Are grey petrels returning to Campbell Island? Survey and census 14 years after rodent eradication

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Abstract

Populations of grey petrels have declined due to both incidental capture in commercial fisheries and predation by introduced mammals at breeding sites. In the New Zealand region grey petrels breed only on Campbell and Antipodes islands. Rats were successfully eradicated from Campbell Island in 2001. To investigate if the grey petrel population had expanded since the rat eradication, we defined the population's spatial extent and produced the first quantitative population estimate on Campbell Island and surrounding islets. We found no clear increase in the number of grey petrels breeding on Campbell Island relative to a historic, non-quantitative population estimate. However, two of the four colonies we found are either recently established or previously went unidentified. We estimated 90 pairs of breeding grey petrels from the four colonies located. This underestimates the breeding population since work was conducted during the mid chick-rearing stage. There may be grey petrels breeding on the off-shore islands that we could not survey, but if so, the number there would not significantly increase the island-wide population estimate. The Campbell Island grey petrel breeding population remains small. Our study provides a baseline for future population estimates of grey petrels on Campbell Island.

Key words

Procellaria, grey petrels, rodent eradication, population estimate

Introduction

Seabirds are one of the most threatened bird groups in the world, with nearly half of all species known or suspected to be declining (Croxall et al. 2012). Grey petrels *Procellaria cinerea*, like many seabird species, have suffered population declines due to both incidental capture in commercial fisheries (Barbraud et al. 2009) and predation by introduced mammals at breeding sites (Newton and Fugler 1989; Zotier 1990; Schulz et al. 2005; Cuthbert et al. 2013). Grey petrels are a large, winter breeding burrowing seabird that breed on islands in the southern Indian, Atlantic and Pacific oceans and forage pelagically throughout the southern ocean, predominantly between 32° and 58°S (Brooke 2004; Torres et al. 2015). Grey petrels have been classed as Near Threatened on the IUCN Red List of Threatened Species since 2004 (BirdLife International 2012). The IUCN also note that further data are urgently needed to inform the threat status of grey petrels. Robust population estimates exist for only two of the nine islands at which grey petrels breed (ACAP 2009). Grey petrels are listed as a priority species in the international Agreement for the Conservation of Albatrosses and Petrels (ACAP 2009), and in New Zealand grey petrels are classified as Naturally Uncommon (Robertson et al. 2013).

Introduced mammals historically occurred in all nine island groups on which grey petrels breed (ACAP 2009). As a winter breeder, grey petrels are susceptible to high rates of predation from introduced mammalian predators because there are fewer food sources available to those predators at that time (Newton and Fugler 1989; Cuthbert and Hilton 2004). For example, cats *Felis catus* on Macquarie Island and Marion Island had a significant impact on grey petrels prior to their eradication, seemingly extirpating the species completely from Macquarie (Schulz et al. 2005) and severely reducing the population on Marion (Newton and Fugler 1989). On the main island in the Kerguelen Islands group, grey petrels are assumed to have been extirpated by the expansion of cats (Say et al. 2002). Norway rats *Rattus norvegicus* greatly limit grey petrel populations on Amsterdam and Gough Islands and ship / black rats *R. rattus* on Crozet (Jouventin et al. 1984; Angel and Cooper 2006). It appears that house mice *Mus musculus* are negatively affecting populations on Gough Island (Cuthbert et al. 2013). Grey petrels co-exist with mice on Antipodes Island (Taylor 2000), but it is unclear whether house mice depredate grey petrel eggs or chicks there (Imber et al. 2005). A mouse eradication is planned for Antipodes Island in the 2016 austral winter (DOC 2015).

The number of grey petrel breeding islands with populations of introduced predators has decreased in recent years from nine to seven. Norway rats were successfully eradicated from Campbell Island in 2001. Cats were eradicated from Macquarie in 2000 (Robinson and Copson 2014) and all other invasive mammals were declared eradicated in 2014 (Hunt 2014). Cats have been eradicated from Marion Island (Bester et al. 2002), but mice remain. The grey petrel population there shows no clear recovery since cat removal (Percy FitzPatrick Institute 2012). Although there is as yet no evidence of mice attacking grey petrels on Marion Island,

research is currently being conducted there (B. Dilley pers.com.). On Campbell Island, the status of grey petrels 14 years after the rat eradication is unknown.

