DISTANCE ASSOCIATIONS AMONG ANTARCTIC AND SUBANTARCTIC SEABIRDS

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Maria Virginia Petry^{1,*}, Elisa de Souza Petersen¹, Lucas Krüger¹

¹Laboratório de Ornitologia e Animais Marinhos – LOAM, Universidade do Vale do Rio dos Sinos – UNISINOS, São Leopoldo, RS, Brazil

*e-mail: vpetry@unisinos.br

Abstract: Seabirds seek environmental cues for find food at sea. One of the cues is the behaviour of other seabirds. The present study aims to demonstrate through spatial correlation analysis, the distance at which species of seabirds are able to associate. Seabird counting was conducted onboard the Brazilian Polar Ship NPo Almirante Maximiano between Southern Argentina and South Shetland Islands, Antarctica. Birds were counted during 10 minutes censuses at intervals of one and half hours during the whole day. Abundances of *Daption capense*, *Macronectes giganteus*, *Thalassarche melanophrys*, Petrels and Albatrosses in spatial correlations were used. We tested if there were any intra-specific associations (autocorrelation) and/or any inter-specific associations (cross-correlation). The coefficients of auto and cross-correlation were used in linear regression with average distance lags to estimate the distance at which seabirds influence each other. All the Autocorrelation coefficients of the evaluated species were negatively related with lag average distance, that is, the further away the seabirds are the less they are able to detect each other. Even so, there were marked differences among species, since R^2 varied from 0.3 (all petrels added together) and close to 0.9 for Southern Giant Petrels. But the inter-specific association does not appear to be related with distance, since from the nine possible pairs, for only three, were the spatial cross-correlations related with the distance.

Keywords: Antarctic seabirds, environmental cues, feeding behaviour

Introduction

Seabirds develop mechanisms to override the difficulty for food detection imposed by the homogeneity of the sea. The mechanisms rely on detection using olfactive cues (Nevitt, 2008), and sight cues, despite the apparent absence of detectable spatial heterogeneity on the ocean surface (Silvermann *et al.*, 2004). Seabirds use morphological and physiological mechanisms to search for odours at over great distances (Nevitt, 1999; Nevitt, 2008; Van Buskirk & Nevitt, 2008). Greater and more aggressive seabirds may detect odours that indicate foraging by other seabirds, while smaller species detect the krill foraging upon phytoplankton (Nevitt, 2008). Seabirds respond to low prey visual detectability by monitoring other individuals for optimizing food detection. Veit (1999) verified that

Cape Petrels *Daption capense* and Southern Giant Petrels *Macronectes giganteus* change flight pattern when they find food spots, they continuously change flight direction and they land on the water. Hence individuals associate to enhance their individual capacity for food searching on wide and homogenous landscapes (Silvermann & Veit, 2001). Both the sensorial strategies (olfaction and sight) are simultaneously applied (Nevitt, 2008). Despite the evidence for such multimodal hypothesis for foraging, the olfaction strategy is more testable to test. *Diomedea* albatrosses, however, often use visual searching, since they are less attracted to odours than other species (Nevitt *et al.*, 2004; Mardon *et al.*, 2010). Silvermann *et al.*, (2004) points out there is a lack of information describing seabird

association feeding flocks, and data of how seabirds search for prey at sea is scarce. Hence, the present study aims to demonstrate the distances that seabird species are able to associate, and demonstrate the distances detected when seabirds are involved in intra and/or interspecific associations. The way seabirds are engaged in associations have consequences on distribution, food detection and, hence, on adult survival, an important demographic parameter for seabird populations.

Materials and Methods

Seabird counting was conducted aboard the Brazilian Polar Ship NPo Almirante Maximiano in October 2009. Seabirds were counted during the ship's deployment between southern Argentina and South Shetlands, Antartica, including here Drake Passage. Birds were counted during 10 minutes censuses at intervals of one and half hours during the whole day, using the ship's side opposed to the sun. Ship-Following birds were excluded from the analysis. Abundances of *Daption capense* (Cape Petrel), *Macronectes giganteus* (Southern Giant Petrel), *Thalassarche melanophrys* (Black Browed Albatrosses), Petrels and Albatrosses were used in spatial correlations. Additive Ln transformations were conducted before running the spatial correlations. We tested if there were intra-specific association (autocorrelation) and inter-specific association (cross-correlation). The coefficients of auto and cross-correlation were used in linear regression with average distance lags to estimate the distance seabirds influence one another.

Results

All the Autocorrelation coefficients of the evaluated species were negatively related with lag average distance, that is, the farther the seabirds are from each other the less they are able to detect each other. Although there were marked differences among species, since R^2 varied from 0.3 (all petrels added together) and close to 0.9 for Southern Giant Petrels (Table 1, Figure 1). The Southern Giant Petrels seems to be the species that is able to detect its own species behavior at long distances, followed by Albatrosses, and Cape Petrels who seem to be limited to smaller distances (Table 1).

But the inter-specific association does not appear to be related with distance, since from the nine possible pairs, the spatial cross-correlations related with the distance only for three species. They were Cape Petrels and Black Browed Albatrosses, Cape Petrels and Albatrosses, Black Browed Albatrosses and Petrels (Figure 2), all pairs with low R-squares (Table 2). This indicates seabirds may opt for use of their own species as sight cues when foraging at greater distances, while they may use other species as cue when they are near available.

