Commission for the Conservation of
Southern Bluefin Tuna

みなみまぐろ保存委員会

CCSBT-EC/2510/14

ERSWG Chair's report on outcomes from the ERS Tech 2025
(EC Agenda item 9.2)

1. Introduction

The 2025 Technical Ecologically Related Species Working Group meeting (ERS-Tech 2025) was held from 7 to 10 April 2025 in Wellington, New Zealand, as a hybrid meeting.

The role of the ERS-Tech is to advise the ERSWG on issues of a technical nature, and the agenda for ERS-Tech 2025 was limited to:

- finalising a Spatially Explicit Fisheries Risk Assessment (SEFRA) model for seabirds in tuna longline fisheries conducted by CCSBT Members; and
- considering a list of non-target shark taxa to be included in a CCSBT ERS and Bycatch Action Plan to be considered by the Extended Commission.

Australia, Indonesia, Japan, Korea, New Zealand, BirdLife International (BLI) and the Agreement on the Conservation of Albatrosses and Petrels (ACAP), together with the ERSWG Chair, the leader of the modelling team and the CCSBT Seabird Project Manager attended the ERS Tech 2025 meeting in person. South Africa, Taiwan and Humane World for Animals (HWA) attended online.

2. Summary of outcomes from ERS Tech 2025

A detailed summary of the outcomes from the ERS-Tech 2025 meeting is included in **Appendix 1** of this paper. Important points from this outcome summary includes the following points.

Finalising a Spatially Explicit Fisheries Risk Assessment (SEFRA) model for seabirds

- ERS Tech 2025 finalised the CCSBT Spatially Explicit Fisheries Risk Assessment (SEFRA) model for seabirds, building on the 2024 model and addressing key issues identified.
- Australia, Fishing Entity of Taiwan, Japan, New Zealand (two fisheries), Republic of Korea, and South Africa (two fisheries) submitted their data on seabird captures from their observer programs in the agreed format for the combined risk assessment, which included these eight model fisheries. Also, all Members provided total effort of pelagic longlines operating in the southern hemisphere, regardless target species.
- Following the meeting, the modelling team agreed to post the results of the model runs and total catch estimates of the final models.
- The technical report summarising the development and results of the 2025 SEFRA was to be developed collaboratively with participants in the ERS-Tech meeting, with a view to finalising the report in good time for submission to the Extended Commission (EC) meeting in October 2025.
- The finalised SEFRA Model is used for the global risk assessment under the CCSBT Seabird Project without any modifications, and input data for the global risk assessment

would be sought from other nations fishing in the southern hemisphere in a process led by the Project Manager of the CCSBT Seabird Project.

Agreeing a list of non-target shark taxa to be included in a CCSBT ERS and Bycatch Action Plan

- ERS-Tech 2025 concluded that the list of shark species currently included as part of existing ERS data exchange requirements will be considered as the default species for the ERS and Bycatch Action Plan.

3. Request to the EC from the ERSWG Chair

The ERSWG Chair requests the following actions:

- That the EC approve the 2025 SEFRA Technical Report, as presented in **Appendix 2** of this paper, to support the ERSWG's ongoing work in line with the CCSBT Seabird Strategy;
- That the EC approve the release of the SEFRA code to allow its use outside of CCSBT (e.g. within other tuna-RFMOs). Note that such release would be strictly limited to the coding element and will not include any of the input data provided by Members; and
- That the EC determine the timing and venue of the 16th Meeting of the Ecologically Related Species Working Group (ERSWG16), and indicate any specific matters on which it seeks advice from the ERSWG in addition to the standing agenda items.

Prepared by ERSWG Chair

Attachment 1

MEETING SUMMARY: ERS-TECH, 7–10 APRIL 2025

Martin Cryer, ERSWG Chair

6 May 2025

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Introduction

The Ecologically Related Species Working Group's Technical Meeting (ERS-Tech) was held using a hybrid in-person and online format, hosted by New Zealand in Wellington, between 7 and 10 April 2025. The agenda was limited to:

- finalizing a spatially-explicit fisheries risk assessment (SEFRA) model for seabirds in tuna longline fisheries conducted by CCSBT Members; and
- considering a list of non-target shark taxa to be included in a bycatch action plan to be considered by the Extended Commission this year.

Representatives from Australia, Indonesia, Japan, Republic of Korea, and New Zealand, together with the Chair and the leader of the modelling team, were present in Wellington (also online for Australia and Japan). Representatives from the Fishing Entity of Taiwan and South Africa were present online. Birdlife International (BLI), the Agreement on the Conservation of Albatrosses and Petrels (ACAP) and Humane World for Animals (HWA) were present in person and online as observers. Key members of the CCSBT secretariat were present in person and online.

Nominally, each day was to consist of a 3-hour morning hybrid session and a 3-hour afternoon in-person session with the Chair writing a summary of the morning session for the information of online participants. After the first two days, however, all sessions had online participants and this seemed to work well enough.

Risk assessment (SEFRA) for seabirds

Background

A spatially explicit fisheries risk assessment (SEFRA) for seabirds was developed collaboratively by Members for the consideration of ERSWG15 in 2024[1]. Although the results for the great albatrosses were considered broadly reliable, a number of modelling issues needed to be resolved for other seabird groups. The most important of these concerns were the difficulties caused by the occurrence of reported captures of seabirds outside the predicted fisheries-seabird distribution overlap based on seabird tracking information, which was considered to cause biologically implausible updates to the priors for key biological inputs (population size and the probability of breeding in a year). Since ERSWG15, the modelling team had developed software to test different approaches to resolving these issues, guided by two online progress meetings in February and March 2025 where initial fits and diagnostics were examined. The 2025 ERS-Tech meeting was tasked with finalizing a 2025 version of the SEFRA and incorporating as much data from CCSBT Members as possible. Results of model runs conducted during the intersessional progress meeting period and reports summarizing the data inputs were available before the meeting.

Model runs

On the first day, following a summary of model runs developed during the progress meetings in February and March, it was agreed that the following model runs would collectively describe the changes made to the 2024 SEFRA as a basis for forming a candidate 2025 SEFRA model. Results and diagnostics from these models would enable readers or reviewers to understand the impact of each change and form a “bridge” from the 2024 model to the 2025 model.

