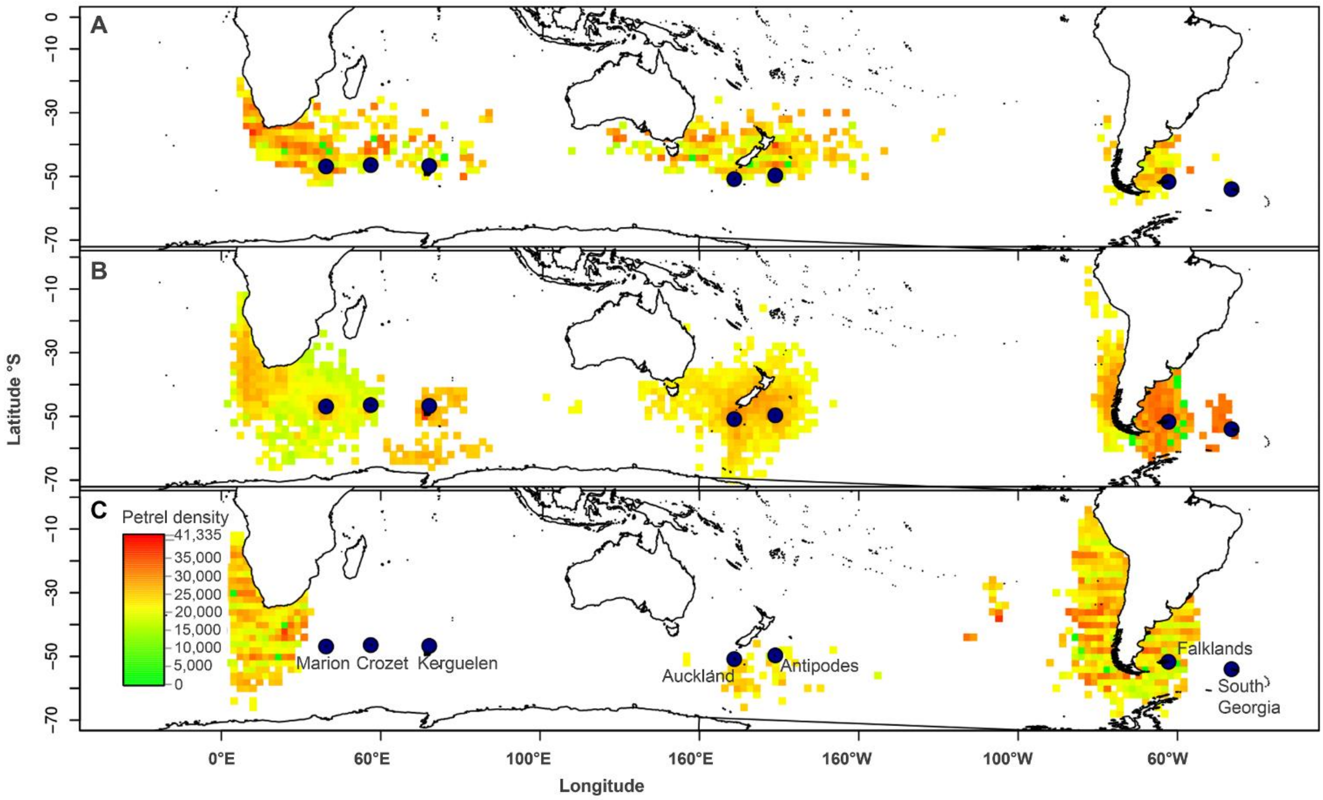

Figure 4. Density patterns of adult white-chinned petrels change during the year. Density is the number of adults from all populations in each 2° grid square, corrected for sampling effort and population size. Density is shown during A October–November (pre-lay); B December–April (breeding); and C May–September (nonbreeding). Breeding islands are shown as dark blue dots for reference, named in C.

Genetic differentiation within white-chinned petrels

Summary of methods

To define the scale of genetic conservation units within white-chinned petrels, we tested connectedness and differentiation within the white-chinned petrel metapopulation using genetic samples from every island population. High-resolution genomic data (60,709 genotyping-by-sequencing loci) were compared with data from widely-used mitochondrial genes (entire cytochrome b gene and the highly variable 1st domain of control region) (Rexer-Huber et al. 2017 in review).

Key findings

Genomic data revealed genetic structure in white-chinned petrels at very fine scale (among islands) and at broad oceanic scales (between Atlantic and Indian Ocean regions) (Rexer-Huber et al. 2017 in review) that was not detected in analyses of single genes (Techow et al. 2009; Rexer-Huber and Robertson 2015) (Fig. 5). This degree of detail yields comprehensive information that should provide more-convincing guidance for conservation priorities and management and policy action. In particular, genomic data confirm that the New Zealand region comprises a distinct white-chinned petrel evolutionarily significant unit (ESU), and show for the first time that South Atlantic and southern Indian Ocean white-chinned petrels separate into two distinct ESUs (Fig. 5) (Rexer-Huber et al. 2017 in review).