In the Australasian region grey petrels breed on Antipodes, Campbell and Macquarie islands (Schofield and Stephenson 2013). Researchers have estimated the size of the Antipodes population on three occasions, with the most recent surveys producing similar estimates [~49,000 pairs (Sommer et al. 2010) and 53,000 (32,000–73,000) pairs (Bell et al. 2013)]. Antipodes Island is thought to support the largest grey petrel population in the world (ACAP 2009). On Macquarie Island the 2013 breeding season was the best since the small grey petrel population was rediscovered in 2000, after an absence of 100 years (Hunt 2014). It is noteworthy that grey petrels recolonised there despite the presence of ship rats. In 2012 workers recorded 152 active grey petrel burrows on Macquarie Island (Pyrke and Hunter 2012), and 183 burrows in 2013 (DPIPWE 2013). There are no quantitative data for the Campbell Island breeding population, but Taylor (2000) suggested the breeding population on main Campbell Island could be up to 100 pairs, almost completely located at Eboulé Peak.

In recent history, grey petrels have been known to breed in only two locations on Campbell Island; the north side of Eboulé Peak and on the upper slopes of Filhol Peak (Bailey and Sorenson 1962; Thorpe *in* Taylor 1985; Henderson 1994). Possible grey petrel burrows have been observed in other areas but not confirmed since then, for example on the Antarctic Peninsula (Torr *in* Taylor 1985) and Puiseux Peak (Charteris 1996). There may have been reports of grey petrel burrows from Courejolles Peninsula but the source of the records for that location is unknown (G. Taylor pers. com.). There are records of high-numbers of burrowing seabirds on the offshore islands surrounding Campbell that remained rat free, for example Dent, Monowai (formerly Lion), Jacquemart and Isle de Jeanette Marie. However the grey petrel population on these islands are reportedly small (Heather and Robertson 2015), but where this estimate originates is unclear.

The key rationale behind this work is that the grey petrel population may now be larger and occupy a greater area than before rats were eradicated in 2001. For the conservation management of grey petrels, it is important to quantify to what extent Campbell Island contributes to the New Zealand and global population. It is also of broader interest to investigate recovery rates of *Procellaria* petrels after a successful eradication of introduced predators.

This study aims to define the spatial extent of grey petrel colonies on Campbell Island and surrounding islets and to produce a quantitative estimate of the breeding population size.

Methods

Campbell Island is the southernmost of New Zealand's subantarctic islands, located at 52°33'S 169°09'E, c.700 km south of the New Zealand mainland. The total area of the island and islets is 11,400 ha and the highest point is the 569 m Mount Honey. The dominant vegetation on Campbell Island consists of *Poa litorosa*, *P. foliosa* and *Chionochloa antarctica* tussock grasslands, *Coprosma, Myrsine* and *Dracophyllum*-dominated scrub and herbfields at higher elevations.

We operated from a 15 metre yacht during two trips to Campbell Island, anchoring predominantly in Northwest Bay and Monument and Perseverance harbours. Research was conducted in July–August 2014 in the austral winter and continued in January 2015. Island wide near-shore boat based surveys for grey petrels were conducted as part of concurrent projects researching southern right whales *Eubalaena australis* and light-mantled sooty albatrosses *Phoebetria palpebrata* in winter and summer trips, respectively. We also surveyed for grey petrels around anchorages.

