**SUPPORTING INFORMATION**

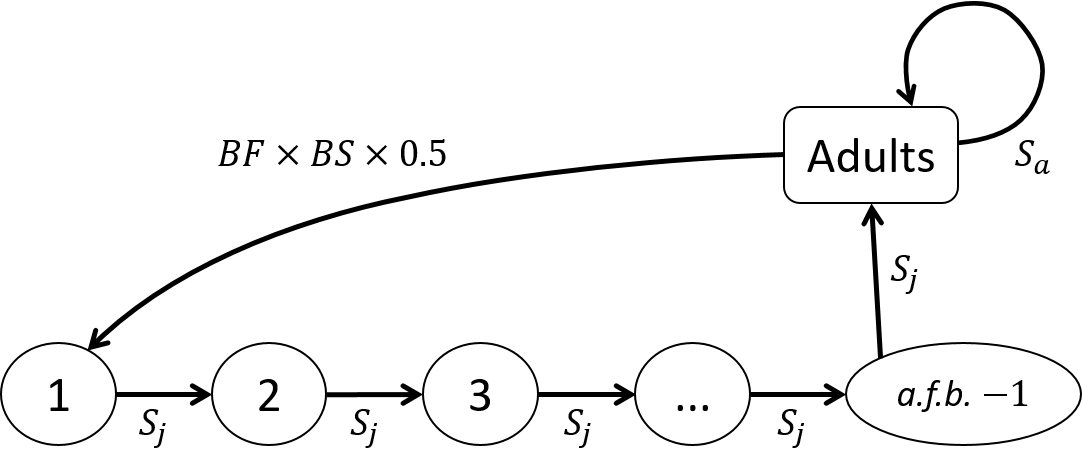
**Appendix S3**

**A framework for mapping the distribution seabirds by integrating tracking, demography and phenology**

More details can be found at <https://github.com/anacarneiro/DensityMaps>

*Demography analysis*

**Figure S1.** State transitions in the general seabird age-structured Leslie-Lefkovitch matrix model used to model a population of females in order to estimate the proportion of each population in each life-history stage, following Abraham et al., (2016). The model has one adult state and one state for each immature year class until recruitment into the breeding population. Each year, a proportion of adult birds and of immature birds survive. All immatures are assumed to recruit into the breeding population at age , the average age at first breeding. For each adult female in the population, first-year female immatures are produced each year, where is the breeding frequency (the approximate proportion of the adult population attempting to breed in any given year), is the breeding success (the proportion of breeding attempts resulting in a fledged chick) and the sex ratio is assumed to be even ().



*Demography modelling*

For each population (each species at each island group), we constructed a matrix model (see Fig. S1) with number of age classes and used the function stable.stage from the R package popbio to calculate the stable stage distribution (R Core Team, 2016; Stubben & Milligan, 2007). The immature age classes were split into “juveniles” (first year fledglings) and “immatures” (sum of all year classes from 2 to recruitment, Fig. S1) in order to create the density distribution maps using juvenile and immature spatial data. The proportion of adults was split into a proportion of adults breeding each year (breeders) and a proportion of adults skipping breeding each year (adult non-breeders) using breeding frequency , where and . The proportion of breeders was further split into successful and fail breeders using breeding success , where and . For more details, please see the R scripts available on GitHub.

*References*

Abraham, E., Yvan, R., & Clements, K. (2016). *Evaluating threats to New Zealand seabirds*. Report for the Department of Conservation, New Zealand.

Stubben, C., & Milligan, B. (2007). Estimating and analyzing demographic models using the popbio package in R. *Journal of Statistical Software*, *22*(1), 1–23. doi: 10.18637/jss.v022.i11