**SUPPORTING INFORMATION**

**Appendix S1**

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

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

*Study species*

We apply this framework to 22 of the species listed under the Agreement for the Conservation of Albatrosses and Petrels (ACAP, see <https://www.acap.aq/en/acap-species> for a complete list). These species represent iconic megafauna that have an important role in ecosystem functioning (Lewison et al., 2014), and are of global conservation concern due to interactions with fisheries (Dias et al., 2019; Phillips et al., 2016). Currently, 21 of the 31 species listed under ACAP are threatened with extinction (BirdLife International, 2018), emphasizing the need to map their at-sea distributions. We considered all ACAP species that breed in the Southern Ocean, except for the pink-footed shearwater (*Ardenna creatopus*), southern royal (*Diomedea epomophora*), Campbell (*Thalassarche impavida*) and shy (*T. cauta*) albatrosses for which insufficient tracking data were available in the Seabird Tracking Database (<http://seabirdtracking.org/>) to confidently map their distributions.

*Tracking data compilation and standardisation*

We compiled tracking data deposited in the Seabird Tracking Database (http://seabirdtracking.org/) for our 22 focal species, which includes data from the three most commonly used tracking devices: Global Positioning Systems (GPS), Platform Terminal Transmitters (PTT) and Global Location Sensors (GLS or geolocators). A basic speed filter was applied for PTT data in order to remove erroneous positions with speeds > 90 km/h (McConnell, Chambers, & Fedak, 1992). GLS data are expected to be cleaned prior to uploading in the Seabird Tracking Database, not requiring additional cleaning. PTT and GPS data were linearly interpolated (i.e. rediscretization every hour) to obtain regular positions. Re-sampling was not conducted for GLS data since the locations of tracked birds collected using this type of device are available at regular intervals (approximately 12-hour). All positions within 5 km (for GPS data) and 15 km (for PTT data) of the colony were excluded.

All tracking data were split into data groups (by pooling all data for each combination of species, breeding site, device type, age class and stage of the annual cycle). The classification of tracking data into age and stage of the annual cycle followed the classification provided by data owners when uploading data into the Seabird Tracking Database, with the exception of adult non-breeding, juvenile and immature data. Adult non-breeding distribution data were further split into year quarters for analysis: quarter 1 (Q1, Jan–Mar), quarter 2 (Q2, Apr–Jun), quarter 3 (Q3, Jul–Sep) and quarter 4 (Q4, Oct–Dec); juvenile and immature data were split into summer (both Q4 and Q1) and winter (both Q2 and Q3) periods instead of year quarters to increase data coverage. We assumed that seabird distributions were largely consistent between years (Croxall, Silk, Phillips, Afanasyev, & Briggs, 2005; Guilford et al., 2011; Phillips, Silk, Croxall, Afanasyev, & Bennett, 2005), and data were aggregated over all available years (data ranged from 1989 to 2017). We recognise that distributions may change between years, and results will be more robust where tracking data exist across multiple years, but annual shifts in distribution are fairly small compared to the transoceanic range of all species considered here (Phillips, Lewis, González-Solís, & Daunt, 2017).

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