1. The 2024 model specification fitted to 2024 biological and fisheries input data

[1] *Report of the Technical Working Group on CCSBT collaborative risk assessment for seabird bycatch with surface longlines in the Southern Hemisphere*, Attachment 4 of Report of 15th Meeting of the ERSWG: https://www.ccsbt.org/sites/default/files/userfiles/file/docs_english/meetings/meeting_reports/ccsbt_31/report_of_ERSWG15.pdf

   a. Fit to empirical rather than cumulative captures (to avoid pseudo-replicated use of capture observations and improve the fit to captures of birds identified to high taxonomic levels)
   b. Use revised seabird distribution maps (merged with BLI range maps) and minor revisions to other biological data
   c. Collapse q's (catchability coefficients) for the great albatrosses (to underpin model 1d)
   d. Aggregate captures to the four genus-level capture codes plus collapsed q's for the great albatrosses
   e. Use genus-specific vectors for π (identification probabilities by taxonomic level)
2. Cumulating 1a–e leads to a 2025 model specification fitted to 2025 biological data and 2024 fisheries input data
3. 2025 model specification fitted to 2025 biological data and 2025 fisheries input data using genus-specific π vectors
4. 2025 model specification fitted to 2025 biological data and 2025 fisheries input data split into three time blocks

Examination of the model fits and diagnostics of the above runs revealed that the modifications in the bird distribution maps only slightly reduced the number of recorded captures outside the predicted range of that taxon (model 1b). The biggest improvement to the model diagnostics, however, came from aggregating all capture identifications to the genus level (model 1e), ignoring any species-level identifications of bycaught birds. This almost completely eliminated captures outside predicted ranges, recognizing that identification of seabirds to species level is difficult, especially for bycaught birds that are often bedraggled or damaged. Model diagnostics suggested none of the modifications a–e caused unwanted model behavior and it was agreed that all should be retained (model 2).

Australia, Fishing Entity of Taiwan, Japan, New Zealand (two fisheries), Republic of Korea, and South Africa (two fisheries) (eight model fisheries in all) submitted their data on seabird captures from their observer programs to the meeting in the agreed format for the combined risk assessment. Although Indonesia collected seabird bycatch data with on-board observers, its data were not incorporated into the combined analysis because of time constraints. No information was provided by the European Union. Also, all Members provided total effort of pelagic longlines operating in the southern hemisphere, regardless target species. These data were progressively added to the SEFRA (model 3) and the diagnostics from initial runs suggested no specific reason to change the model specification. Thus, the meeting concluded that the agreed SEFRA model for 2025 includes all five changes a–e to the 2024 SEFRA specification and updated fisheries information.

The fits and diagnostics of models wherein time was split into three blocks (model 4) were examined late in the meeting. Depending on data availability, some fisheries had sufficient data to fit only one or two of the three time-blocks. The meeting agreed that differences in catchability (q) and seabird identifiability (π) among fisheries and between time blocks were largely consistent with Members' perceptions of seabird bycatch occurrence and mitigation management, as well as observation through observers, including electronic monitoring, over time. These patterns, together with acceptable model behaviors, led the meeting to conclude that time-varying catchability on this temporal scale was defensible and informative.

Technical report on the 2025 SEFRA

The meeting discussed the content of a technical report to summarize the development and results of the 2025 SEFRA. The following components were discussed and agreed, pending review of an initial draft.

- Text from the 2024 SEFRA to be used to describe the model structure and estimation procedures with necessary updates to cover the changes made for the 2025 SEFRA;
- Figures and tables from the 2024 SEFRA report to be retained, including necessary and desirable modifications to suit the 2025 SEFRA;
- Sensitivity runs to help describe the total uncertainty around the 2025 SEFRA, in addition to model runs a–e based on the 2024 SEFRA[2];
- A list of outstanding uncertainties and caveats attached to the 2025 SEFRA;
- To avoid any confusion, the report should include separate sections for model development and the final agreed model.

There was divergence in views on how to show geographic distribution of overall risks as well as on potential approaches to identifying higher risk areas. New Zealand agreed to provide a data set of cell location, month, total effort, total deaths per species, and deaths relative to population productivity metrics. Members could use this to explore different methods of identifying areas of higher risk and/or catch rate.

Next steps

ERS Tech 2025 meeting summary report

Within a few days of the meeting, the Chair would draft a summary report for the meeting (this document) recording the key discussions and conclusions. This would be distributed for comments but the final decision on content lies with the Chair.

[2] Members requested a single sensitivity run, with family-specific π (rather than genus).

The Chair will provide an oral summary of the ERS-Tech meeting to the full ERSWG when it meets in 2026. Also available for that meeting will be the ERS-Tech meeting summary report (this document), the technical report summarizing the 2025 SEFRA for CCSBT Members' fisheries, and, potentially, the results of the FAO southern hemisphere risk assessment using the same model.

Final Model run

Following the meeting, the modelling team will post the results of the model runs and total catch estimates of the final models to the shared SEFRA folder. **Members and observers should scrutinize these results carefully and identify any results or fits that appear anomalous to them and report them to the modelling team, the Chair and the secretariat**.

2025 SEFRA Technical Report

The technical report summarizing the development and results of the 2025 SEFRA will be developed collaboratively with participants in the ERS-Tech meeting, with a view to finalizing the report in good time for submission to the Extended Commission meeting in October 2025. A first draft should be available within a few weeks of the ERS-Tech meeting.

Transition to the Seabird Project Global Assessment

The transition to phase 2, the global (southern hemisphere) risk assessment under the FAO/GEF Common Oceans Seabird Project, starts immediately following the ERS-Tech meeting. In practice, it is expected that the global southern hemisphere assessment would use the model finalized at this meeting without any modifications. Data would be sought from other nations fishing in the southern hemisphere in a process led by the Project Manager of the Seabird Project, Dr Ross Wanless, coordinating with interested Members.

An update on progress with the CCSBT SEFRA, and the transition to the global assessment, will be reported to the Extended Commission (6–9 October 2025), although the format for this update has yet to be determined. Therefore, formally, the technical report and description of the 2025 SEFRA will be made available outside CCSBT only after the completion of the Extended Commission. However, this does not prevent the CCSBT Seabird Project Manager from engaging with potential data-contributing, non-CCSBT Members immediately; the agreed 2024 SEFRA Technical Report (Attachment 4 of ERSWG 15 report) can be used as the base material, noting the substantial progress made during the 2025 ERS-Tech process. If required, an intersessional decision by the Extended Commission can be sought to release specific information or documents publicly or to specified parties.

Non-target shark taxa

Background

In 2024, ERSWG 15 agreed to recommend that the Extended Commission adopt (in 2025) the draft ERS Bycatch Plan[3], developed following the Action Plan of the CCSBT Strategic Plan. In line with one of the proposed actions of the plan, Members committed to developing a list of non-target shark species to be covered by this plan, to be finalized at ERS-Tech 2025 (this meeting).

Proposals

The secretariat provided an information paper to describe the background for the discussion about the list of non-target shark taxa to be included in a bycatch action plan. Australia proposed the addition of several shark species to the list and New Zealand proposed to add a single species of thresher shark. At the start of the discussion, Australia revised their position to support New Zealand's proposal on the basis that this would cover the majority of shark captures in SBT fisheries.

Discussion

After a short discussion of the costs and benefits of expanding the list of non-target shark species, Members agreed that a better plan would be to engage more closely with other tuna RFMOs that are already collating the necessary information and conducting stock assessments and other appraisals. If CCSBT Members had access to these analyses, they would better be able to assess whether CCSBT's alignment of management measures with other tuna RFMOs was sufficient to mitigate risk to non-target bycatch species. The list of shark species currently included as part of existing ERS data exchange requirements will be considered as the default species for the ERS Bycatch Plan.

