**SUPPORTING INFORMATION**

**Appendix S5**

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

More details can be found at <https://github.com/anacarneiro/DensityMaps> and <https://github.com/lizziepear/seabird-phenology>

*Estimating temporal changes in distribution by incorporating phenology*

The distribution of successful breeders started from the beginning of the breeding season and spanned over breeding and non-breeding periods, including the pre-laying, incubation, brood-guard, post-guard, and non-breeding phases. Utilization distributions during pre-laying, incubation and brood-guard were multiplied by 0.5 as one member of each pair is at the breeding colony at any given time during those stages (Carneiro et al., 2016; Hedd, Montevecchi, Phillips, & Fifield, 2014). When tracking data were not available for the pre-laying phase we used incubation data as a replacement.

For non-breeding adults we considered the non-breeding (sabbatical) distribution during both the breeding and non-breeding seasons. As very few tracks were available for failed breeders, we gave this life-history stage the distribution of successful breeders until half-way through the breeding season, after which they took the distribution of adult non-breeders. This approach accounts for the tendency in many populations for failed breeders to leave the colonies much earlier than successful breeders (Phillips, Lewis, González-Solís, & Daunt, 2017). For populations with breeding seasons spanning slightly longer than one year (e.g. wandering albatross, *Diomedea* *exulans*), we truncated the post-brood period for successful breeders, removing the short time between completion of a full year since the start of pre-laying and fledging of the chick. Curtailing the breeding season to a single year enables the same framework to be used for all species regardless of breeding-season duration.

The distributions of juveniles and immatures were estimated from UDs based on a seasonal combination of tracking data. In several cases, when tracking data were not available for juvenile and immature birds, the juvenile distribution was replaced by the distribution of adults during the non-breeding season, when birds are away from the colony and not constrained by central place foraging, which in many species is likely to be broadly similar to the distribution of juveniles (Clay et al., 2019; Weimerskirch, Åkesson, & Pinaud, 2006). For immatures, unavailable data were substituted with the annual distribution of non-breeding adults as immatures (particularly the older ones) tend to visit the breeding grounds and may have similar strategies to those of breeders, at least during certain periods of the breeding season (Campioni, Dias, Granadeiro, & Catry, 2019; Fayet et al., 2015; Jaeger et al., 2014; Weimerskirch, 2018).

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