

SUPPORTING INFORMATION

Appendix I Sensitivity analysis of K_V

We estimated that the value of K_V is between 88,000 and 132,000 individuals (between two and three times K_H , the carrying capacity at Helgeland). To take a conservative estimate, we used the lower value. Here, we determine whether a higher value would have led to different model results. Computational constraints did not allow to repeat the complete procedure for a different value of K_V . Instead, we performed two new smaller ABC-analyses, each for a different values of K_V (88,000 and 132,000). The smaller ABC-analysis was performed as in the main text, now randomly drawing parameter combination not from the prior distributions, but from the 100 simulations of each model that gave the best results in the main analysis.

In both cases, the same three models were selected as in the main analysis: models 16, 18 and 21 (Table S1). Although the proportion of each model among the selected runs differed between the two ($\chi^2_2 = 10.2$, $p = 0.002$), the qualitative results are the same. We conclude that the model selection procedure has a low sensitivity to substantially higher values of K_V . This confirms our expectation that according to the best simulations, density-dependent competition for grazing opportunities does not yet occur at Vesterålen.

SUPPLEMENTARY TABLES AND FIGURES

Table S1. Hundred best simulation runs in smaller analysis for different values of K_V

| Model | Decision rule | Number of selected runs | |
|-------|--|-------------------------|---------------|
| | | $K_V=88,000$ | $K_V=132,000$ |
| 10 | Memory + Groups | 0 | 0 |
| 12 | Reconsider _{geese} + Memory + Groups | 0 | 0 |
| 15 | Reconsider _{geese} *Age + Groups | 0 | 0 |
| 16 | Reconsider _{geese} + Groups*Age | 57 | 36 |
| 17 | Memory*Age + Groups | 0 | 0 |
| 18 | Memory + Groups*Age | 8 | 15 |
| 19 | Reconsider _{geese} *Age + Memory + Groups | 0 | 0 |
| 20 | Reconsider _{geese} + Memory*Age + Groups | 0 | 0 |
| 21 | Reconsider _{geese} + Memory + Groups*Age | 37 | 49 |