Grey petrels breed in colonies, so we first aimed to locate breeding colonies and count all burrows in the time available, 13 July–August 6 2014. This corresponds to the chick rearing phase, so early breeding failures were not accounted for (Wolfaardt and Phillips 2011). Nevertheless, grey petrel burrows on Campbell are conspicuous and at least a proportion of burrows from failed breeding attempts were still readily identified. We returned to Campbell Island in the austral summer 19–29 January 2015 and expanded our surveys for grey petrel colonies. While breeding birds are not present at this time of the year, the burrows remain conspicuous. The only potential confusion is with burrows of white-chinned petrels *Procellaria aequinoctialis*, which breed over summer. White-chinned petrel burrows are generally larger and wetter than grey petrel burrows (Bell et al. 2013), but we carried a burrowscope to confirm the species present.

Priority was placed on surveying the areas where grey petrels were recorded historically. We then expanded our surveys, firstly to surrounding areas with habitat features similar to known grey petrel habitat (primarily altitude, vegetation type and structure, and aspect). Secondly we surveyed possible 'overflow' areas; that is, habitat on the main island adjacent to offshore islands with high numbers of burrowing seabirds. We restricted these surveys to areas opposite islands that have remained rat free through Campbell's history (e.g. Jacquemart, Monowai and Dent islands) and which reportedly have large numbers of burrowing seabirds (Heather and Robertson 2015). Lastly, we surveyed Monowai and Dent islands.

Seventeen days were spent surveying and quantifying grey petrel burrow density on Campbell Island during winter 2014. Survey effort was focused in the southern portion of the island. The following summer a further six days were spent surveying for burrows. The summer surveys were in the southwest of the main island and around the main ridge and cliff

tops in the northwest of the island. Two offshore islands, Monowai (8 ha) and Dent (23 ha), were also surveyed in January. In all areas we sampled any accessible habitat.

In winter the available working days were restricted due to the short day length of the winter season, high winds limiting shore landings, and snow. Snow interrupted surveys, falling to sea level on 25 July, above 150 m above sea level (asl) on 1 August and again to sea level on 3 August. On all of these days snow increased travel times and reduced the ability to detect burrows and sign of grey petrel breeding activity. However the snow largely melted by midday so areas were able to be resurveyed on those afternoons.

Surveys for grey petrel burrows were conducted by one to two people walking line transects to locate breeding colonies within historical breeding areas. The 2 m transect width was scanned for any evidence or sign of grey petrel burrows. Evidence was considered any combination of the following: fresh digging or trampled vegetation indicating a potential concealed burrow entrance, conspicuous burrow entrances, seabird guano or feathers on the ground or vegetation, seabird corpses, and eggs or egg fragments that may have been expelled from a burrow. Only burrows extending beyond 400 mm (elbow depth) were included. As grey petrels are known to use natural cavities such as rock overhangs and caves we thoroughly inspected any of these during surveys. If any sign were noted we then thoroughly surveyed a one hectare area centred on the burrow to determine whether further burrows were present.

We pilot-tested two census techniques to estimate burrow numbers on the main island before settling on the most suitable technique. These methods were random transect sampling and exhaustive strip searches. For both random transect and strip-search methods, transects stopped at the high and low end of the slope when no further grey petrel burrows were detected on an entire transect. Random transect sampling to estimate burrow density was trialed on the south slope of Eboulé. However, no burrows were found on 20 replicate transects 10 m in length and 2 m wide, despite burrows being present in the area and at a similar density to the other three areas with grey petrel colonies. We then counted the number of burrows and the total area burrowed using exhaustive strip counts. These were conducted by one person walking strip transects spaced approximately 15–20 m apart running parallel across the slope. When walking lines the entire width until the next line was searched for burrows, making the effective transect width 7.5–10 m. To estimate a correction factor quantifying the number of burrows missed in strip transects, validation transects were conducted running perpendicular or at a 45° angle to the strip transects. All strip searches were conducted by G. Parker. Strip searches produced a useful burrow count estimate so this method was used in other areas.

Randomised transects were used to sample small islands like Monowai and Dent. Since replicate line transects would overlap in these small areas, we used spot point transects Spot points were distributed randomly over each island using a random numbers table and a

minimum separation of 20 m. At each point, all burrows within a 275 cm diameter plot were counted. At least half of a burrow had to occur within the sampling area for it to be counted.