Discussion

Greater associations occur among individuals from the same species, which has also been established in other studies (Silvermann & Veit, 2001; Silvermann *et al.*, 2004). Silvermann *et al.*, (2004) showed that albatrosses are indicators of environmental cues for other species by their conspicuousness. The latter has not been entirely discarded from our results since the greater inter-specific correlations were those in which Albatrosses were involved.

Table 1. R^2 , P and equation parameters (a and b) of linear regression Between Autocorrelation coefficient and estimated average lag distance, for each seabird species between Argentina and South Shetlands Island.

Especies	R^2	P	A	B
Cape Petrel	0.34	0.018	0.902	-0.108
Black Browed Albatross	0.551	0.001	1.123	-0.132
Southern Giant Petrel	0.857	<0.001	2.259	-0.248
Albatrosses	0.61	<0.001	1.419	-0.152
Petrels	0.315	0.024	0.792	-0.096

The association between Cape Petrels and Albatrosses suggests the Black Browed Albatross is a major contributor, mainly due to its abundance in the sampled region. On the other hand, some cross-correlation tended to be negative (however non-significant), and an indication that there is a certain level avoidance between some species, i.e. Cape Petrel and other Small Petrels do not seem to interact with Giant Petrels, a potential predator, in accordance with the available literature (Silvermann & Veit, 2001),

which is even found in the olfactory strategies adopted by smaller species (Nevitt, 1999; Nevitt *et al.*, 2004). Although, available literature about sight association between seabirds sampled mainly marine areas close to breeding colonies within the breeding season when the birds are engaged in breeding activities (Silvermann *et al.*, 2004), our sample was made at the beginning of breeding season when most birds were just starting to breed. The energy inputs required at the peak of reproduction justifies a change in

Figure 1. Spatial Autocorrelation coefficients in response to estimated average lag distance for species. Cape Petrels (CP), Black Browed Albatrosses (BBA), Southern Giant Petrel (SGP), Sum of Albatrosses (ALB) and sum of Petrels (PTR).

Figure 2. Spatial cross-correlation coefficients in response to estimated average lag distance for pairs of species. Cape Petrels and sum of Albatrosses (CP-ALB), Cape Petrel and Black Browed Albatrosses (CP-BBA), Black Browed Albatrosses and sum of other Albatrosses (BBA-ALB).

Table 2. R^2 , P and equation parameters (a and b) of linear regression Between cross-correlation coefficient and estimated average lag distance, for each pair of seabird species between Argentina and South Shetland Island. The equation parameters presented are from significant regressions with R^2 greater than 0.2.

Pairs	R^2	P	A	B
Cape Petrels and other Petrels	0.054	0.195	-	-
Cape Petrels and Southern Giant Petrels	0.04	0.265	-	-
Cape Petrels and Black Browed Albatrosses	0.297	0.001	0.476	-0.039
Cape Petrels and Albatrosses	0.351	<0.001	0.535	-0.042
Black Browed Albatrosses and Southern Giant Petrel	0.109	0.065	-	-
Black Browed Albatrosses and Other Albatrosses	0.116	0.05	-	-
Black Browed Albatrosses and Petrels	0.21	0.008	0.394	-0.028
Southern Giant Petrels and Other Petrels	0.01	0.92	-	-
Southern Giant Petrels and Albatrosses	0.045	0.23	-	-

the foraging habits of seabirds (Markones *et al.*, 2010). The interaction differences may also exist as intrinsic factors of the communities as a response to abiotic gradients in the hydrographic, bathymetric and climatic characteristics (Woehler *et al.*, 2010). Yet our responses suggest similarities with Silvermann *et al.* (2004).

Due to restrictions in segregation of sampling space and time, in order that our model could be validated it is necessary to inform that in the span of a short time interval (up to 24 hours), one individual remained in a similar latitude, that is, its position being able to vary longitudinally, just because our samples were spatialized in a latitudinal gradient. Hyrenbach *et al.* (2007) demonstrates that between a set of spatial variables, there is an association of many species with longitudinal gradients.

Associations may therefore be an important process in the foraging behaviour, and so the effect on the foraging success is obvious. The successful detection of food will allow a bird to fulfil its energy requirements (Markones *et al.*, 2010) and survive. Adult survival is the most important demographic parameter driving population dynamics of seabirds (Rolland *et al.*, 2009).

By accepting that seabirds are strongly associated with productive ocean currents (Bost *et al.*, 2009), our model

can be considered valid. In this case, the area we sampled is crossed by the Antarctic Circumpolar Current, suggesting the longitudinal movements of the seabirds.

Conclusion

The association between birds in open sea is a sparsely explored field of research in ornithology. There are few evaluations of seabird species association related to sight, principally in the pelagic environment, and the efforts on the theme are justified. On the other hand, the relation of birds regarding weather and productivity as a response to climatic changes is an actual and expanding topic in marine ecology. Further research on the deviation of bird associations as a response to the biotic and abiotic environment would allow a broader understanding of the changes on the Antarctic Environment.

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