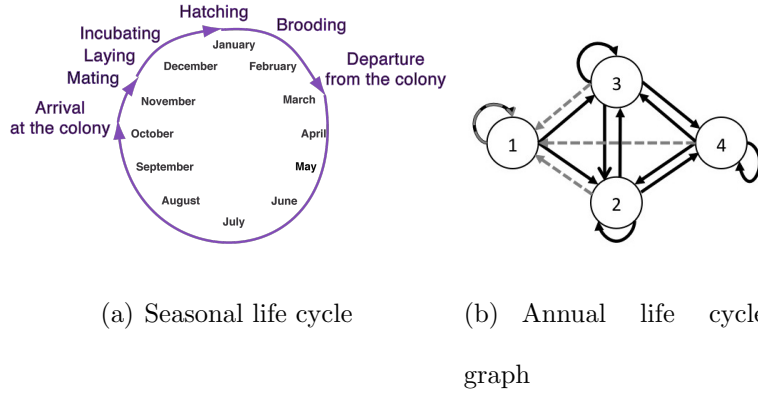


A. Supplementary figures

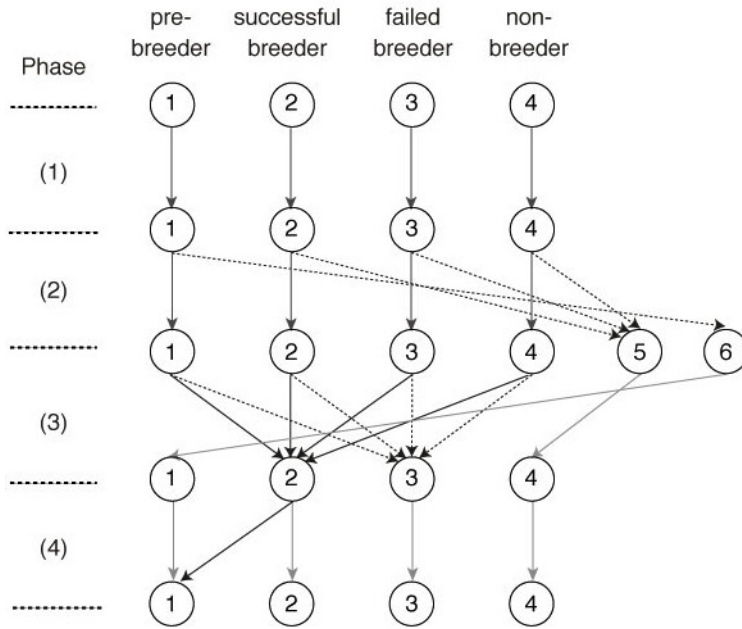
The life cycle distinguishes four stages defined at the end of the breeding season t (Fig. A1):

1. Prebreeders have yet to breed for the first time and include fledged chicks from season t .
2. Successful breeders have raised a chick successfully during season t .
3. Failed breeders have not raised a chick successfully during season t and have failed either on egg or chick.
4. Nonbreeders have bred at least once, but not in season t .



(a) Seasonal life cycle

(b) Annual life cycle graph



(c) Periodic life cycle graph

Figure A1: (a) Seasonal life cycle of Southern fulmars. (b) Annual life cycle and (c) periodic life-cycle graphs for a periodic matrix model. (b) Dark lines indicate transitions among individual already present in the population, while gray dashed lines show the production of new individuals. (c) During the year, (1) individuals survive, (2) individuals either do or do not return to their breeding site (solid lines and dotted lines, respectively), (3) individuals either do or do not raise a chick successfully (solid lines and dotted lines, respectively) and (4) chicks fledge. Because we consider only females, the sex ratio is included in phase four. The numbering of the nodes on each line of the life-cycle graphs corresponds to the rows and columns of the matrices $\mathbf{M}_1 - \mathbf{M}_4$. For example, stage 5 and 6 are the adults and prebreeders who do not return to the colony at season $t + 1$ (rows 5 and 6 of \mathbf{M}_2). The gray lines refer to transition probability of 1.