We used hand-held GPS units (Garmin Map 62s and 60Csx) with topographical mapping software to record all line transect surveys and strip transects, the start and end or central point of randomised transects, and the location of all burrows detected. To obtain a randomised sub-sample of burrow contents, burrow occupancy was assessed for every third burrow found using an infrared burrowscope (Taupe, Sextant Technologies, New Zealand). All burrowscoping was conducted by G. Parker. For the purposes of this study, burrows with eggs and chicks were considered a breeding attempt and thus recorded as occupied. We also recorded when adults were present and whether they were with chicks, eggs or a second adult.

As grey petrels are diurnally active in flight around colonies (Bell 2002) and at sea (Zotier 1990) we also recorded any grey petrels observed whilst conducting survey transects, during coastal circumnavigation and at anchorages. Birds in flight over land, or rafts of birds offshore, could indicate a nearby colony.

Results

The total distance of line transect surveys was 219 km and exhaustive search coverage 124.5 ha (Table 1). Grey petrel burrows were found in four areas: the northeast and southeast slopes of Eboulé, the northern slopes of Filhol and the western slopes of Puiseux (Figure 1, Table 1).

Burrows were distributed between 100–280 m asl. Topographically, grey petrel burrows were more commonly found on small steep and well-draining spurs dominated by the tussock grass *Poa litorosa* and the fern *Polystichum vestitum*. The tussocks *Chionochloa antarctica* and *P. foliosa* interspersed with *Coprosma* spp. and *Myrsine divaricata* shrubs were common in the general altitudinal band associated with grey petrel areas.

Exhaustive strip searches were conducted in the colonies on the north and south side of Eboulé and Filhol (Figure 2 A–C). Although we had insufficient time for complete coverage of the fourth area, on the west side of Puiseux (Figure 2 D), exhaustive searches for burrows targeted the key altitudinal band where other grey petrel colonies occur.

