

Recent population estimates and trends in numbers of albatrosses and giant petrels breeding at the sub-Antarctic Prince Edward Islands

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The second mid-summer survey of surface-nesting seabirds at the Prince Edward Island group (Marion and Prince Edward islands) was conducted during December 2008, seven years after the initial mid-summer survey. Wandering albatrosses *Diomedea exulans* may have decreased slightly at Prince Edward Island, mirroring a decrease of roughly 2% per year at Marion Island from 1998 to 2005, a decline that has since reversed. Numbers of grey-headed albatrosses *Thalassarche chrysostoma* on Marion Island have remained stable, whereas the population on Prince Edward Island decreased by 20% from 2001 to 2008 (3% per year). The estimate of Indian yellow-nosed albatrosses *T. carteri* at Prince Edward Island was similar in 2001 and 2008. Counts of both sooty albatrosses *Phoebastria* spp. were substantially higher at Prince Edward Island in 2008, possibly as a result of better coverage compared to 2001. Dark-mantled sooty albatrosses *P. fusca* on Marion Island have decreased by almost 2% per year since 1996, continuing a negative trend from the early 1980s, whereas light-mantled sooty albatrosses *P. palpebrata* have increased by almost 6% per year at Marion Island since 1996. Counts of both giant petrels increased at Prince Edward Island (northern *Macronectes halli* by 44%; southern *M. giganteus* by 28%), whereas their numbers have remained stable at Marion Island. Current best estimates for annual breeding populations (pairs) at the two islands are 3 650 wandering albatrosses, 9 500 grey-headed albatrosses, 7 000 Indian yellow-nosed albatrosses, 2 900 dark-mantled sooty albatrosses, 800 light-mantled sooty albatrosses, 750 northern giant petrels and 2 800 southern giant petrels, confirming the global importance of the Prince Edward Islands for these seven species. Apart from the dark-mantled sooty albatross, their populations are reasonably healthy despite fishing mortality.

Keywords: *Diomedea*, *Macronectes*, Marion Island, population size, population trends, *Phoebastria*, Prince Edward Island, *Thalassarche*

Introduction

The Prince Edward Islands are globally important breeding sites for seabirds (Crawford et al. 2003, Ryan et al. 2003, Ryan and Bester 2008), including five albatross and four petrel species listed under the Agreement on the Conservation of Albatrosses and Petrels (ACAP). Most of these species are globally Threatened or Near-Threatened, mainly as a result of accidental mortality in commercial fishing operations (BirdLife International 2008). Numbers of albatrosses and surface-nesting petrels breeding at Marion Island are fairly well known (Nel et al. 2002a, Crawford et al. 2003), but there have been few counts of seabirds breeding on Prince Edward Island. The first mid-summer survey of seabirds breeding on Prince Edward Island was conducted during December 2001 (Ryan et al. 2003), providing a baseline against which trends can be assessed.

In this paper, we report a second set of mid-summer counts of albatrosses and giant petrels breeding at Prince

Edward Island, conducted in December 2008, seven years after the original mid-summer survey. We also update population estimates and test for significant trends in numbers of these species at Marion Island, based on standardised annual surveys conducted since the mid-1990s.

Study area and methods

The Prince Edward Islands (46°50' S, 37°50' E) lie roughly 1 800 km south-east of Port Elizabeth, South Africa. They comprise two main islands 19 km apart: Marion Island (290 km²) and Prince Edward Island (46 km²). Marion Island has a meteorological and research station and a larger diversity of introduced species than Prince Edward Island, including house mice *Mus musculus*. Human activities at Prince Edward Island are severely curtailed to limit human

impacts on this near-pristine island, which remains free of introduced vertebrates (de Villiers and Cooper 2008).

Prince Edward Island

Following the initial mid-summer survey of Prince Edward Island during 17–22 December 2001 (Ryan et al. 2003), we visited the island during 16–22 December 2008. Observers worked systematically around the island, counting all albatross and giant petrel colonies either by entering the colonies or by scanning from outside the colonies with binoculars. Coverage of the island was similar to that attained in 2001 (Ryan et al. 2003), but with the addition of the sea cliffs on the south-west coast between Kent Crater and McNish Bay, which were scanned from above by walking the cliff tops past High Bluff (Figure 1). Coverage also was enhanced by the experience gained in 2001, which allowed observers to concentrate efforts in areas where birds were known to breed, while also allowing better exploration of adjacent areas. Albatrosses tend to have fairly well-defined, discrete breeding areas, but giant petrels are more dispersed, especially northern giant petrels *Macronectes halli*. Coordinates of all breeding groups of giant petrels were recorded with GPS, both accurately to map their distributions and to prevent double counting of the same groups by different observers. Limited time did not permit the routine multiple counting necessary to estimate census accuracy, but repeat counts were made of several key sites. The main concentration of wandering albatrosses *Diomedea exulans* in Albatross Valley was counted twice, on different days and by different observers, as were numbers of grey-headed *Thalassarche chrysostoma* and Indian yellow-nosed albatrosses *T. carteri* on the cliffs above Albatross Valley.