Next steps

The Extended Commission will consider the proposed Bycatch Action Plan at its meeting in October 2025.

Members will facilitate closer engagement between CCSBT and other tuna RFMOs, especially by ensuring analyses and assessments from other tuna RFMOs are available for discussion by ERSWG, starting in 2026.

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[3] The ERS Bycatch Plan does not cover seabirds and should be seen as complementary to the Multi-Year Seabird Strategy

Other issues

Two information papers were provided by Birdlife International:

- A copy of a paper from the journal *Biological Conservation* describing 20 years of work on the Seabird Tracking Database, and
- A copy of a paper to the WCPFC Commission in November-December 2024 reviewing that RFMO's Conservation and Management Measure to mitigate the impact of fishing for highly migratory fish stocks on seabirds.

A national report was submitted by Indonesia.

The Chair highlighted these three papers for Members' information and attention and especially thanked Indonesia for their national report.

End of meeting

The meeting had been planned to cover the five days 7 to 11 April 2025. However, the agenda had been covered by the afternoon session of 10 April and the meeting was therefore closed. The Chair thanked the modelling team for their excellent support, Members for their helpful and collegial discussions, and online participants for their patience with the occasional difficulties with audio. He wished safe travels to all, encouraged them to enjoy the delights of Wellington while the weather was nice, and looked forward to seeing papers on both seabirds and sharks at the ERSWG in 2026.

Attachment 2

Commission for the Conservation of
Southern Bluefin Tuna

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Report of the Technical Working Group on

CCSBT collaborative risk assessment for seabird bycatch with surface longlines in the Southern Hemisphere 2025

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1. ABSTRACT

A quantitative, spatially-explicit risk assessment for 25 taxa of albatrosses and petrels potentially caught in surface longline fisheries by participating Members of the CCSBT (Australia, Japan, Korea, New Zealand, South Africa, and the Fishing Entity of Taiwan) is described. This 2025 Spatially Explicit Fisheries Risk Assessment (SEFRA) builds on the 2024 SEFRA tabled at the CCSBT's ERSWG15 in April 2024. Diagnostics suggest that the 2025 SEFRA model had converged, fitted the data very well, and did not appreciably update any of the priors for biological inputs. The key concerns raised about the 2024 iteration have been resolved in the 2025 iteration in that: conflicts between estimated overlap of fishing and seabirds and the observed captures (i.e., the presence of observed captures where the estimated overlap was zero) have been resolved; and the fitted models no longer require implausible updates to the priors on biological inputs. Updating the available information on seabird distributions reduced the number of "zero overlap captures" somewhat but fitting to genus-level (or higher) capture data (as opposed to species-level, where available) was by far the most influential change. The broad patterns of estimated risk were similar in the 2024 and 2025 SEFRA models; Gibson's albatross, Amsterdam albatross, Tristan albatross and Sooty albatross were the taxa estimated to be at highest risk in both model iterations. The estimated risk for many seabird taxa was higher in the 2025 SEFRA than in the 2024 SEFRA because the lower risk for many taxa in the 2024 SEFRA appears to be largely an artefact caused by data conflicts and the consequent updates to biological priors. At the scale of 5-degree squares, estimated annual deaths of great albatrosses and mollymawks were highest in the Tasman Sea, south-eastern Indian Ocean and south-eastern Atlantic Ocean. Sooty albatross deaths were highest in the south-eastern Atlantic Ocean and in the Tasman Sea. Deaths of medium petrels were highest around South Africa and off Namibia, and in the south-eastern Pacific Ocean. The 2025 SEFRA was not very sensitive to fitting to capture data aggregated to family-level (or higher) but was somewhat more sensitive to fitting only to data from 2012–2019 (as in the 2024 SEFRA). This is thought to be due to lower catchability in more recent years. A 2025 SEFRA with three time-blocks (2012–2016, 2017–2019, 2020–2023) appears to provide useful estimates of catchability and mortality for great albatrosses and mollymawks. Catchability was estimated to be somewhat lower since 2020 for some fleets. Several uncertainties and caveats remain but the 2025 SEFRA is considered to be a substantial improvement on the 2024 version.

2. BACKGROUND and INTRODUCTION

The issue of substantial interactions between SBT fisheries and seabirds was well recognised even at the time of establishment of the CCSBT in 1994. An initial draft of recommendations on reducing the incidental bycatch of seabirds was developed in 2006 at the 6th meeting of the CCSBT Ecologically Related Species Working Group (ERSWG), which ignited the debate whether the CCSBT can make binding measures for ERS related issues. Subsequently, the 7th meeting of ERSWG could not reach agreement on draft recommendations. The debate around the CCSBT's legal capacity to establish mandatory measures on ERS related matters continued until 2018 when the CCSBT agreed on the Resolution to Align CCSBT's Ecologically Related Species measures with those of other tuna RFMOs at the 25th Annual Meeting, which was updated at the 28th Annual Meeting in 2021.

A Performance Review was conducted in 2008 that criticised the ERSWG and pointed to, at the very least, a need to assess the risks and impacts of SBT fisheries on ERS species and adopt an appropriate mitigation strategy to address those risks and impacts. In response, the 15th Annual Commission meeting in 2008 agreed to develop a non-binding recommendation for the CCSBT covering bycatch mitigation for seabirds, sea turtles and sharks. Additionally, it agreed to develop a Strategic Plan and established Strategy and Fisheries Management Working Group. The Plan was adopted at a Special Meeting held in 2011, which included three items and seven action items under the ERSWG.

In 2014, the Strategy and Fisheries Management Working Group was re-established to discuss revisions of the action plan. At the same time, following the recommendation of ERSWG, a small technical group, Effectiveness of Seabird Mitigation Measures Technical Group (SMMTG), was established to provide advice to the ERSWG on feasible, practical, timely, and effective technical approaches for measuring and monitoring the effectiveness of seabird mitigation measures in SBT longline fisheries. Both groups tabled their reports in 2015. The ERSWG took the SMMTG recommendations to progress in two directions: 1) undertaking a global assessment of seabird bycatch collaboratively among all tuna RFMOs through the support of the ABNJ Tuna Project Seabirds component that was concluded in 2019 (Abraham et al 2019), and 2) developing an ERSWG work plan. The latter led to the development of the CCSBT Multi-year Seabird Strategy, which was adopted at the 26th Annual Meeting of CCSBT.

A range of actions to be undertaken under each specific objective of the Multi-year Seabird Strategy was developed at the 14th meeting of ERSWG in 2021 and adopted by the 29th Annual meeting of CCSBT, which included an action to "update SEFRA seabird risk assessment" (1E) with New Zealand and Japan volunteering to take a leading role inter-sessionally. This would also allow work to "assess the cumulative impacts of fishing for SBT on seabirds, particularly threatened albatross and petrel species, across tuna RFMOs including developing methods for extrapolating seabird bycatch levels and seabird bycatch rates to identify total mortalities and total mortality rates" (3D) to be undertaken.