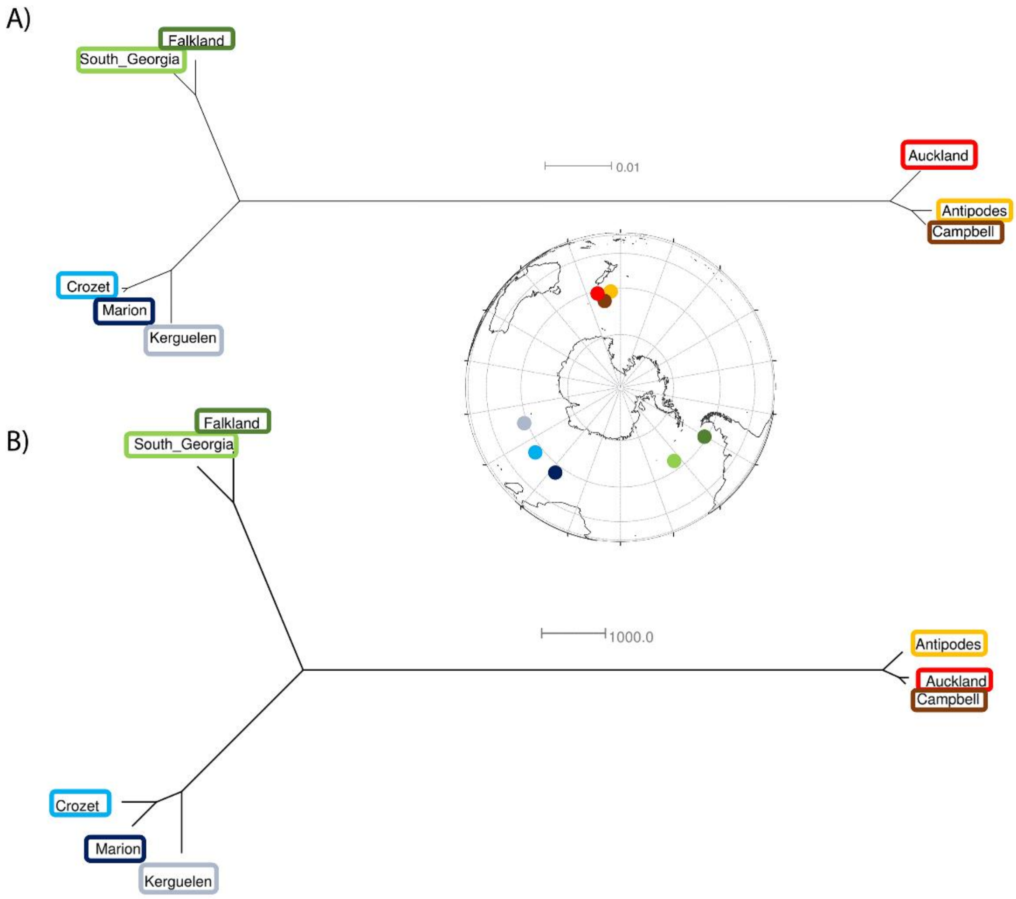

Figure 5. Population divergence A compared with geographic distance B in white-chinned petrels. Trees are UPGMA; population divergence is measured by F_{ST} from genomic data; and geographic distances are rhumb line distances in kilometres. Colours correspond to island colony location on map inset.

Within the New Zealand ESU, Auckland Island white-chinned petrels are genetically distinct, and Antipodes and Campbell Island populations group together, supporting findings of morphological differentiation between Auckland and Antipodes petrels (Fraser 2005; Mischler et al. 2015). Despite such local differences, it is the diversity of the New Zealand regional population as a whole—the NZ ESU—that must be maintained, because diversity within white-chinned petrels is greatest among the three ocean-basin level ESUs (NZ, South Atlantic and southern Indian Ocean) (Rexer-Huber et al. 2017 in review). In other words, reductions in numbers within any of the three ocean basins is expected to erode white-chinned petrel diversity, and slow the species' ability to respond to future changes.

Moving forward, island-level differences in genomic data show promise for development of tools to assign bycatch white-chinned petrels to island of origin, and is most promising for the New Zealand region (Rexer-Huber 2017). This would build on earlier efforts which could only assign bycatch birds to broad geographic region (New Zealand or Atlantic-Indian ocean regions) (Barquete 2012; Techow et al. 2016). More broadly, the large differences among white-chinned petrels from different ESUs (Fig. 5) will allow easy identification of bycatch in those areas where adult petrels from different ESUs overlap geographically (Rexer-Huber 2017). These opportunities require further testing and development.

Recommendations

Survey data from Antipodes need analysing fully. Estimated numbers of white-chinned petrels on Campbell are coarse; local burrow occupancy data and surveys of Jacquemart have greatest potential to improve accuracy. For population trend data at New Zealand islands, Auckland and Campbell white-chinned petrel estimates should be repeated (5–10 years). The Antipodes population needs re-survey in the next 1–2 years.

Tracking is needed for white-chinned petrels from Campbell (only island population with unknown range). Bycatch white-chinned petrels in areas used by only one population should be linked to island of origin; e.g. off Peru, in Tasman Sea. Petrel density data should be overlaid with fishing effort. Resightings at the Adams Island study colony should continue for demographic parameter estimates.

The potential to genetically assign bycatch white-chinned petrels to island of origin- needs testing and development, targeting bycatch petrels from areas where populations overlap.

For more detail, please see:

Rexer-Huber K (2017) White-chinned petrel distribution, abundance and connectivity have circumpolar conservation implications. http://hdl.handle.net/10523/7778. PhD thesis, University of Otago

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