Because some species were already well advanced in their breeding seasons, and some were just starting, counts were corrected to estimate total numbers of pairs attempting to breed. Few wandering albatrosses had laid eggs by mid-December. Counts of birds holding breeding sites in mid-December underestimate the number of pairs that actually lay eggs in January (Ryan et al. 2003). Daily checks of the study colony at Gony Plain on Marion Island in mid-December 2008 ($n = 150$ pairs) found that the number of pairs sitting on nests averaged 90–92% of the number of pairs that laid eggs in January 2009 (MGWJ unpublished data). However, the number of loafing adults varied greatly within and between days, so only birds on nests were counted at Prince Edward Island, and this number was inflated by 8% to account for additional pairs that were not present or had not yet arrived to establish sites. All other species surveyed had passed the peak laying period, so counts were corrected for breeding failures prior to the time of the survey. The other four albatross species were either at the end of incubation or brooding small chicks. The correction factor for grey-headed albatross was based on data from study colonies on Grey-headed Albatross Ridge, Marion Island, in 2008 (MGWJ unpublished data); the other three albatrosses were corrected based on average breeding success rates in the literature (see Ryan et al. 2003). All four breed on cliffs, so their numbers were estimated by scan counts from adjacent promontories or from above or below the cliffs. In most cases, only occupied nests could be

counted as it was not possible to determine nest contents. This may lead to inflated estimates of breeding pairs if a significant number of nests are occupied by pre-breeders, non-breeders (adults skipping a year or searching for a new mate), or failed pairs (which have already been accounted for in the correction factor for early breeding failures). Both species of giant petrels had chicks at the time of the survey, and these were counted. Northern giant petrels breed earlier than do southern giant petrels *M. giganteus* at Marion Island (Cooper et al. 2001), and their chicks were large and typically left unattended, whereas some southern giant petrel chicks were still brooded during the survey. We used the same correction factors for pre-census breeding failures among giant petrels applied in 2001 (Ryan et al. 2003, based on data in Cooper et al. 2001). Historical counts at the islands were taken from Berruti et al. (1981) and Watkins (1987).

Marion Island

Researchers working on birds at Marion Island have counted breeding populations for albatrosses and giant petrels in most years since at least the mid-1990s (Nel et al. 2002a, Crawford et al. 2003). Surveys are conducted during the early incubation period, to record peak breeding numbers. The timing of surveys for different species are as follows: wandering albatross in the second half of January (extreme dates for count sectors 9 January–10 February); grey-headed albatross in late October–early November (22 October–12 November); sooty albatrosses *Phoebastria* spp. in late November–early December (15 November–18 December, but with some inland sites until 4 January), northern giant petrel in September (4–25 September, except 2004, when counts were made in August); and southern giant petrel in late October (6 October–4 November). Wandering albatrosses mainly lay in January and their chicks fledge in November–December, so it is easy to assign breeding attempts to a calendar year. However, the December counts on Prince Edward estimate the following year's breeding effort (2002 and 2009, not 2001 and 2008). Other species breed across the austral summer, straddling two calendar years. Throughout for brevity we refer to the year when breeding commences and censuses take place (thus 1997/1998 is termed 1997). There were no counts of northern giant petrels in 2001, and counts were too poor to include in the analyses for dark-mantled sooty albatrosses *Phoebastria fusca* in 2001 and 2002, and for light-mantled sooty albatrosses *P. palpebrata* in 2001, 2002 and 2005. Sooty albatrosses are hard to count accurately, and counts were discounted if more than half the count sections had estimates less than half the value expected from the long-term average estimates.

Counts of wandering albatrosses at Marion Island have been divided into 20 zones around the island's coast. Boundaries to these zones are rivers or coastal features such as distinctive hills or points. Since 1996/1997, most other seabird counts at the island also have been divided into these zones. It is usually fairly easy to assign breeding populations to a given zone, but some populations straddle boundaries, and in these cases counts from the adjacent zones were pooled. Grey-headed albatrosses only breed in three count zones, so for this species counts were analysed