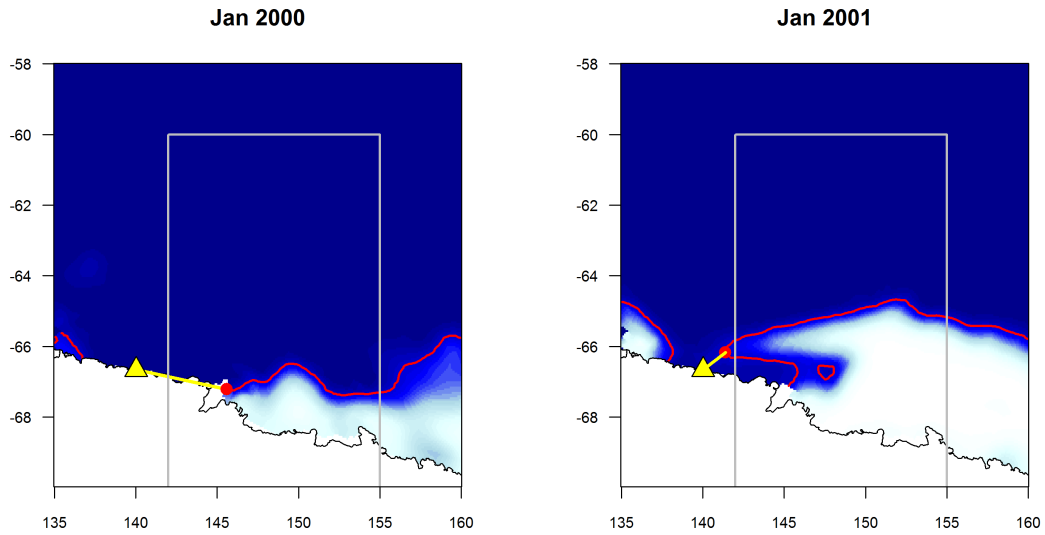


Figure A2: Example of DC index calculation for the two tracking years. The DC index is defined by the ratio of the distance between the ice edge (15% SIC limit) and the colony over the sea-ice area. The sea-ice area corresponds to the percentage of the area within the gray rectangle covered by sea ice concentration $>15\%$. The sea-ice edge defined by the 15% SIC is the red contour and the red dot, the closest ice edge from the East side of the colony (yellow triangle).

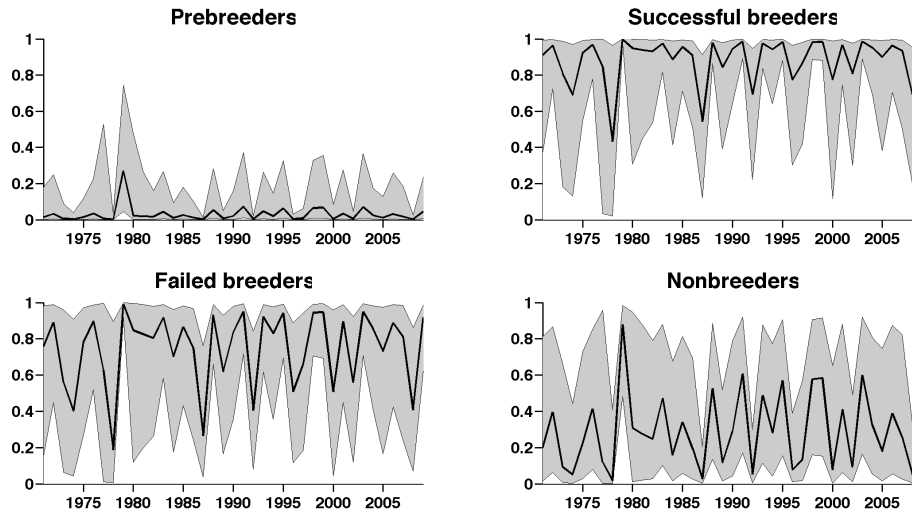


Figure A3: Return probabilities of Southern fulmars from 1971 to 2009 for each states. Gray area show the 95% confidence intervals of the model averaged estimates.

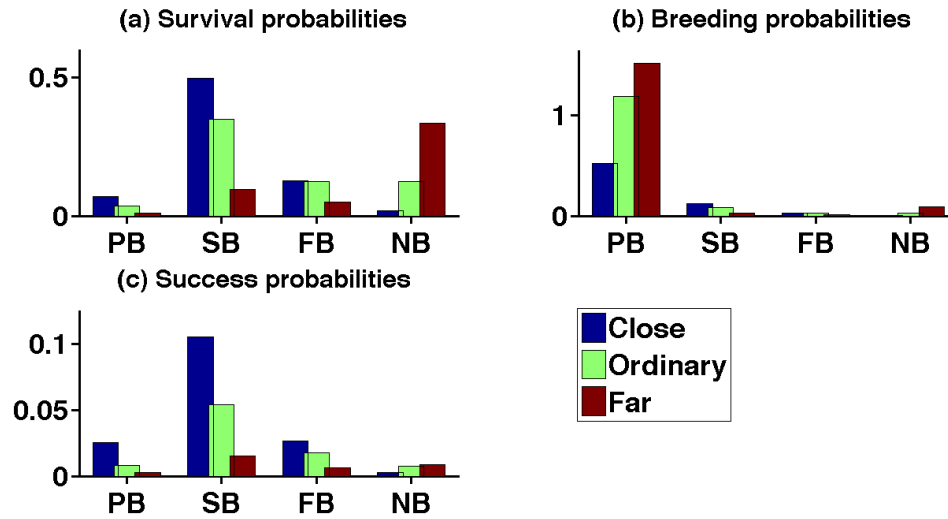


Figure A4: Selection gradients for (a) survival, (b) breeding and (c) success probabilities are shown for environments characterized by extreme and ordinary conditions. For each vital rates θ_i the selection gradient δ_i is calculated as the product of the inverse deterministic population growth rate (λ^{-1}) and the sensitivity of λ to θ_i (van Tienderen 2000). Same legend as figure 6.

Literature cited

van Tienderen, P. 2000. Elasticities and the link between demographic and evolutionary dynamics. Ecology 81:666-679.