New Zealand and Japan held initial discussions in Wellington, New Zealand in June 2022 and agreed on a tentative work plan that included two technical workshops, one online and the other hybrid, and one face-to-face data preparatory meeting (Appendix 1). It was also agreed that the CCSBT collaborative assessment would begin after the completion of a seabird risk assessment of fisheries within New Zealand and would be developed based on the model developed for the New Zealand domestic risk assessment.

Following the decision at the 29th meeting of the Commission to hold one technical workshop before ERSWG-15, the original work plan was modified to hold one combined meeting to review the Spatially Explicit Fisheries Risk Assessment (SEFRA) procedure developed by New Zealand and to agree on basic data requirements in 2023, and one assessment meeting online, but with voluntary participation face-to-face.

The first technical workshop (hybrid) was held in Wellington, New Zealand, from 21 to 22 June 2023 with the participation of Australia, Japan, New Zealand and the Fishing Entity of Taiwan. Agreed outcomes from the meeting can be found in Appendix 2. The meeting agreed the first collaborative assessment would be based on the best available science and knowledge and provide a basis for future regular assessments with continuous improvements. The technical workshop agreed a range of basic assumptions, the time-period subject to the analysis, a range of species to be covered, and the temporal and spatial resolutions. The workshop established two expert teams: 1) for reviewing seabird biological parameters and distribution data, and 2) for incorporating modifications agreed at the workshop and evaluating them, together with the draft work schedule.

A review of biological parameters was shared among the group in January 2024. The New Zealand domestic seabird risk analysis was concluded in October 2023 and the program package including seabird observed catch and effort preparation package was provided in late 2023. Thereafter, the Members processed the observed seabird catch and effort data and ran the model for catchability estimation independently, using each Member's domestic information.

The second technical workshop (hybrid) was held in Wellington, New Zealand, from 27 to 29 February 2024 with participation from Australia, Japan, New Zealand and the Fishing Entity of Taiwan. The workshop reviewed the model outputs step-by-step and evaluated the reliability/ feasibility of estimated parameters. The workshop noted problems in estimating species-specific catch, mainly due to potential errors in observed seabird identification, and a mismatch in overlap caused by partial coverage of bird density distribution information with tracking data.

Consequently, the workshop agreed to further modify the model by incorporating new aggregation as a species complex for those species difficult to identify at species level. Observed capture and observed overlaps were summed across species within the species complex during the model fitting. Therefore, the model would ignore the species identification confusion within a species complex but would make a prediction of total mortality at species level relying on the overlap information (discussed further in section 4.2). The revised procedure was reviewed at an online discussion held on 4 April 2024 that confirmed general consistencies between the predicted and observed catches with the agreed aggregations.

The technical group examined the outputs of the modified model including the estimates of total bycatch mortalities and corresponding risks at an online discussion held on 23 April, 2024. The technical group noted that at least two of the biological parameters (the number of breeding pairs and the probability of breeding for some species) show a large shift away from the priors when the model was run (discussed further in Section 4.3). This would impact on the assessment of catchability estimates and evaluation of relative risks in particular for small albatrosses (mollymawks) and medium petrels, so the model output for those species groups should be interpreted carefully.

This document describes the process and results of the CCSBT collaborative seabird risk assessment for the surface longline fishery using the SEFRA framework. The document includes the methodology used, assumptions, input data and their preparation, initial review results and subsequent model modifications, and the final outputs. The document is focused on the description of facts and observations and does not include interpretations, particularly on potential implications for CCSBT seabird management.

While the outputs of the SEFRA update are expected to provide a basis for addressing other actions in the CCSBT Multi-year Seabird Strategy, including "to agree on a SBT seabird bycatch target for reducing the level of impact of SBT fishing operations on seabird populations" (1A), to "agree on the list of priority species and corresponding management targets, taking into account the status of seabird population, distributional overlaps with SBT fisheries, and significance of SBT fisheries in their mortality" (1D), and "establish a robust definition of high risk areas that takes into account the precautionary approach" (1F), such considerations are left to the individual Members and subsequent discussions at the ERS.

3. METHODS

The SEFRA model was based on that used for CCSBT's 2024 seabird risk assessment (Anon., 2024; Edwards et al., 2025b), and is described here in full for clarity.

3.1 General concept of SEFRA

The Spatially Explicit Fisheries Risk Assessment (SEFRA) framework used in this risk assessment was developed and has been utilised in New Zealand as standard procedure to estimate the risk to seabirds and other protected species caused by commercial fishing (Edwards et al. 2023, Abraham et al. 2017, Sharp 2019) and subsequently applied to the capture of albatrosses and petrels in southern hemisphere longline fisheries (Ochi et al 2018, Abraham et al. 2019). A glossary of model terms is provided in Table 1.

The framework is designed to accommodate multiple species and fisheries simultaneously, constructing risk profiles as a function of spatial and temporal overlap. Application has been primarily within the New Zealand Exclusive Economic Zone (EEZ; e.g., Richard & Abraham 2015, Richard et al. 2017, 2020), but, since seabirds migrate widely across the southern hemisphere, a comprehensive assessment of the fisheries risk needs to account for all the fishing effort that may be encountered as the birds move through international waters. This has motivated application of the method in a wider context.

The SEFRA approach is a quasi-spatial model where temporal and spatial overlap of the seabird distribution and fishing effort are used to predict catch. Parameterisation of the capture rate per unit of overlap occurs via a fit to fisheries observer capture data, and total captures are calculated by multiplication of the total overlap (including the unobserved component) with this estimated rate (referred to as the catchability). Deaths are calculated from the predicted captures using a mortality multiplier that accounts for the probability of dead capture and cryptic mortality. Following estimation of the total deaths, the SEFRA approach often quantifies risk using a limit reference point referred to as the Population Sustainability Threshold (PST; Sharp 2019).

PST per species s is calculated as:

$$PST_s = \frac{1}{2} \cdot \varphi \cdot r_s \cdot N_s \tag{1}$$

where r_s is the theoretical unconstrained maximum population growth rate (i.e., under optimal conditions and in the absence of density dependent constraints), and N_s is the total population size, which we assume in the current setting to be the total number of adults. φ is an adjustment factor used by management to ensure that deaths equal to the PST correspond to a defined population stabilisation or recovery objective. In this risk assessment, φ was set to 1.

Risk ratios per species are calculated as:

$$\text{risk ratio} = \frac{D_s}{PST_s} \tag{2}$$

However, this assessment only considers fishing using surface longlines by CCSBT members and, therefore, cannot estimate overall risk to the population from fishing. Since the PST reference point is designed to allow a measurement of risk, and includes management related tuning parameters, the comparison of deaths to the PST may be misleading. Following the 2024 CCSBT risk assessment, therefore, the 2025 SEFRA compares deaths with the theoretical maximum growth rate in numbers per year, i.e., $r_s \cdot N_s$, using relative mortalities defined as:

$$\text{relative mortality} = \frac{D_s}{r_s \cdot N_s} \tag{3}$$

The relative mortality approach typically provides the same relative ranking as that achieved using the PST reference point, because the φ term is commonly assumed to be the same for all species during comparative assessments.