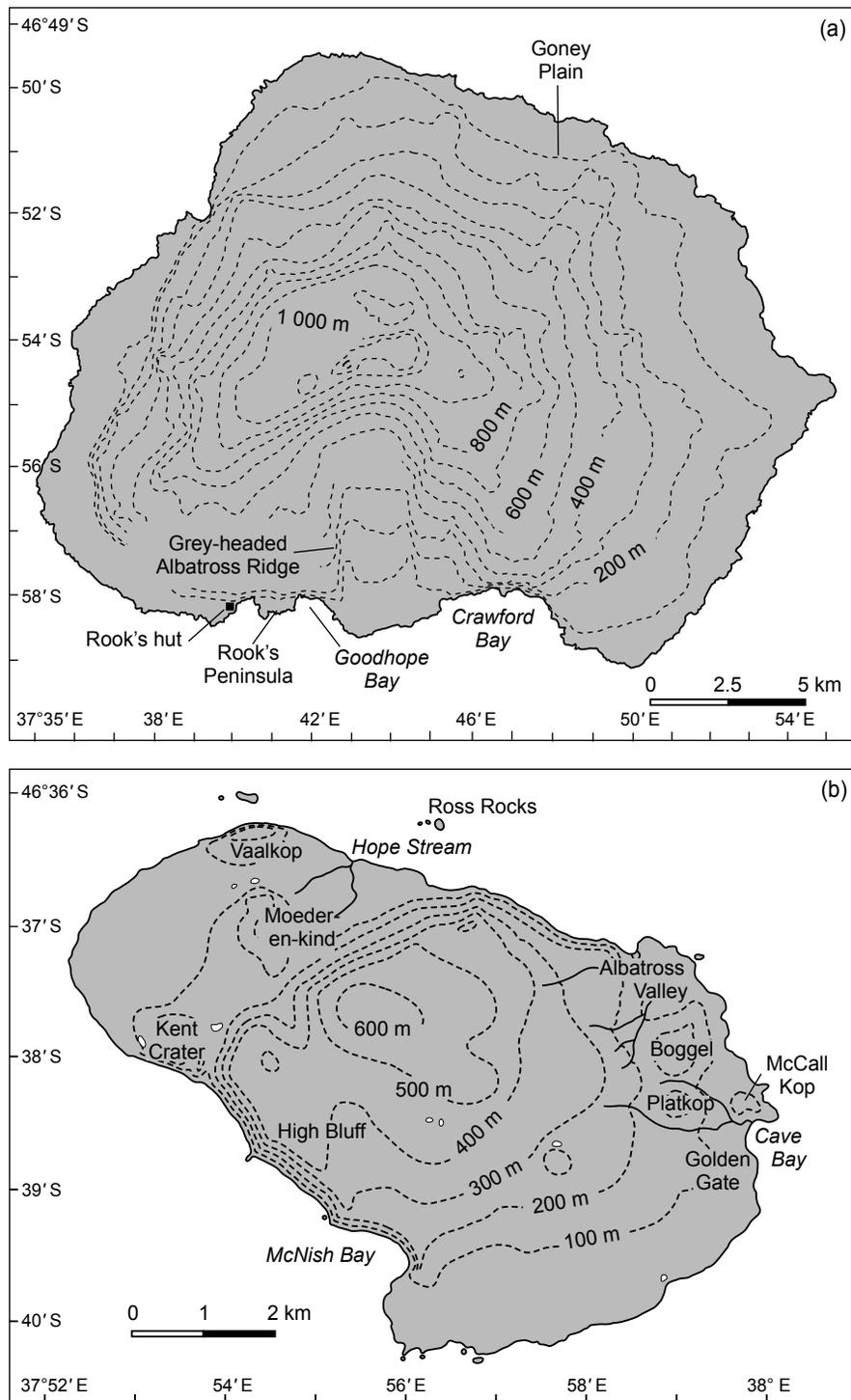


Figure 1: Maps of (a) Marion Island and (b) Prince Edward Island showing localities mentioned in text

for six colonies (Rook's hut, Rook's Peninsula west, Rook's Peninsula east, Goodhope Bay, Grey-headed Albatross Ridge and Crawford Bay). Repeated counts of zones in successive years allows the use of TRIM (Pannekoek and van Strien 2005) to estimate the island population with appropriate confidence intervals, and to test for statistically robust trends. TRIM also imputes missing data, which

was especially useful for light-mantled sooty albatrosses, for which there are few accurate counts of inland breeding populations. Counts for specific sectors also were imputed in cases where observers noted adverse counting conditions (e.g. when mist obscured sea cliffs, or very strong winds prevented safe counting along cliff tops). Counts of breeding attempts are more accurate in closely monitored study

colonies. Accordingly, separate analyses were run for study colonies of wandering ($n = 3$) and grey-headed ($n = 3$) albatrosses, which respectively comprise some 15% and 8% of the total island populations.

Results

In addition to the five species of albatross known to breed at the Prince Edward Islands, a single shy albatross *Thalassarche cauta* (probably of the white-capped form *steadi*) was found incubating among a small colony of grey-headed albatrosses at the western end of the colony on the cliffs near Ross Rocks. A black-browed albatross *T. melanophris* has bred with a grey-headed albatross on Grey-headed Albatross Ridge on Marion Island sporadically since at least 2002 (MGWJ pers. obs.).

Wandering albatross

The distribution of breeding wandering albatross on Prince Edward Island was similar in 2008 as in 2001. Outside the main breeding areas, one loafer was observed above the northern sea cliffs at more than 200 m above sea level in 2008 (where a pair probably bred in 2002), and several birds loafed on the lower slopes of Platkop in 2008, where there were no birds in 2001. Counts increased in all areas from 2001 to 2008, except Albatross Valley. The west coast count was 496 compared to 390 in 2001, and the east coast (excluding Albatross Valley) increased to 130 from 115. Both counts of Albatross Valley made in 2008 (1 007 and 1 014) were 14–15% less than the number counted in 2001 (1 182), suggesting a real decrease at this site. Because Albatross Valley supports the majority of pairs breeding on the island (Ryan et al. 2003), the total count was 3% lower in 2008 than 2001 (Table 1). The best estimate of Prince Edward Island's demi-population in 2009 (successful pairs breed every second year) is approximately 1 800 pairs.

The overall tendency in numbers of wandering albatrosses breeding at Marion Island has been for a moderate increase since 1982 (regression slope 1.012 ± 0.001 , $p < 0.01$). However, there was support for a more complex model, with a sustained increase from 1986 to 1998, a decrease from 1998 to 2005, and then an increase from 2005 to 2009 (Wald tests for change points at 1986, 1998 and 2005 all $p < 0.001$; Figure 2). The estimated demi-population in 2009 was $1\,830 \pm 71$ (SE). The population in 2009 was 1% lower

than that in 2002, similar to the difference observed at Prince Edward Island over this period. The two islands support approximately similar populations of this species. Compared to counts made in the early 1980s (during the brood-guard phase in April–May, correcting for early breeding failures; Watkins 1987), the changes in the wandering albatross population on Prince Edward Island closely mirror those observed on Marion Island (Figure 2).