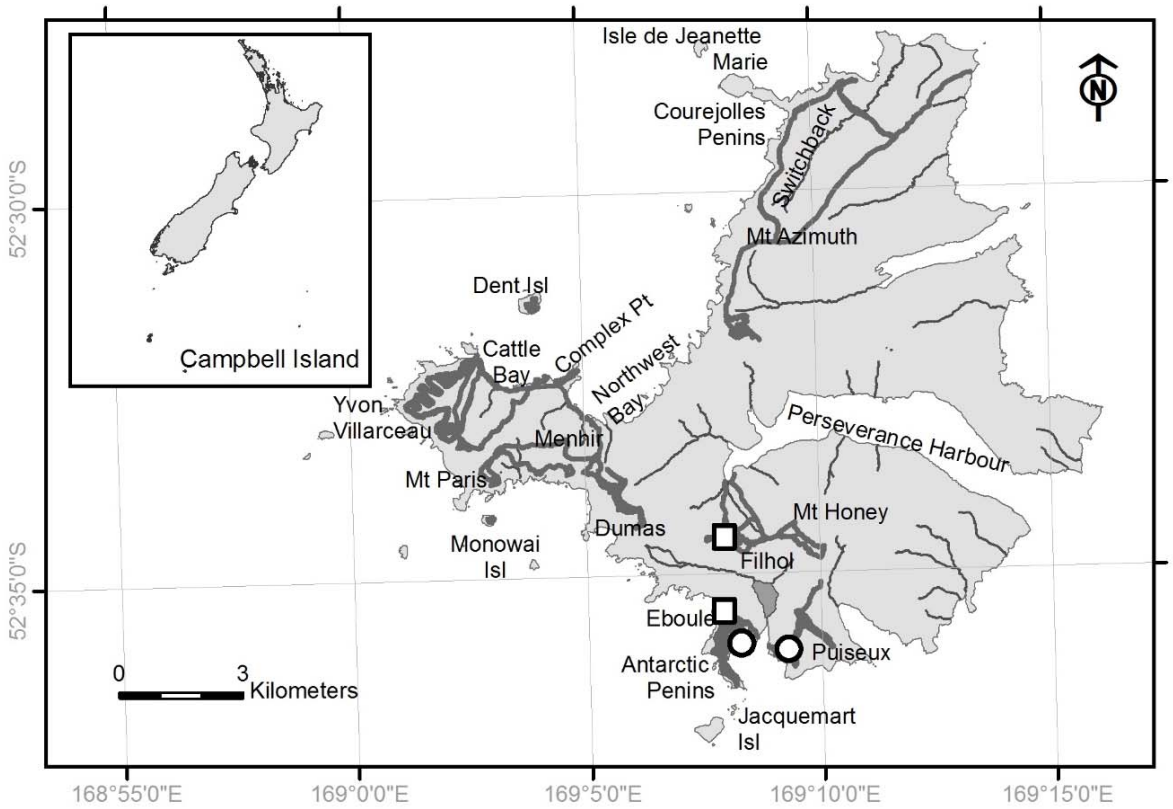

Figure 1. Grey petrel survey transects (bold lines) and colonies, Campbell Island, New Zealand. Squares represent historically-reported colonies that are still active, and circles represent colonies not previously reported.

A total of 149 burrows were found in four colony areas on Campbell Island (Table 1). Eboulé north contained the highest number and density of grey petrel burrows, with 59 burrows at a density of 3.49 burrows/ha. The mean grey petrel burrow density in burrowed areas was 2.37 burrows/ha (SD 0.94; 95% CI 1.45–3.30). Thirty-three spot-point transects were conducted on Monowai Island and 60 on Dent Island. No grey petrel burrows were found on either island (Table 1), although a large number of sooty shearwater *Puffinus griseus* (Dent) and white-chinned petrel (Dent and Monowai) burrows were recorded (G. Parker, unpublished data). Grey petrels were absent from all areas surveyed in the southwest and north of Campbell Island, despite substantial search effort in those areas (Figure 1; Table 1).