3.2 Seabirds potentially at risk of capture in the CCSBT fishery

Estimates of seabird population size are typically reported as the number of breeding pairs per colony. The number of adults per species (s) was therefore calculated from the global sum of the number of breeding pairs and the probability of breeding:

$$N_s^{\text{adults}} = 2 \cdot \frac{N_s^{\text{BP}}}{P_s^{\text{B}}} \tag{4}$$

The number of adults available to be caught by longline fishing fleets of CCSBT Members during any month of the year was determined from the probability that they are in the southern hemisphere (SH), the probability that they are breeding, and whether they are likely to be attending the nest whilst doing so. The number of available adults per species and month (m) is:

$$N_{s,m} = N_s^{\text{adults}} \cdot \left(1 - P_s^{\text{B}} \cdot P_{s,m}^{\text{nest}}\right) \cdot P_{s,m}^{\text{SH}} \tag{5}$$

Outside the breeding season the probability of attending the nest is typically zero, (i.e. $P_{s,m}^{\text{nest}} = 0$), and all adults in the southern hemisphere are considered available to fishing gear.

The number of adults available for capture by CCSBT longline fleets ($N_{s,m}$; Equation 5) was used for predicting captures and fitting the model, whereas the total adult population size (N_s^{adults}; Equation 4) was used for calculation of the risk ratios and relative mortalities.

3.3 Spatial overlap

The SEFRA model requires that the individuals available to be caught are represented as a spatial distribution. In this case, spatial distributions were estimated from tracking data (see Section 4.2). The spatial distribution is treated as a fixed data input and described using a density term ($d_{s,m,x}$) per species s, grid cell x and month m. Specifically, if $y_{s,m,x}$ is the number of birds in grid cell x and A_x is the area of grid cell x in square kilometres, then:

$$d_{s,m,x} = \frac{y_{s,m,x}}{A_x \cdot \sum_x y_{s,m,x}} \tag{6}$$

The value $y_{s,m,x} / \sum_x y_{s,m,x}$ is effectively being treated as the multinomial sampling probability of an individual being in grid cell x during that month. The absolute density, in number of birds per square kilometre, is therefore:

$$\mathbb{D}_{s,m,x} = d_{s,m,x} \cdot N_{s,m} \tag{7}$$

If fishing effort ($a_{f,m,x}$) for each fishery group f is allocated to grid cell x, and assuming a uniform distribution of birds and fishing effort within that cell, then we can construct an overlap metric that measures the opportunity for interaction between a bird population and fishing effort:

$$\text{overlap}_{f,s,m,x} = a_{f,m,x} \cdot d_{s,m,x} \tag{8}$$

The overlap provides a measure of the exposure of birds to fishing effort at a particular time and place, relative to the population as a whole. To estimate the catchability, SEFRA uses the density overlap, $\mathbb{O}_{f,s}$, given by:

$$\mathbb{O}_{f,s} = \sum_{m,x} a_{f,m,x} \cdot \mathbb{D}_{s,m,x} \tag{9}$$

The density overlap is a summation across grid cells and months, per species and fishery, and provides an input to the regression model.

3.4 Prediction of captures per species

Multiplication of the density overlap ($\mathbb{O}_{f,s}$) with the catchability ($q_{f,z}$) yields the model predicted captures per species and fishing fleet:

$$C_{f,s} = q_{f,z} \cdot \mathbb{O}_{f,s} \tag{10}$$

The catchability itself is a function of fishery group (f) and species group (z) covariates:

$$\log(q_{f,z}) = \beta_0 + \beta_f + \beta_{z|f} \quad (11)$$

where the fishery group coefficient β_f is centred on the intercept term, with deviations around this intercept constrained to sum to zero. Species group coefficients ($\beta_{z|f}$) were specific to the fishery group and were similarly constrained to sum to zero. This allowed the catchability per species group to deviate from the fishery group effect in a fishery group-specific manner.

The probability of live capture was a function of fishery group (f) and species group (z) covariates:

$$\text{logit}(\Psi_{f,z}) = \gamma_0 + \gamma_f + \gamma_{z|f} \quad (12)$$

where γ_0 is an intercept term and with coefficients γ_f and $\gamma_{z|f}$ similarly constrained to sum to zero. Predictor coefficients for the catchability (β_f and $\beta_{z|f}$) and live capture (γ_f and $\gamma_{z|f}$) were given standard normal priors, whereas the intercept terms β_0 and γ_0, were given improper (unbounded) prior distributions.

3.5 Prediction of captures per capture code

The model predicts captures per species. However, observed captures of seabirds are not always identified to a species level. In order to fit the model to observed captures, it is necessary to assign the predicted captures per species to one or more capture codes that reflect the taxonomic resolution of identifications by observers (Table 3). For example, captures of Gibson's albatross may have been identified to a species complex level (capture code DWC), a genus (DIZ) or family (ALZ) level, or as an unspecified bird (BLZ).

A vector of probability terms is used to predict the captures per capture code: $\boldsymbol{\pi}$, which are a set of probabilities describing the taxonomic resolution to which a species capture is identified (Edwards et al., 2025b). These probabilities are estimated per fishery group, but the f subscript is omitted for clarity of presentation:

$$\boldsymbol{\pi} = \{\pi_{\text{subgenus}}, \pi_{\text{genus}}, \pi_{\text{family}}, \pi_{\text{class}}\} \quad (14)$$

The 'subgenus' probability term refers to captures recorded at either the species-level or as part of a species complex (Table 3). This approach requires the condition that there is at most one capture code per species at each taxonomic resolution. This required adjusting the capture codes used for the initial data preparation, with the removal of species-specific capture codes for the royal albatrosses, i.e., southern royal (*Diomedea epomophora*) and northern royal albatross (*D. sanfordi*), and black-browed albatrosses, i.e., black browed (*Thalassarche melanophris*) and Campbell black-browed albatross (*T. impavida*). Otherwise, the capture codes used for the initial data preparation were consistent with those used in the 2024 risk assessment (Anon., 2024).

We can also define:

$$\begin{aligned}
\pi^{+}_{\text{subgenus}} &= \pi_{\text{subgenus}} \\
\pi^{+}_{\text{genus}} &= \pi_{\text{subgenus}} + \pi_{\text{genus}} \\
\pi^{+}_{\text{family}} &= \pi_{\text{subgenus}} + \pi_{\text{genus}} + \pi_{\text{family}} \\
\pi^{+}_{\text{class}} &= \pi_{\text{subgenus}} + \pi_{\text{genus}} + \pi_{\text{family}} + \pi_{\text{class}} = 1
\end{aligned} \quad (15)$$

These are the cumulative probabilities, i.e., the probability of a capture being recorded at that taxonomic resolution or higher, or to "at least" that resolution. For example, for southern royal albatross, π_{genus} gives the probability that a captured individual was identified as a great albatross (DIZ), and π^+_{genus} the probability that the individual was identified as either a great albatross (DIZ) or an unspecified royal albatross (DRA).

