

**Supporting Information.** Nathan Pacoureau, Karine Delord, Stéphanie Jenouvrier, and Christophe Barbraud. 2019. Demographic and population responses of an apex predator to climate and its prey: a long-term study of south polar skuas. *Ecological Monographs*.

### **Appendix S2: Goodness-of-fit**

Goodness-of-fit tests were performed for multistate models (Pradel et al. 2003) to ensure that the starting (general) model adequately fits the data, using the software U-Care, version 2.3.2 (Choquet et al. 2009). The goodness-of-fit test has two main components. Component Test 3G examines the effect of the past capture history on the future of animals captured and released at the same time and in the same state. Test 3G has three subcomponents: Test 3G.SR examines specifically the presence of transients in each sample defined by a state and an occasion, Test WBWA aims at detecting whether individuals stay in the same state from one occasion to the next (“memory effect”), and the complementary composite Test 3G.Sm which has no clear biological interpretation. Component Test M contrasts the individuals not caught at a given occasion – but known to be alive – to those caught at the same occasion. Test M has two subcomponents: Test M.ITEC which tests for short-term trap-dependence, and the complementary composite Test M.LTEC which has no clear biological interpretation. Goodness-of-fit tests indicated that some assumptions of the JollyMoVe (JMV) model for multistate data were not supported (Table S1). A closer inspection of the GOF tests indicated that the lack of fit was largely due to a transient or age effect (Test 3G.Sr:  $\chi^2 = 315.41$ ,  $df = 47$ ,  $P < 0.001$ ; Pradel et al. 1997, 2005) and trap-dependence effect or heterogeneity in capture (Test M.ITEC:  $\chi^2 = 248.79$ ,  $df = 32$ ,  $P < 0.001$ ; Gimenez et al. 2017). The transient effect was partly due to fledged individuals never seen again. Indeed when the first capture, corresponding to the fledging stage,

was removed, the test 3G.SR became non-significant ( $\chi^2 = 44.82$ ,  $df = 71$   $P = 0.99$ ). When both the tests for the presence of transience and trap-dependence are significant, and only them, there is suspicion of heterogeneity in detection (Péron et al. 2010). By modeling age structure and heterogeneity in detection probability in our initial model, we took account for a part of this variance not captured by the JollyMoVe model. However, there was still a lack of fit and we estimated a variance inflation coefficient ( $\hat{c}$ ), computed as the ratio between the sum of the  $\chi^2$  statistic and the sum of the degree of freedom of test components WBWA, 3G.Sm and M.LTEC, which was used in model selection (Burnham and Anderson 2002).

**Table S1.** Results from the GOF tests for the JollyMoVe model performed on the adult component of south polar skuas.

<b>Test</b>	<b><math>\chi^2</math></b>	<b>df</b>	<b><i>P-value</i></b>
WBWA	156.8	149	0.31
3G.SR	315.4	47	<0.001
3G.Sm	410.1	257	<0.001
M.ITEC	248.8	32	<0.001
M.LTEC	4.3	3	0.23

## References

- Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Springer Science & Business Media.
- Choquet, R., J.-D. Lebreton, O. Gimenez, A.-M. Reboulet, and R. Pradel. 2009. U-CARE: Utilities for performing goodness of fit tests and manipulating CAPture-REcapture data. *Ecography* 32:1071–1074.
- Gimenez, O., E. Cam, and J.-M. Gaillard. 2017. Individual heterogeneity and capture-recapture models: what, why and how? *Oikos*.
- Péron, G., P.-A. Crochet, R. Choquet, R. Pradel, J.-D. Lebreton, and O. Gimenez. 2010. Capture–recapture models with heterogeneity to study survival senescence in the wild. *Oikos* 119:524–532.
- Pradel, R., O. Gimenez, and J.-D. Lebreton. 2005. Principles and interest of GOF tests for multistate capture–recapture models. *Animal Biodiversity and Conservation* 28:189–204.
- Pradel, R., J. E. Hines, J.-D. Lebreton, and J. D. Nichols. 1997. Capture-recapture survival models taking account of transients. *Biometrics*:60–72.
- Pradel, R., C. M. Wintrebert, and O. Gimenez. 2003. A proposal for a goodness-of-fit test to the Arnason-Schwarz multisite capture-recapture model. *Biometrics* 59:43–53.