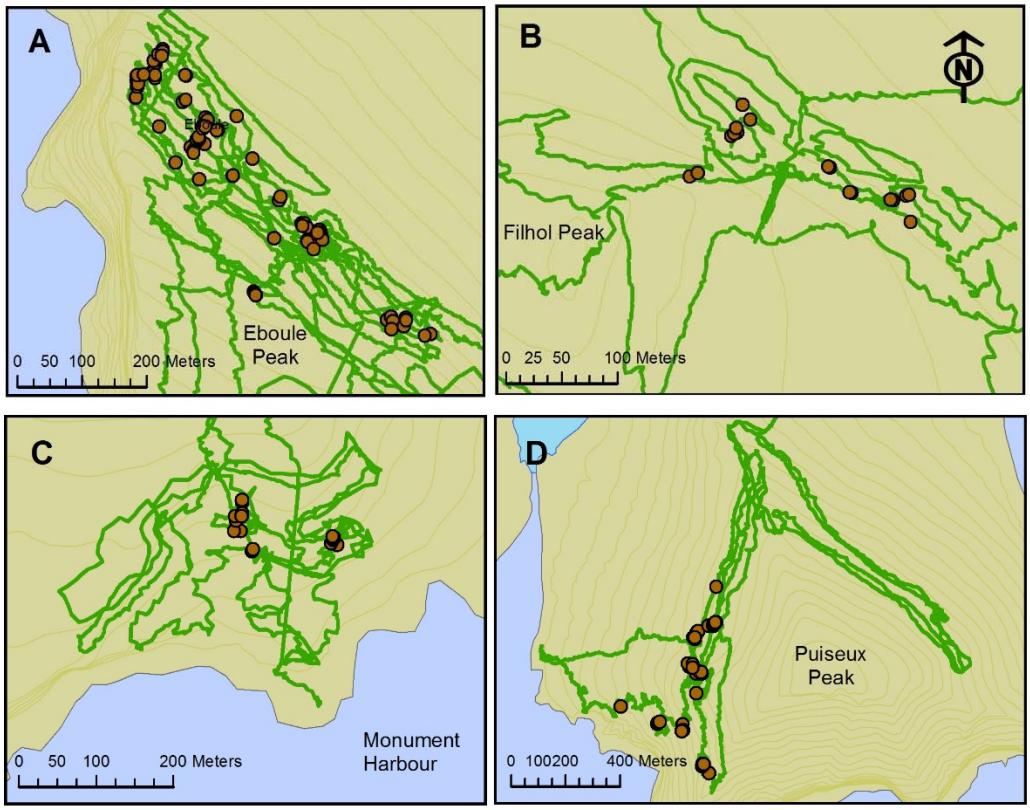

Figure 2. Grey petrel burrows (circles) detected during exhaustive strip searches (bold green lines) in the four colonies located during surveys on Campbell Island. A. Eboulé north, B. Filhol Peak, C. Eboulé south and D. Puiseux.

Validation transects searched a total of 1.3 km. At Eboulé north, one unrecorded burrow was detected during 713 m of validation transects; at Eboulé south, two burrows from 500 m of validation transects; and on Filhol, a single 112 m validation transect did not detect any previously unrecorded burrows. The correction factor, calculated as the number of burrows detected in validation transects divided by the number of burrows previously found (excluding Puiseux), is therefore +3%. This correction factor was applied to burrow numbers found to estimate the total number of burrows present (Table 1). Overall, 59% of burrows contained a breeding attempt (egg, broken egg or chick) and of those 48% had chicks only (Table 2). Chicks appeared to be a similar age; fully downy and approximately two-thirds the size of adults. Four burrows contained non-breeding adults; two with single birds and two with a pair.

Table 1. Grey petrel distribution and abundance on Campbell Island

Location	method	n burrows	area (ha)	length (km)	n point transects	burrows / ha
Eboulé north	exhaustive	59	16.9	-	-	3.5
Eboulé south	exhaustive	30	11.0	-	-	2.7
Filhol	exhaustive	17	13.0	-	-	1.3
Puiseux west [a, b]	exhaustive	43	21.2	-	-	2.0
Puiseux east [a]	exhaustive	0	26.3	-	-	0
Antarctic Peninsula	exhaustive	0	12.9	-	-	0
Cattle Bay – Complex Point	exhaustive	0	23.2	-	-	0
Mount Dumas	survey	0	-	12.2	-	0
Yvon Villarceau Peak – Mt Paris	survey	0	-	34.3	-	0
Switchback ridge – Mt Azimuth	survey	0	-	22.2	-	0
Monowai Island	random point	0	7.9	-	33	0
Dent Island	random point	0	24.1	-	60	0
Total		149				2.4
Corrected total *		153				2.5

[a] Puiseux exhaustive count not complete coverage of area
[b] Two adults found underneath separate rock-overhangs
* Including correction factor of +3% calculated from validation transects

Table 2. Grey petrel burrow occupancy, 2014 breeding season, Campbell Island

Burrow contents	Total	%
Chicks; egg whole; egg broken	25	59
Adult no egg	2	5
Two adults, no eggs	2	5
Empty	13	31
Total	42	100

Table 3. Inshore boat-based surveys for grey petrels, Campbell Island

Area	Distance (km)	Date	Grey petrels observed
Perseverance Harbour to Northwest Bay (via north)	42.9	July 15	0
Northwest Bay (inner and outer bay)	11.4	July 16	0
Monument Harbour to Perseverance Harbour (return)	13.1	July 19	0
Northwest Bay to Monument Harbour (via south)	33.2	July 29	0

A total of 149 burrows was located, and with a detection probability of 97% and an occupancy rate of 59% we estimate a minimum of 90 (SD 0.94) pairs of grey petrels in the four colonies we located and surveyed on Campbell Island.

During the winter visit, when grey petrels were in the chick feeding phase of the breeding season, the vessel had 13 anchor nights at Perseverance Harbour, nine nights at Northwest Bay and three nights at Monument Harbour. No grey petrels were observed flying or sitting on the water singly or in rafts at any of these locations. In addition 54 nautical miles of

coastline within 0.5–2.5 nautical miles of the shore were surveyed by yacht over a two week period during the mid-chick rearing phase, and grey petrels were not observed on any occasion (Table 3). Grey petrels were observed in flight from land on just four occasions, twice in the largest grey petrel colony, Eboulé, and once in each Filhol and Puiseux colony areas. All were recorded from land, in the late afternoon.