The cumulative probabilities have the property that:

$$\pi^+_{\text{subgenus}} \leq \pi^+_{\text{genus}} \leq \pi^+_{\text{family}} \leq \pi^+_{\text{class}} \tag{16}$$

As described above, the $\boldsymbol{\pi}$ and $\boldsymbol{\pi}^+$ probability vectors are specific to a fishery group. Within each fishery group, the probability vectors can be shared amongst groups of species, e.g., shared amongst all species within a genus, family, or species group (z).

Using either the $\boldsymbol{\pi}$ or $\boldsymbol{\pi}^+$ probability vectors we can now predict the observed captures per capture code from the model predicted captures per species. We use the following notation.

The observed data are:

- C_k: captures per capture code k, referred to as "empirical captures";
- C_k^+: cumulative sum of the captures per capture code k (i.e., the sum of all observed captures to capture code k or a higher taxonomic resolution);

and the model predictions are:

- $\hat{C}_s$: captures per species s;
- $\hat{C}_k$: captures per code k;
- $\hat{C}_k^+$: cumulative sum of the captures per code k.

The relationship between observations C_k and C_k^+ can be written explicitly using a two-dimensional matrix. A simplified example is provided here (using capture codes from Table 3), assuming that only Gibson's albatross (DIW), Salvin's albatross (DKS), and sooty albatross (PHU) are being assessed. Note there is no species-level capture code for Gibson's albatross (DIW). In this example, the relationship between the observed captures per capture code (C_k) and the cumulative sum of the observed captures (C_k^+) is:

$$\begin{bmatrix} C^+_{DKS} \\ C^+_{PHU} \\ C^+_{DWC} \\ C^+_{DIZ} \\ C^+_{THZ} \\ C^+_{PHZ} \\ C^+_{ALZ} \\ C^+_{BLZ} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix} \times \begin{bmatrix} C_{DKS} \\ C_{PHU} \\ C_{DWC} \\ C_{DIZ} \\ C_{THZ} \\ C_{PHZ} \\ C_{ALZ} \\ C_{BLZ} \end{bmatrix} \quad \begin{array}{c} \text{Salvin's albatross} \\ \text{Sooty albatross} \\ \text{Wandering complex} \\ \textit{Diomedea}\text{ spp.} \\ \textit{Thalassarche}\text{ spp.} \\ \textit{Phoebetria}\text{ spp.} \\ \text{Diomedeidae} \\ \text{Bird} \end{array} \tag{17}$$

The relationship between the model predicted captures per species ($\hat{C}_s$; right-hand side of equation) and the predicted captures per capture code ($\hat{C}_k$; left-hand side of equation) is:

$$\begin{bmatrix} \hat{C}_{DKS} \\ \hat{C}_{PHU} \\ \hat{C}_{DWC} \\ \hat{C}_{DIZ} \\ \hat{C}_{THZ} \\ \hat{C}_{PHZ} \\ \hat{C}_{ALZ} \\ \hat{C}_{BLZ} \end{bmatrix} = \begin{bmatrix} 0 & \pi_{\text{subgenus}\,(DKS)} & 0 \\ 0 & 0 & \pi_{\text{subgenus}\,(PHU)} \\ \pi_{\text{subgenus}\,(DIW)} & 0 & 0 \\ \pi_{\text{genus}\,(DIW)} & 0 & 0 \\ 0 & \pi_{\text{genus}\,(DKS)} & 0 \\ 0 & 0 & \pi_{\text{genus}\,(PHU)} \\ \pi_{\text{family}\,(DIW)} & \pi_{\text{family}\,(DKS)} & \pi_{\text{family}\,(PHU)} \\ \pi_{\text{class}\,(DIW)} & \pi_{\text{class}\,(DKS)} & \pi_{\text{class}\,(PHU)} \end{bmatrix} \times \begin{bmatrix} \hat{C}_{DIW} \\ \hat{C}_{DKS} \\ \hat{C}_{PHU} \end{bmatrix} \tag{18}$$

which has the property that $\sum_k \hat{C}_k = \sum_s \hat{C}_s$ because each species-level predicted capture is partitioned between the possible capture codes using probabilities that sum to one; i.e., for each species, $\pi_{\text{subgenus}} + \pi_{\text{genus}} + \pi_{\text{family}} + \pi_{\text{class}} = 1$.

The relationship between model predicted captures per species ($\hat{C}_s$; right-hand side of equation) and the cumulative sum of model predicted captures per capture code ($\hat{C}_k^+$; left-hand side of equation) is:

$$\begin{bmatrix} \hat{C}^+_{DKS} \\ \hat{C}^+_{PHU} \\ \hat{C}^+_{DWC} \\ \hat{C}^+_{DIZ} \\ \hat{C}^+_{THZ} \\ \hat{C}^+_{PHZ} \\ \hat{C}^+_{ALZ} \\ \hat{C}^+_{BLZ} \end{bmatrix} = \begin{bmatrix} 0 & \pi^+_{\text{subgenus}\,(DKS)} & 0 \\ 0 & 0 & \pi^+_{\text{subgenus}\,(PHU)} \\ \pi^+_{\text{subgenus}\,(DIW)} & 0 & 0 \\ \pi^+_{\text{genus}\,(DIW)} & 0 & 0 \\ 0 & \pi^+_{\text{genus}\,(DKS)} & 0 \\ 0 & 0 & \pi^+_{\text{genus}\,(PHU)} \\ \pi^+_{\text{family}\,(DIW)} & \pi^+_{\text{family}\,(DKS)} & \pi^+_{\text{family}\,(PHU)} \\ 1 & 1 & 1 \end{bmatrix} \times \begin{bmatrix} \hat{C}_{DIW} \\ \hat{C}_{DKS} \\ \hat{C}_{PHU} \end{bmatrix} \tag{19}$$

which has the property that $\hat{C}^+_{BLZ} = \sum_s \hat{C}_s$. This is useful because the total number of bird captures is independent of the estimated $\boldsymbol{\pi}$ terms. Equality of model prediction $\hat{C}^+_{BLZ}$ and the observed value C^+_{BLZ} ensures that the model is accurately predicting the total number of bird captures.

3.6 Parameter estimation

Equations 18 and 19 can both be used to construct a likelihood for the model fit, based on predicted and observed ‘empirical captures’ (Equation 18), or predicted and observed cumulative captures (Equation 19). As described above, cumulative capture data have the property that the cumulative captures at a class level ($\hat{C}^+_{BLZ}$) is equal to the total catch across species, and is independent of the estimated $\boldsymbol{\pi}$ terms. In the 2024 risk assessment, the model was fitted to cumulative captures data, on the expectation that the sum of the captures should be a more reliable data point than captures at finer taxonomic resolutions. A consequence of the approach is that, when calculating the cumulative sum, the data are being pseudo-replicated. In the 2025 risk assessment, fits to cumulative and empirical captures were both explored, and predicted and observed cumulative captures compared for both likelihoods to ensure that the model was accurately predicting total captures.