Grey-headed albatross

On Prince Edward Island, grey-headed albatrosses breed on the north-east- and north-facing cliffs of Albatross Valley, with a small isolated group at the far western end of the sea cliffs opposite Ross Rocks (Ryan et al. 2003). The numbers of occupied sites both in Albatross Valley (1 489) and at the west end of the cliffs (17) were less than those counted in these areas in 2001 (1 845 and 52 respectively). Count accuracy was good; duplicate counts of the Albatross Valley population in 2008 yielded counts within 1% of each other. Given an average hatching success of 60% at Marion Island (Ryan et al. 2003), this suggests that the annual demi-population is approximately 2 500 pairs. However, it was not possible to control for the proportion of birds sitting on empty nests. An *ad hoc* survey of a single colony revealed 25–30% of occupied nests lacked either an egg or a chick. Accordingly, the population is likely to be smaller than that suggested by simple extrapolation and a best estimate of 2 000 pairs is suggested (Table 1).

By comparison, numbers of grey-headed albatrosses breeding on Marion Island have remained constant over the past decade (Figure 3). At Marion Island, this species is confined to the south coast, breeding along cliffs between Rook's hut and Crawford Bay. Counts are reasonably accurate at most sites, but the large colonies above the western end of Rook's Peninsula are hard to count, especially in adverse weather. There was no significant trend in numbers since 1997/1998, either across all colonies or at accurately counted study colonies. The estimate of the Marion Island population in 2008 was $7\,826 \pm 561$ (SE) pairs, with $7\,444 \pm 560$ pairs averaged over the past three years.

Indian yellow-nosed albatross

This species breeds on the north-east-facing cliffs at the western end of Albatross Valley, Prince Edward Island, extending west along the sea cliffs almost to the start of

Table 1: Counts of albatross and giant petrel populations (number of breeding pairs) at Prince Edward Island in 2001 (from Ryan et al. 2003) and 2008. Because wandering albatrosses start breeding in mid-summer, the December counts on Prince Edward estimate the following year's breeding effort (2002 and 2009, not 2001 and 2008). The best estimates are for the current population, compensating for breeding failures prior to the census period (see results for details)

| Species | Count | | Change (%) | Best estimate |
|-------------------------------|-------|-------|------------|--------------------|
| | 2001 | 2008 | | |
| Wandering albatross | 1 687 | 1 640 | -3 | 1 800 |
| Grey-headed albatross | 1 897 | 1 506 | -20 | 2 000 |
| Indian yellow-nosed albatross | 4 870 | 5 234 | 7 | 7 000 ¹ |
| Dark-mantled sooty albatross | 637 | 1 210 | 90 | 1 500 |
| Light-mantled sooty albatross | 92 | 129 | 40 | 200 |
| Northern giant petrel | 133 | 191 | 44 | 350 ¹ |
| Southern giant petrel | 567 | 723 | 28 | 1 350 |

¹ Species that breed in early spring, resulting in considerable extrapolation and thus relatively low confidence in the estimated population

the western coastal plain (opposite Ross Rocks). Unlike in 2001, no adults were observed loafing on the cliffs below McCall Kop in 2008. Two counts of the Albatross Valley cliffs in 2008 (1 290 and 1 314 occupied sites) were remarkably similar to the count in 2001 (1 300 pairs). Accurate counts of birds on the sea cliffs farther west are not easy. As in 2001, we counted with binoculars from the point north of Albatross Valley beach and augmented this count with numbers of birds breeding on west-facing slopes (invisible from the Albatross Valley vantage) observed from the cliff tops towards Ross Rocks. Occasional mist during the cliff-top survey hampered this exercise in 2008. The final estimate in 2008 was slightly greater than that in 2001 (Table 1), but this difference was within the likely count accuracy (10%; Ryan et al. 2003). Also, the proportion of occupied nests lacking eggs or chicks was high in 2008 (30–40% in one colony checked in Albatross Valley), so the estimated population was revised from 7 500 to 7 000 pairs (Table 1).

Indian yellow-nosed albatrosses do not breed on Marion Island, so there are no trend data from that island.

Dark-mantled sooty albatross

Dark-mantled sooty albatrosses breed on cliffs and are difficult to count, because their dark plumage blends with the cliffs much more so than do grey-headed and yellow-nosed albatrosses. Counts of sea cliffs require favourable viewing conditions and a good head for heights. At Prince Edward Island, most breed along the north-east coast between Cave Bay and Ross Rocks, with smaller numbers on the south-west coast near Kent Crater and McNish Bay (Ryan et al. 2003). Counts in 2008 were up compared to 2001 in all areas except the northern sea cliffs between Albatross Valley and Ross Rocks (185 vs 213), where sporadic mist probably affected counts. The total count in 2008 was almost double that in 2001 (Table 1), with moderate increases at Kent Crater (9 vs 6) and Albatross Valley inland cliffs (173 vs 156), but much greater increases in other areas: Albatross Valley coastal cliffs 420 vs 120, McCall Kop 181 vs 91, Cave Bay and Golden Gate 164 vs 44 and McNish Bay 76 vs 7. The 10-fold increase at McNish Bay resulted from surveys from along the top of the cliffs rather than scanning from below. The other increases possibly result from more adventurous descents to observe the cliffs, as counts were made from above the cliffs in both surveys. However, given the low proportion of adults that breed each year (Delord et al. 2008), some of the difference may be due to interannual variability. Assuming a mean hatching success of approximately 60% (Berruti 1979), the annual demi-population is approximately 1 800 pairs. However, there was no control for birds occupying empty nests, so we make a more conservative estimate of 1 400 pairs (Table 1).