Discussion

Despite extensive searches totalling 212 km of survey transects, we found grey petrels breeding in only four areas on Campbell Island. Two were at previously known locations, Eboulé and Filhol Peak, and two were new colonies not previously reported, south Eboulé Peak and Pusieux Peak. Despite this expansion to new areas, the grey petrel population on Campbell Island is similar to previous estimates (Taylor 2000) and remains small, with 90 pairs raising chicks in August 2014. This underestimates the number of breeding pairs since earlier failed breeding attempts are not included, but breeding data to estimate the proportion of breeding failures prior to survey (at the large chick phase) are not available. It is also unclear if the year of our study was representative of breeding success on Campbell Island.

Perhaps the most striking result of this research was the small number of 153 grey petrel burrows found on Campbell Island. In the two areas where grey petrels are known to have bred historically, north Eboulé and Filhol (Taylor 1985), there was no clear evidence of an increase in the number of grey petrels breeding relative to the estimate in Taylor (2000). We assumed grey petrel habitat on the offshore islands is spatially limited as survival was not constrained by rats which were only present on the main island. Thus we speculated colony growth since rats were eradicated in 2001 would be most likely around existing colonies on the mainland, where the presence of calling and displaying birds, or other breeding sign, would act as a lure to prospecting conspecifics (Brooke 2004). It is therefore surprising that if there has been a small increase in the number of grey petrels breeding on Campbell since rats were eradicated, it is at colonies that are either recently established or previously went unnoticed.

In a note on sooty shearwater burrows, Charteris (1996) reported ‘odd’ looking burrows, with possible grey petrel feathers on the surface on the western slopes of Puiseux in October–November 1996. This area was visited regularly by workers studying southern royal albatrosses *Diomedea epomophora* (M. Charteris pers. com.) and we consider it unlikely they would have missed the tens of grey petrel burrows we found on the west side of Puiseux. Even though visits by summer workers were outside of the peak of the grey petrel’s winter breeding season, there is has some overlap since grey petrels return to breeding grounds in mid-February and chicks fledge as late as December (Warham and Bell 1979; Weimerskirch et al. 1989). Further, grey petrel burrows and colonies are conspicuous due to the large burrow entrances and clustering of burrows, so even without conspicuous sign of activity (guano, feathers, trampled vegetation) we assume they would have been noted. It seems

likely that Charteris (1996) discovered the few grey petrel burrows in that area, and that there has been an increase in burrows since. Whilst our surveys on Puiseux were not complete, combined with other evidence (see below) we believe it is that there are many hundreds more burrows in the area.

The burrows found on the south-eastern slope of Eboulé, above Monument Harbour, are in an area where to the best of our knowledge grey petrels have not been recorded previously. It is not clear if they represent a recent colony or one that was not noticed historically. Petrel burrows were reported from the Antarctic Peninsula in 1984 (Torr *in* Taylor 1985). The area with grey petrel burrows could be considered part of the peninsula, although it is separated from the peninsula base by approximately 250 m of cliff. A colony in this area could plausibly have been missed since it is a steep area to access by land and there are no nesting southern royal albatrosses where we found grey petrel burrows, so visits to the area have likely been very few.

Historic observations from the offshore islands record large numbers of burrowing seabirds (Taylor 1985). Our surveys of Monowai and Dent islands confirmed high numbers of burrowing petrels, but no evidence of grey petrels. Grey petrels are no longer breeding in January, and the larger burrows on Monowai and on the lower slopes of Dent were very wet, muddy and occupied by white-chinned petrels. There is some evidence that burrow sharing occurs. For example, Despin (1976) reported a white-chinned petrel in a burrow containing a grey-petrel chick, and grey petrels have been found burrows with sooty shearwaters on Campbell (Bailey and Sorenson 1962) and on Antipodes Island (Bell et al. 2013). However, the asynchronous breeding seasons would not allow a burrow to be used by both species in every year. We could not land on Jacquemart Island, so it remains a possibility that grey petrels are present there. Even if grey petrels are breeding on Jacquemart (19 ha) and burrows are at similar densities to where we found them on the main island (3.5–1.3 burrows/ha), it would not significantly increase the size of the Campbell Island grey petrel population.