The model was fitted to the capture data using a Poisson likelihood conditioned on either the cumulative captures:

$$C_k^{+} \sim Poisson\left(\hat{C}_k^{+}\right) \tag{20}$$

or empirical captures:

$$C_k \sim Poisson\left(\hat{C}_k\right) \tag{21}$$

A Binomial likelihood function, conditioned on the number of captures for which life status was recorded, was used to estimate the probability of a capture being alive ($\Psi_{f,z}$).

Estimated parameters are listed in Table 1. Estimation of the vector of $\boldsymbol{\pi}$ values allows the model to predict $\hat{C}_k^{+}$ from $\hat{C}_s$ and $\boldsymbol{\pi}^{+}$ (Equation 19), as well as $\hat{C}_k$ (Equation 18). Biological parameters N_s^{BP} and P_s^{B} were estimated, with strongly informed priors, whereas $P_{s,m}^{\mathrm{SH}}$ and $P_{s,m}^{\mathrm{nest}}$ were fixed on input. Estimation of N_s^{BP} and P_s^{B} allows incorporation of uncertainty in these parameters (through the prior distribution), and is justified because these parameters are the most important determinants of the number of birds available for capture (Equations 4 and 5). The model is able to fit the captures data by changes in either $q_{f,z}$ or $N_{s,m}$, and by estimating $N_{s,m}$ we can use it as a diagnostic of the model fit. In a correctly specified model, we would not expect N_s^{BP} or P_s^{B} to be updated from their prior values. If this occurs, it can indicate a deficiency in either the data or the structural assumptions, which can then be investigated. Usually, it would indicate that $q_{f,z}$ is constrained in a way that prevents it from adequately describing the data, requiring the model to update $N_{s,m}$ instead. If only minor updates occur, then these are incorporated directly into the estimates of risk ratios and relative mortality estimate, ensuring internal consistency. For the same reasons S_s^{opt} and A_s^{curr} (see below) are also estimated, because these are used internally by the model for estimation of r_{max}. Similar to the other biological parameters, they are provided with informative priors, which we do not expect to be updated. If updates do occur, then this approach allows deficiencies in either the data or the model to be diagnosed, whilst maintaining consistency between the parameters required for calculation of the relative mortality.

All estimation was performed within a Bayesian framework using rstan (Stan Development Team 2020). Two chains were run for 1,000 iterations each, with the first half discarded. Posterior samples from estimated parameters were inspected visually to ensure convergence of the model. Assessment of the model fit to the data was based on comparisons of values of C_k^{+} and $\hat{C}_k^{+}$, and C_s^{+} and $\hat{C}_s^{+}$. Finally, we inspected updates to the biological inputs, particularly N_s^{BP} and P_s^{B}. If either of these demonstrated strong prior updates then this would indicate model mis-specification or data deficiencies.

3.7 Prediction of total deaths

During the fitting process we estimate the catchability $q_{f,z}$ (Equation 11), which describes the rate of observed capture per unit of density overlap. Using this estimated value, we can then predict the total observable captures across all the fishing effort included in the assessment. However, observable captures are only a subset of the total captures resulting from the interaction between fishing effort and birds, as some captures are cryptic, i.e., unobservable even were an observer present.

To calculate the number of deaths from the number of observable captures we used a mortality multiplier ($\kappa_{f,z}$). We assume that captures that occur during setting invariably cause death by drowning, and can be lost (and so unobservable), but that live birds are caught during the haul and are always observable. To estimate the total number of deaths we therefore need $\kappa_{f,z}$ to account for drowned birds that are lost, and live birds that die post-release.

The probability of a bird being alive at capture ($\Psi_{f,z}$) was estimated as part of the model fit; for this assessment it was assumed that almost all seabirds that were caught subsequently died (post-release survival was given a mean value of $\omega = 0.01$). For birds caught during setting and subsequently lost, it was decided to use the surface longline multipliers (K) from Edwards et al. (2023, see their Table 4), based on the analysis of the dataset from Brothers et al (2010) by Zhou et al (2019).

The total number of deaths for the surface longline fishery groups was therefore predicted from the estimated values of $q_{f,z}$ and $\Psi_{f,z}$ using:

$$D_{f,s} = q_{f,z} \cdot \mathbb{O}_{f,s} \cdot \left(\Psi_{f,z} \cdot (1-\omega) + \left(1 - \Psi_{f,z}\right) \cdot K\right) \tag{22}$$

where:

$$\kappa_{f,z} = \Psi_{f,z} \cdot (1-\omega) + \left(1 - \Psi_{f,z}\right) \cdot K \tag{23}$$

All deaths were generated using posterior predictive simulation from a Poisson distribution conditioned on the expected value. The number of total deaths per species is a summation of the deaths across fishery groups:

$$D_s = \sum\nolimits_f D_{f,s} \tag{24}$$

The total deaths can then be compared against relative mortality to calculate the relative species-specific risk (Equation 3).

3.8 Theoretical maximum intrinsic growth rate (r_s)

For the relative mortality reference point, we are required to estimate a distribution for $r_s = \ln(\lambda_s)$. This was achieved using allometric theory. Following the approach of Niel & Lebreton (2005), and dropping species subscripts, mean generation time is first approximated as:

$$\bar{T} = A + \frac{S}{\lambda - S}$$

Allometric theory defines the optimal generation time such that:

$$T_{[opt]} \cdot \ln(\lambda) = k$$

where $k \approx 1$ is a constant. Therefore, under constant fecundity and assumed optimal conditions we can write:

$$\frac{k}{\ln(\lambda)} = A + \frac{S^{\mathrm{opt}}}{\lambda - S^{\mathrm{opt}}}$$
$$\Rightarrow \lambda = \exp\left(k \cdot \left(A + \frac{S^{opt}}{\lambda - S^{opt}}\right)^{-1}\right) \tag{25}$$

which can be solved numerically. This provides the so-called demographic-invariant solution for λ that has been used for all applications of the SEFRA methodology to date.

To implement this approach, we required information on the optimum survivorship (S_s^{opt}) and the current age at first breeding (A_s^{curr}), with the latter assumed to be indicative of the current environmental conditions. These were treated as estimated parameters within the model, each with strongly informative priors. In this way, local minimisation of Equation 25 (i.e., using a root finding algorithm to estimate λ), could be performed for each posterior sample of S_s^{opt}, A_s^{curr}, P_s^{B} and N_s^{BP}, to calculate the product $r_s \cdot N_s^{\mathrm{adults}}$ as a model output.