Numbers of dark-mantled sooty albatrosses breeding at Marion Island have decreased significantly over the past decade or so (regression slope 0.9814 ± 0.0089 , $p < 0.05$), continuing an apparent trend since the early 1980s (Figure 4). The estimate of the Marion Island population in 2008 was $1\,283 \pm 126$ (SE) pairs, but averaged over the past three years the population was $1\,363 \pm 125$ pairs. Given that counts almost certainly underestimate the actual population, the best estimate of the Marion population is some 1 400 pairs.

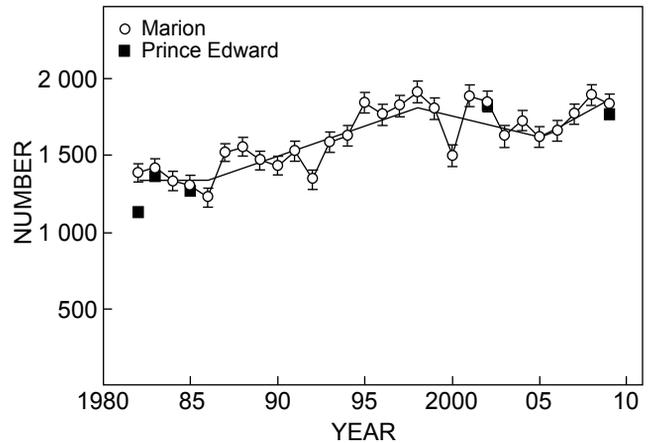


Figure 2: Trends in wandering albatrosses breeding on Marion Island (standard errors estimated with TRIM) and population estimates at Prince Edward Island. The fine line shows the model of population change

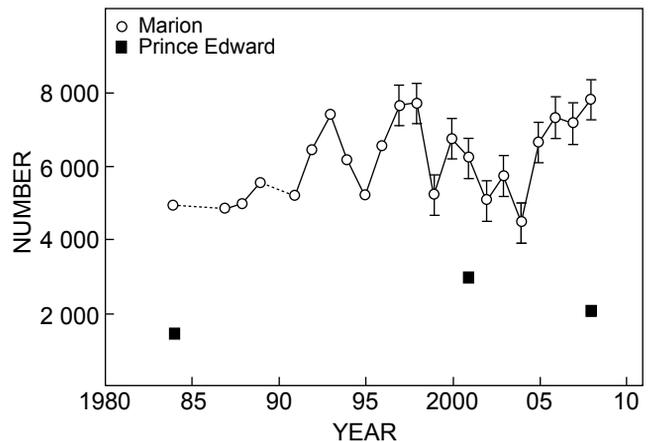


Figure 3: Trends in grey-headed albatrosses breeding on Marion Island and population estimates at Prince Edward Island. Conventions as Figure 2

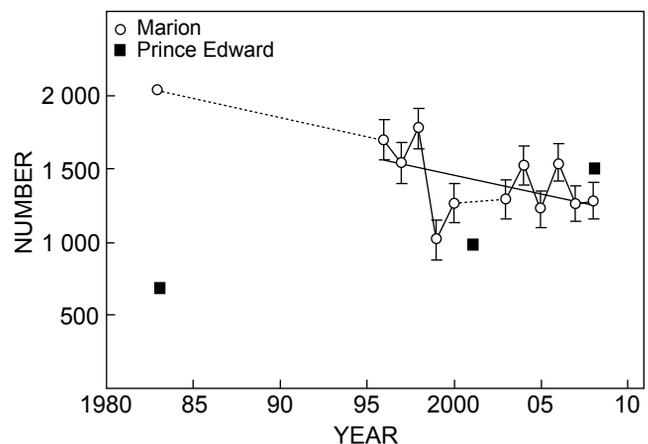


Figure 4: Trends in dark-mantled sooty albatrosses breeding on Marion Island and population estimates at Prince Edward Island. Conventions as Figure 2

Light-mantled sooty albatross

Light-mantled sooty albatrosses also breed on cliffs and are relatively hard to count, especially on Marion Island where a significant proportion of the population breeds along inland cliffs that are seldom surveyed. At Prince Edward Island, this species was mainly found in the western half of the island in 2001 (Ryan et al. 2003). Its distribution was similar in 2008, but eight nests were found on the cliffs above Cave Bay, immediately behind the camp. It seems unlikely that birds breeding in this area would have been overlooked in 2001. Counts in 2008 generally were higher than 2001, although numbers on the cliffs of Moeder-en-kind were down from 46 to 39 pairs. The greatest increases were along the south-west cliffs, with 36 adjacent to Kent Crater (9 in 2001) and 8 in McNish Bay (1 in 2001), linked to the cliff-top survey of this region for the first time. The total count of 129 occupied sites was up 40% on the 2001 count, with most of this increase (92%) along the south-west cliffs. Assuming a hatching success of 60% (Berruti 1979), the annual breeding population is estimated as approximately 200 pairs.