Campbell Island is a large island (11,700 ha) so it is possible that grey petrels were not detected in some areas. However, no grey petrels were observed at sea or anchorages and only four individuals in flight terrestrially over 24 days on the island during the chick rearing phase. Grey petrels are frequently seen in flight ashore during early and late daytime hours on Antipodes Island (Bell et al. 2013). Similarly, grey petrel rafts are common in waters close to the breeding grounds on the Kerguelen Islands during the breeding season (Zotier 1990). The absence of grey petrels at sea and on land over Campbell Island suggests it is unlikely that large breeding colonies were missed.

As the only winter-nesting burrowing seabird on Campbell Island, chick predation and general interference with breeding by rats would likely have resulted in nil to very low chick survival before rats were eradicated. Breeding success for the summer-nesting sooty shearwater was zero on main Campbell Island in the mid-1980s in the presence of rats (G. Taylor pers. com.). In the presence of cats, grey petrel chick survival was negligible on

Marion Island (Newton and Fugler 1989). In the closely related white-chinned petrel, higher incidences of divorce and burrow switching, leading to missed breeding years, were attributed to disturbance by rodents (Bried and Jouventin 1991). Grey petrels are a long-lived seabird; whilst age at recruitment is not known, it will likely be similar to other *Procellaria* petrels [6.1 years in white-chinned petrels (Barbraud et al. 2008) and 7.7 years in Westland petrels *P. westlandica* (Waugh et al. 2015)]. In combination with zero breeding success in the presence of rats, deferred maturity is probably still contributing to the apparent slow rate of population recovery on Campbell. In contrast, grey petrel populations on Macquarie Island have recovered markedly since cats were eradicated in 2000, even in the presence of ship rats (now eradicated). Grey petrels were rediscovered breeding on Macquarie in 2000 (Schulz et al. 2005). There were 74 pairs in 2007 (ACAP 2009), 152 pairs in 2012 (Pyrke and Hunter 2012) and 183 pairs in 2013 (DPIPWE 2013). The lack of significant population growth on Campbell Island is not, however, unique; grey petrels on Marion Island have not recovered since cats were eradicated in 1991 (Percy FitzPatrick Institute 2012). It is possible that house mice on Marion Island are attacking grey petrels, given evidence that they attack other winter-nesting seabirds on the island such as wandering albatross *Diomedea exulans* (Jones and Ryan 2010).

It is important to note that the original estimates of the grey petrel breeding population at Campbell Island were not quantitative, so it is possible the number of burrows was under or overestimated making small changes hard to detect. Equally, grey petrel numbers may have declined in the 16 years between the estimates of the number of burrows in 1985 (Taylor 1985) and when rats were eradicated. It is encouraging that 10% of the burrows checked for occupancy had non-breeding adults and two birds were found under rock-overhangs. In a colonising species, a sizeable proportion of available burrows can be occupied by non-breeding birds on prospecting visits to the breeding area (Schulz et al. 2005).

In conclusion, the Campbell Island grey petrel population remains very small 14 years after rats were eradicated from the island. There has been no clear increase in the size of the two historically recorded colonies. However, two previously unknown colonies appear to have established, or expanded, since rats were eradicated. We recommend further research into this small grey petrel population, including tracking studies to compare with the much larger Antipodes Island population and genetic studies, as Indian Ocean grey petrels and New Zealand birds appear to be completely non-overlapping (Torres et al. 2015). Our work provides a baseline to understand population trends. The grey petrel population should be re-surveyed in five to ten years to produce a further population estimate.

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Appendix

If needed, this section could include detailed maps from each sector searched on Campbell Island