Contrasting changes in at-sea distribution and abundance of subantarctic seabirds in the Southern Ocean

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Long-term demographic studies have recently shown that global climate change together with increasing direct impacts of human activities, such as fisheries, are affecting the population dynamics of marine top predators. However, the effects of these factors on species distribution and abundance at sea are still poorly understood, particularly in marine ecosystems of the Southern Hemisphere. Using a unique long-term dataset of at-sea observations, we tested for inter-decadal (1980s versus 2000s) changes in summer abundance and distribution of 12 species of albatrosses and petrels along a 30° latitudinal gradient between subtropical and Antarctic waters of the Southern Ocean. The Southern Ocean is a major component of the global ocean and climate system and several studies have documented an increase in air and sea-surface temperatures (SST) over the past 50 years concomitant with important changes in sea-ice extent and surface wind stress (Mayewski et al. 2009). Such changes in oceanographic conditions are known to affect the distribution and abundance of marine pelagic species and, consequently, the availability of prey to top predators. Given the shifts in the at-sea distribution and abundance of several marine species in some other parts of the world (Beaugrand et al. 2003, McMahon & Hays 2006, Parmesan 2006), we may expect environmental changes to have an impact on the Southern Ocean communities.

Vessel-based surveys are vital tools to investigate species range expansions or contractions and/or changes in abundance as seabirds spend most of their time at sea. They provide information on abundance of species inaccessible on land and on the non-breeding fraction of the population, a component frequently missed by land-based monitoring. We used count data collected on board R.V. Marion Dufresne I and II during 12 southward cruises between La Réunion Island and the French subantarctic islands of Crozet and Kerguelen. We analysed surveys conducted during two periods, 1981–84 and 2002–07, in November and December, corresponding to the breeding period of the 12 seabird species: Wandering Albatross Diomedea exulans, White-chinned Petrel Procellaria aequinotialis, Black-browed Albatross Thalassarche melanophris, Light-mantled Sooty Albatross Pheoetria palpebrata, Grey-headed Albatross Diomedea chrysostoma, Yellow-nosed Albatross Thalassarche chlororhyncus, Giant Petrel sp. Macronectes sp., Cape Petrel Daption capense, Prions spp. Pachyptila spp., Wilson’s Storm-petrel Oceanites oceanicus, Blue Petrel Halobaena caerulea and Soft-plumaged Petrel Pterodroma mollis.

The first 10 species listed above tended to follow the ship, so we used counts made every hour at the rear of the boat as an instantaneous picture of birds following in the wake in order to avoid over-estimation of abundances. For the two non-following species (Blue Petrel and Soft-plumaged Petrel), we used the strip transect method (Tasker et al. 1984) and counted all birds within a 300-m strip quadrant for 10 min every hour. The observation protocol of the 10-min count at the front of the ship changed between the two decades (see Péron et al. 2010).
For each species, occurrence and abundance were modelled simultaneously in a generalized mixed model fitted with a zero-inflated negative binomial distribution. Latitude and sea-surface temperature anomalies (SSTa) were included as explanatory variables and survey identity as a random effect to test for decadal differences in latitudinal range of the six most abundant species and abundance of the 12 species as well as the effect of sea-surface warming on occurrence and abundance.

![Graphs showing predicted probability of presence along the latitudinal gradient](http://www.bou.org.uk/bouproc-net/ccb/peron-etal.pdf)

**Figure 1.** Predicted probability of presence (occurrence) along the latitudinal gradient (lines) and observed presence (1) and absence (0) in dots for the two decades. Delta corresponds to the mean decadal difference and confidence interval (95%) between the slopes of the Occurrence–Latitude linear relationships on a logit scale (from Péron *et al.* 2010).
The 12 seabird species exhibited contrasting decadal trends in their distributions and abundances at-sea. Although subtropical waters had the highest rate of warming in the study area, cosmopolitan species that visited these waters (<38°S) during summer exhibited most changes in distribution and abundance. The northern range of Wandering Albatross and Prions sp. tended to shift southward whereas White-chinned Petrels were observed further north since the 2000s and the three other species did not change (Fig. 1). The southward shift of Wandering Albatross and Prions sp. distributions may reflect species redistribution or a decrease in abundance due to warming of the subtropical waters. Rising SST may influence seabird distribution either directly at their range limits or indirectly through availability of prey. Surprisingly, the distribution of White-chinned Petrels shifted northward, suggesting other mechanisms, such as a reduction of competition with other species that shifted southward or a specialization of some individuals following fishing vessels, as fisheries activity has generally expanded in subtropical waters since the 1980s.

The abundance of Wandering Albatrosses, White-chinned Petrels and Giant Petrels declined markedly, whereas the other species showed contrasting trends or no change. With the exception of the White-chinned Petrel, these decreases were at least partly related to a regional increase in SST as most of these species were adversely affected by positive SSTa. The concordance between at-sea observations (Woehler 1997, present study) and demographic trends on land (Delord et al. 2008) favours the hypothesis of a decline in population sizes over the redistribution hypothesis. There is in fact growing evidence of a negative impact of rising SST on the abundance of subantarctic seabirds, with fisheries having an additional effect.

This study is the first to document a shift in species range in the Southern Ocean related to climate change and contrasting abundance changes. It suggests that some species might experience more severe impacts from climate change depending on the water masses they visit. Given the threats remaining over these species (Delord et al. 2008), studying their response to climate change may provide valuable information for conservation management.

As climate changes are predicted to continue in the next decades, understanding species responses to climate change is crucial, especially when their conservation status is critical or unknown.

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**References**