Numbers of light-mantled sooty albatrosses breeding at Marion Island have increased significantly over the past decade or so (regression slope 1.052 ± 0.014 , $p < 0.01$; Figure 5). The estimate of the Marion Island population in 2008 was 534 ± 49 (SE) pairs, but averaged over the past three years the population was 591 ± 45 pairs. Given that counts almost certainly underestimate the actual population, the best estimate of the Marion Island population is some 600 pairs.

Northern giant petrel

Breeding northern giant petrels are difficult to count because their nests occur singly or in loose groups up to at least 1 km inland, and are usually sheltered by rock outcrops, making detection and comprehensive coverage difficult. During the 2001 survey of Prince Edward Island, 133 nests with chicks were counted, 40 on the western coastal plain and 93 on the eastern coastal plain (Ryan et al. 2003). Counts in 2008 were 44% higher (Table 1), with numbers on the west coast

up 45% (58) and those on the east coast up 43% (133). However, within these regions, increases were not uniform. On the west coast, the northern area between Kaalkop, Moeder-en-kind, Hope Stream and the escarpment saw a marked increase from 19 to 49 nests, whereas there was a decrease from 22 to 9 nests around Kent Crater. This might reflect relatively rushed coverage of Kent Crater by a single observer in 2008. On the east coast, increases also varied regionally, with the strongest increase around Albatross Valley-Boggel (36 vs 17), a moderate increase inland from Cave Bay (28 vs 18) and only a small increase along the south-eastern plain between Cave Bay and McNish Bay (69 vs 58). Assuming a breeding success of c. 55% to the large chick stage (Cooper et al. 2001), the 2008 census suggests a minimum population of 350 pairs (Table 1). This is almost certainly an underestimate of the total population, because nests are easily overlooked.

On Marion Island, numbers of northern giant petrels have remained constant since 1996/1997 (Figure 6). The higher values recorded in 1998/1999 and 2007/2008 may reflect greater search effort in these years. The estimate of the Marion Island population in 2008 was 365 ± 45 (SE) pairs, with 399 ± 45 pairs averaged over the past three years.

Southern giant petrel

Breeding southern giant petrels are more easily detected than are northern giant petrels, because they typically nest in larger groups and in more open habitats, and in December their chicks have more striking white down. The count at Prince Edward Island in 2008 was 28% higher than that in 2001 (Table 1), with the west coast up 34% and the east coast 23%. As was the case with northern giant petrels, there were regional differences in the rates of increase. On the west coast, the northern sector between Kaalkop, Moeder-en-kind, Hope Stream and the escarpment saw a 44% increase from 186 to 267 active nests, whereas the number of nests around Kent Crater remained constant at 50. On the east coast, the strongest increase was between McCall Kop and Boggel (54 vs 18), with a 61% increase around Albatross Valley (185 vs 115) and a

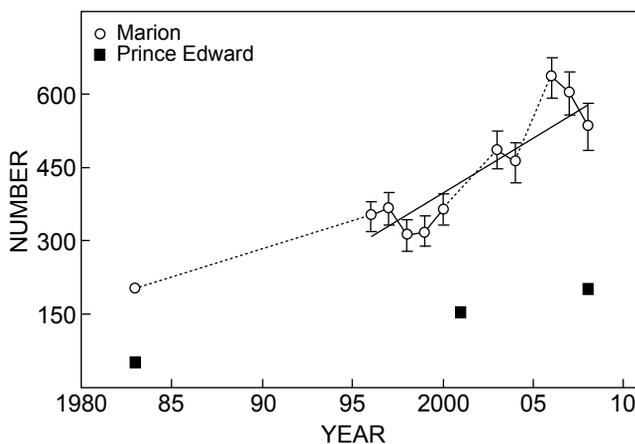


Figure 5: Trends in light-mantled sooty albatrosses breeding on Marion Island and population estimates at Prince Edward Island. Conventions as Figure 2

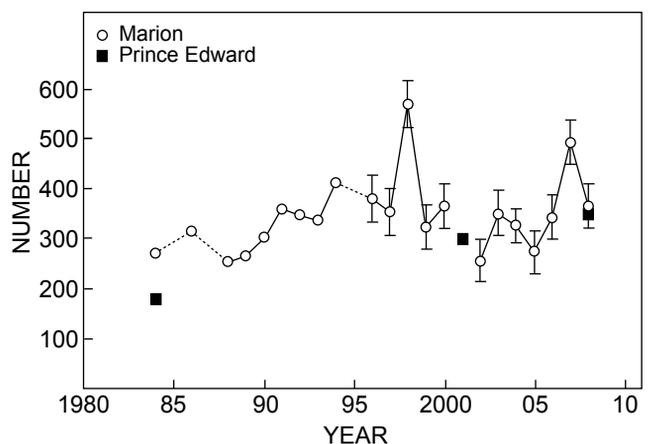


Figure 6: Trends in northern giant petrels breeding on Marion Island and population estimates at Prince Edward Island. Conventions as Figure 2

decrease along the south-eastern plain between Cave Bay and McNish Bay (167 vs 198). Assuming breeding success to December (in the absence of human disturbance) to be around 55% (Ryan et al. 2003), the total population of Prince Edward Island is approximately 1 350 pairs (Table 1). Even after accounting for early breeding failures, colonies generally were smaller on Prince Edward Island (20 ± 25, max. 118 pairs) than on Marion Island (40 ± 41, max. 174 pairs; Cooper et al. 2001).