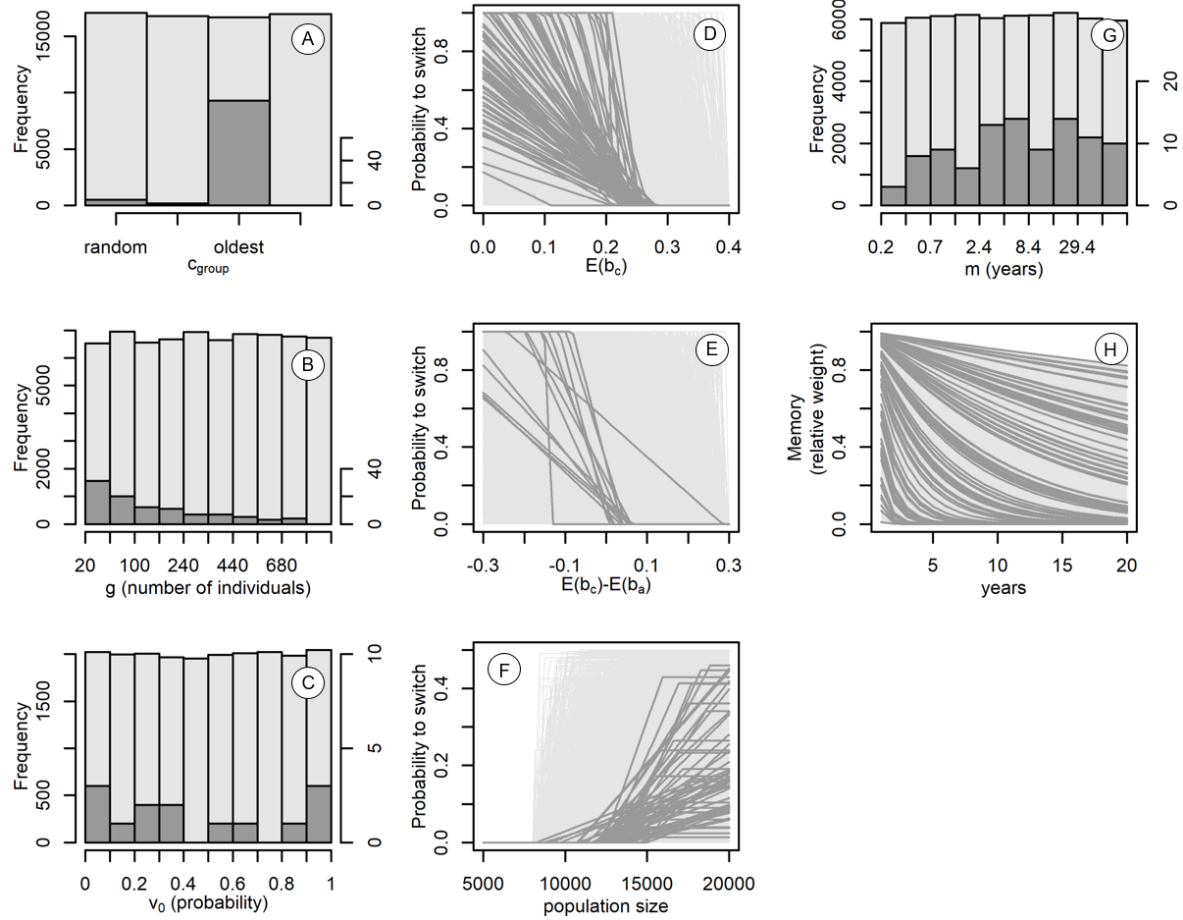


Figure S1: Parameter values of selected simulations in first model selection

The pre-defined parameter distributions from which random values were drawn for each simulation are given in light grey. The frequency distributions of parameter values among the hundred selected simulation runs in the preliminary model selection (see Table S1) are given in dark grey. Panel A gives the following criterion in each simulation of the models with ‘groups’ (parameter c_{group} : 1=follow random, 2=follow parent, 3=follow oldest, 4=majority vote, see methods). Panel B is the frequency distribution of the maximum group size in each simulation run (parameter g). Panel C is the frequency distribution of the probability of exploring for each model with ‘exploration’ (parameter v_0). The lines in panel D define how the annual switch probability depends on the individual’s expected probability of reproducing at the current staging site, $E(b_c)$. They are determined by parameters x_a (threshold value below which the probability becomes non-zero) and x_r (the slope of the line below x_a) in the models with ‘memory’ but without ‘exploration’. Similarly, the lines in panel E are determined by the parameters x_b and x_r in the models with exploration. They define how the switch probability depends on the difference between the individual’s expected probability of reproducing in the alternative and the current staging site: $E(b_c) - E(b_a)$. In panel F, the lines are determined by parameters ge_0 , ge_r and ge_m in the models with ‘reconsider_{geese}’, which determine how the probability to switch preference after arrival at the staging site, depending on the number of geese there. Panel G is the frequency distribution of parameter m , which determines the rate of memory loss in the models with ‘memory’. Panel H shows how, resulting from differences in m , the weight of each memory declines over the years.

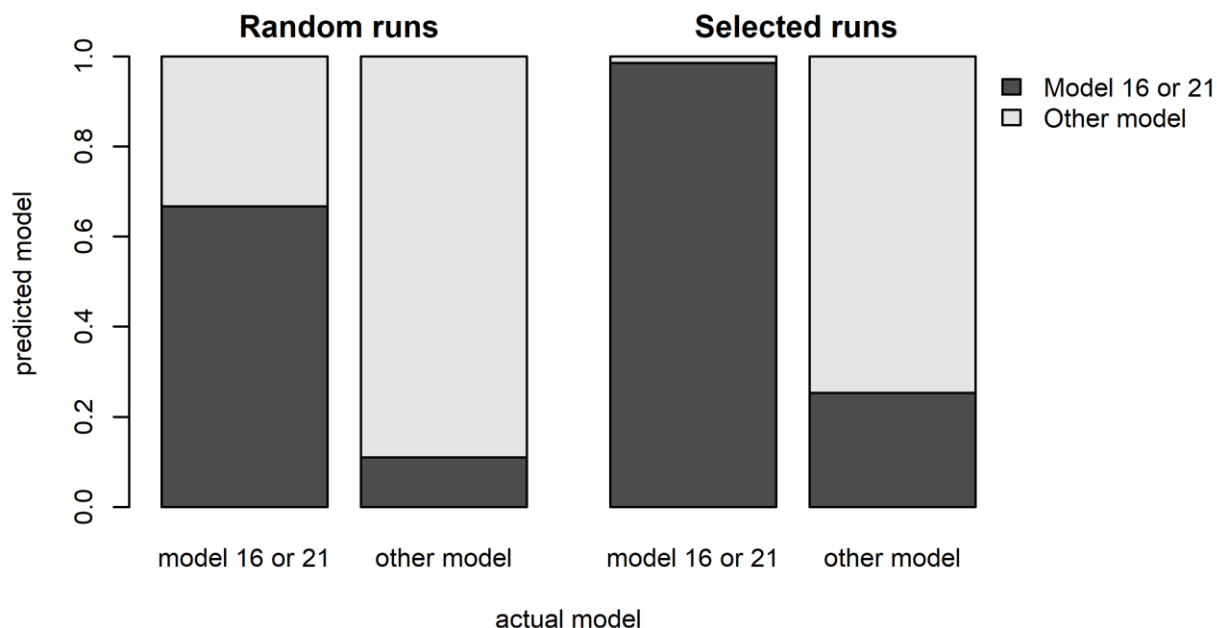


Figure S2. Results of model cross-validation

Cross validation was carried out by 1000 times drawing one of the simulation runs, and perform the model selection procedure as if that was the empirical data. Left two bars are the results when drawing simulations at random, the right two bars are the results when taking the best 100 runs from each model. Each bar shows how many runs from both groups of models (one group consisting of models 16 and 21, the other group of the rest of the models) are estimated by the model selection procedure as belonging to either of the two groups.

SUPPORTING INFORMATION REFERENCES

Tombre, I.M., Oudman, T., Shimmings, P., Griffin, L., and Prop, J. (2019). Northward range expansion in spring-staging barnacle geese is a response to climate change and population growth, mediated by individual experience. *Global Change Biology* 25, 3680-3693. <https://doi.org/10.1111/gcb.14793>