On Marion Island, numbers of southern giant petrels decreased from 2 500 to 3 000 pairs in the 1980s and early 1990s to around 1 500 pairs in the late 1990s (Nel et al. 2002a, Figure 7). The overall trend from 1997/1998 to 2008/2009 is for a slight decrease, but this is not significant if the 1997/1998 year is omitted, suggesting that their numbers have stabilised at around 1 500 pairs (Figure 7). The estimate of the Marion Island population in 2008 was 1 606 ± 137 (SE) pairs, with 1433 ± 140 pairs averaged over the past three years.

Discussion

Our findings confirm the importance of the Prince Edward Islands as a breeding site for albatrosses and giant petrels, with the islands supporting large proportions of global

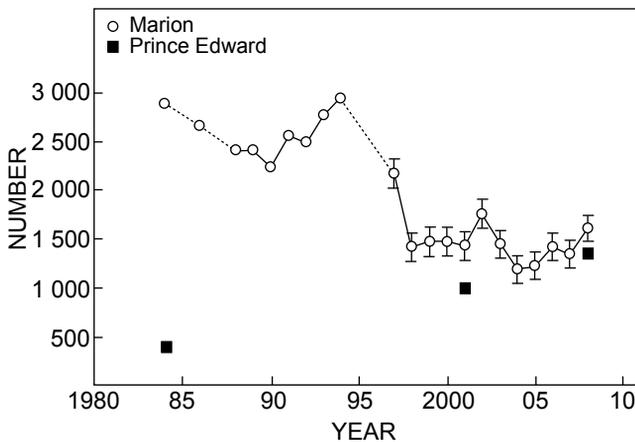


Figure 7: Trends in southern giant petrels breeding on Marion Island and population estimates at Prince Edward Island. Conventions as Figure 2

populations (Table 2). The islands are especially important for wandering albatrosses (Vulnerable), with each island in the group supporting approximately 20% of the world population. The island group also supports more than 20% of dark-mantled sooty albatrosses (Endangered) and almost 20% of Indian yellow-nosed albatrosses (Endangered). The 2008 survey significantly increased the estimate of dark-mantled sooty albatrosses breeding on Prince Edward Island, offsetting the losses caused by the population decline at Marion Island. With the exception of grey-headed and light-mantled sooty albatrosses, both characterised by more southerly distributions, Prince Edward Island supports similar-sized breeding populations of albatrosses and giant petrels as the much larger Marion Island (Table 2).

With the exception of grey-headed albatrosses, estimates of all albatrosses and both giant petrels breeding at Prince Edward Island remained roughly constant or increased from 2001 to 2008. Grey-headed albatrosses appear to have decreased at Prince Edward Island despite their population remaining constant on Marion Island. The main difference between colonies on the two islands is their orientation. It is possible that grey-headed albatrosses perform less well on the relatively warm, north-east-facing slopes on Prince Edward Island than on the cooler, south-facing slopes they occupy on Marion Island, especially given a climate that is becoming warmer and drier (le Roux 2008). Prince Edward Island is the northernmost breeding site in the world for grey-headed albatrosses (Brooke 2004), so impacts of climate change are likely to be detected here first. We did not spend sufficient time in the colonies to assess whether heat stress may be a factor affecting chicks of this species, but southern giant petrel chicks were visibly stressed on hot days, panting audibly, and several freshly dead chicks were found in two colonies after a particularly hot day.

Numbers of wandering albatrosses at Prince Edward Island may have decreased slightly from 2001 to 2008, with the decrease driven by a fall in numbers breeding in the main concentration in Albatross Valley. It is unclear why numbers breeding in this area should have decreased, whereas there were more birds in all other colonies. However, successful birds typically breed only every two years, so regional differences in breeding success may account for this pattern. Overall, the population on Prince Edward Island appears to have closely tracked trends in the population on Marion Island (Figure 2), with roughly equal populations on each island. An encouraging result is

Table 2: Best estimates of albatross and giant petrel populations (number of breeding pairs) breeding each year at the Prince Edward Islands, and the proportion they represent of the estimated global population

| Species | Marion ¹ | Prince Edward | Total | Global (%) ² |
|-------------------------------|---------------------|---------------|-------|-------------------------|
| Wandering albatross | 1 850 | 1 800 | 3 650 | 44 |
| Grey-headed albatross | 7 500 | 2 000 | 9 500 | 10 |
| Indian yellow-nosed albatross | 0 | 7 000 | 7 000 | 17 |
| Dark-mantled sooty albatross | 1 400 | 1 500 | 2 900 | 23 |
| Light-mantled sooty albatross | 600 | 200 | 800 | 4 |
| Northern giant petrel | 400 | 350 | 750 | 6 |
| Southern giant petrel | 1 450 | 1 350 | 2 800 | 6 |

¹ Average of the past three annual estimates, rounded to reflect count accuracy

² Based on global population estimates from BirdLife International (2008), with updates from the current study, as well as Ryan (2007), Delord et al. (2008) and Rolland et al. (2009)

the cessation in the slow decrease in wandering albatross numbers on Marion Island since the population peaked in 1998, with breeding pairs increasing since 2005. Delord et al. (2008) reported a steady increase in this species at Île de la Possession in the Crozet Islands from the mid-1980s until the late 1990s, with a stable or slowly decreasing population to 2005.

Numbers of Indian yellow-nosed albatrosses on nest sites in Albatross Valley remained remarkably constant from 2001 to 2008. Counts on the sea cliffs farther west were not conducted under ideal conditions, but also suggest that there has been no decrease in the population of this species since the 2001 survey. The species is killed in moderate numbers on tuna and toothfish longlines (Nel et al. 2002b, Petersen et al. 2009), and longline mortality initially was blamed for the decrease at the species' largest breeding population at Amsterdam Island (Weimerskirch and Jouventin 1998). However, subsequent work suggests that disease is the main factor driving its decline at Amsterdam Island (Weimerskirch 2004, Rolland et al. 2009). The majority of the population on Amsterdam Island now appears to have stabilised at around 25 000 pairs (Rolland et al. 2009). Current estimates of the other significant populations of this species in the Crozet Islands are a conservation priority: Îles des Pengouins (3 200 pairs in 1986) and Îles des Apôtres (1 230 pairs in 1981) (Tickell 2000).

The increases in estimates of both sooty albatrosses at Prince Edward Island are at least in part the result of better coverage of the island in 2008, including the first survey of the south-west sea cliffs. However, the threefold increase in dark-mantled sooty albatross numbers along the north-eastern cliffs between Golden Gate and the coast of Albatross Valley occurred in an area counted using similar approaches (but different observers) in the two surveys. A real increase in this species at Prince Edward Island cannot be ruled out, but it runs counter to the negative trend in numbers of dark-mantled sooty albatrosses at Marion Island and at Île de la Possession in the Crozet Islands (Delord et al. 2008). Given no obvious island-specific cause for different trends between Marion and Prince Edward islands for this species, it seems likely that most of the increase between 2001 and 2008 results from more 'adventurous' counting in 2008, when observers went farther down cliffs to detect a greater proportion of nests.

By comparison, the increased count of light-mantled sooty albatrosses at Prince Edward Island in 2008 can almost wholly be ascribed to better coverage of the south-west sea cliffs. Only the apparent range extension to colonise Cave Bay between 2001 and 2008 indicates an expanding population of this species at Prince Edward Island. The moderate increase at Prince Edward Island contrasts with the rapid increase (5% per year) in light-mantled sooty albatrosses at Marion Island over the past decade or so. Crawford et al. (2003) reported a decreasing trend in the coastal population of light-mantled sooty albatrosses at Marion Island from 1996 to 2002, but this conclusion was influenced by poor-quality counts in 2001 and 2002. Delord et al. (2008) estimated that numbers of light-mantled sooty albatrosses increased by over 6% per year at Île de la Possession in the Crozet Islands between 1995 and 2005.

Estimates of both giant petrel populations at Prince Edward Island increased between 2001 and 2008, despite no trend in their populations over this period at Marion Island. This contrasts with the situation at Île de la Possession in the Crozet Islands, where numbers of northern giant petrels have varied considerably with no long-term trend, whereas southern giant petrels have increased rapidly since the late 1990s (Delord et al. 2008). Some of the increases at Prince Edward Island might be due to better coverage in 2008, but there were marked differences in the pattern of change across the island between the two surveys, with the greatest increases for both species in areas that were well covered in both years. The population of southern giant petrels probably has increased at Prince Edward Island. Some of this increase may still be driven by immigration from Marion Island (Ryan et al. 2003). The shift away from the south-east coast of Prince Edward Island by southern giant petrels (and only a modest increase in northern giant petrels in this area) is peculiar. Increasing fur seal populations along the south-east coast (Bester et al. 2003) may have impacted some colonies, but giant petrels often breed close to high concentrations of fur seals.

Overall, the populations of albatrosses and giant petrels breeding at the Prince Edward Islands appear to be in reasonably good health, despite ongoing mortality on fishing gear at sea in the region (Tuck et al. 2003, Delord et al. 2005, Petersen et al. 2009). The largely consistent trends exhibited by populations at the Prince Edward Islands and Île de la Possession in the Crozet Islands (Delord et al. 2008) suggest that large-scale factors are responsible. An interplay between climate change and fishing mortality are the most likely drivers of trends (Rolland et al. 2008, 2009), but more data are needed to confirm the roles of these factors in each case. The only species which appears to be decreasing in numbers is the dark-mantled sooty albatross, but this species is seldom caught by fishing vessels (Ryan and Boix-Hinzen 1998, Nel et al. 2002b, Ryan et al. 2002, Delord et al. 2008, Petersen et al. 2009), and the cause of its apparent decline at Marion Island may be linked to other factors such as climate change. Southern giant petrels decreased at Marion Island during the early 1990s, but this trend has ceased and the population appears to have stabilised at a lower level. The decrease in this species at Marion Island may have been offset to some extent by an increase in its numbers at Prince Edward Island.

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