3.9 Species groups and fisheries groups

The 2025 risk assessment covered all ACAP albatross species and *Procellaria* petrel species that primarily occur in the southern hemisphere (Table 2), representing 23 of the 31 ACAP albatross and petrel species. Here, Antipodean (*Diomedea antipodensis antipodensis*) and Gibson's albatross (*D. a. gibsoni*) as well as northern (*T. bulleri bulleri*) and southern Buller's albatross (*T. b. platei*) are considered separately, as they likely have different risk profiles, resulting in a total of 25 taxa under assessment. These species were grouped into "species groups" according to their ecology and behaviour. The catchability was shared across species within a species group, assuming that their vulnerability to fishing is determined by these shared behavioural characteristics. Five species groups were initially assumed: wandering albatross; royal albatross; mollymawks; sooty albatross; and medium petrels, with the definition of species groups refined as the risk assessment progressed (see Section 5). Following the 2024 SEFRA, *Macronectes* spp have been excluded because data are limited and current conservation status is relatively favourable.

The fishery coverage of the assessment was defined as surface longline fisheries operated by the CCSBT members in the southern hemisphere, regardless of target species, in the period from 2012 to 2023 inclusive. Individual members of the CCSBT were each treated as one fishery group, except the joint-venture (JV) operations between New Zealand and Japan, and South Africa and Japan. These JVs were each treated as a separate fishery group to the domestic South African and New Zealand fleets, based on differences in their characteristics in Japanese operational style under strict management and surveillance under the joint venture arrangement.

4. DATA

4.1 Seabird biological input parameters

Biological data inputs to the risk assessment model include demographic parameters, generally represented with statistical distributions (referred to as priors), and information on the spatial distributions of the seabird taxa, included as point estimates without uncertainty. Demographic parameters with prior distributions are estimated during the model fit, whereas parameters represented as point estimates are fixed.

Biological inputs to the risk assessment model were reviewed by seabird researchers coordinated through ACAP in 2024 (Anon., 2024; Edwards et al., 2025a). Researchers were selected based on their publication record and known involvement with the species covered by the risk assessment. The review process included compilation of available information relevant to the demographic parameters of interest at a colony level. The review is summarised in **Appendix B**, along with a comprehensive overview of the biological inputs to the risk assessment model and data sources. Prior distributions for breeding pairs were updated this year (2025) for Gibson's albatross, Antipodean albatross, wandering albatross (*D. exulans*), southern royal albatross, black-browed albatross (*T. melanophris*), Campbell albatross (*T. impavida*), shy albatross (*T. cauta*), white-capped albatross (*T. cauta steadi*), Salvin's albatross (*T. salvini*), grey-headed albatross (*T. chrysostoma*) and southern Buller's albatrosses. Prior distributions for the probability of breeding were also updated for Gibson's albatross and Antipodean albatross.

The probability of breeding adults being on nest by month ($P_{s,m}^{\mathrm{nest}}$), and the probability of adults being in the southern hemisphere ($P_{s,m}^{\mathrm{SH}}$) are provided in Table 5 and Table 6. Summary statistics of the prior distributions for annual breeding pairs (N_s^{BP}), probability of adults breeding (P_s^{B}), current age at first reproduction (A_s^{curr}) and optimum survivorship (S_s^{opt}) are provided in Table 7. Summary statistics of prior values of total adult population size (N_s), theoretical unconstrained maximum population growth rate (r_s) are provided in Table 8.

It was cautioned that the bird population dynamics data are incomplete. ACAP reports that gaps in population data remain for globally significant breeding populations at sites that are logistically difficult to access and for species that are particularly difficult to census (ACAP, 2024). Nine albatross or petrel species on nine islands groups, estimated to hold >10% of the species' global population, have not had a population estimate in >10 years. Similarly, four species at seven island groups, which account for >5% of the species' total global breeding population, have not been censused since 2012. As an example, New Zealand is assumed to hold 33% of the world population of light-mantled sooty albatross (*Phoebetria palpebrata*), but, as this species is notoriously difficult to survey, population estimates rely on incomplete data from the 1970s and 1990s, depending on the island group. Other population parameters, such as breeding probability, are even more limited for these poorly surveyed populations. If parameters were unavailable for a given species (e.g., for breeding probability for Chatham Island albatross), a genus-level mean was used instead.

4.2 Seabird distribution information

Density maps used in the 2024 iteration of the risk assessment were taken from Devine et al. (2023), based on spatiotemporal 3-dimension generalized additive models (GAMs) fitted to tracking data. These density maps were reviewed in 2024 as part of the broader review of the biological inputs to the risk assessment model (see Appendix B). For some species, a lack of available tracking data was identified as an issue while, for other species, existing tracking data that had not yet been included was highlighted, resulting in absences of known foraging areas from density maps. Consequently, new density maps were generated for the species in need of improvements.

Density maps were generated for the 2025 SEFRA using a similar approach to Devine et al. (2023), but with refinements in response to feedback from the 2024 review (see Appendix A). First, available tracking data were weighted by the relative size of the colony before model fitting. This ensures that larger colonies have more influence on the species-level density maps. Second, additional tracking data were incorporated into the modelled datasets, including tracking data held by New Zealand's Department of Conservation[1], as well as data from Birdlife International's seabird tracking dataset[2]. For species for which the available tracking data were limited (not all major colonies had data), distribution maps were augmented with mapping layers from Carneiro et al. (2020), weighted according to the proportion of breeding populations that had been tracked. After this step, only four species had distributions that lacked substantial data from the main colonies.

The density maps were for adults only, noting the difficulty in distinguishing older immatures and pre-breeders from adults for some species, even with necropsy (Lonergan et al, 2017). The working group noted that, ideally, the density maps would also cover juveniles and immature birds. However, for many taxa there were no available tracking data for these life stages. In this context, the working group agreed to continue with an 'adults only' approach to the risk assessment model. This approach is precautionary, in the sense that the estimated deaths (which could include sub-adults) resulting from fishing are compared with relative mortality calculated using only the number of adults.

The working group acknowledged that the incorporation of additional tracking data had partially resolved issues raised in the 2024 review relating to an absence of analysed tracking data from major colonies. The working group noted that the updated density maps addressed the absence of known foraging grounds for some taxa, e.g., regions off Western Australia and Chile for Campbell black-browed albatross. The working group also noted that the weighting of tracking data by colony size had appeared to improve the quality of density maps more

[1] https://docnewzealand.shinyapps.io/albatrosstracker/
[2] https://data.seabirdtracking.org/

generally, e.g., reducing the apparent over-estimation of densities of black-browed albatrosses off the Great Australian Bight.

4.3 Seabird bycatch and effort from surface longlines

The assessment utilised the observed monthly catch and effort data provided by the participating Members in the calendar years 2012 to 2023. The spatial resolution of input data was decided by each Member, though ultimately 5x5 degree cells were used in the model fitting. Individual Members compiled their own data using an R package provided by the modeling team. The Member-specific data submissions then collated into a combined dataset which was used to generate inputs for the risk assessment model.

In the 2024 risk assessment, information on observed captures and effort was limited to the longline fleets of Japan, New Zealand and the Fishing Entity of Taiwan. For the 2025 risk assessment, information was also provided by Australia, South Africa and Korea. These six Members provided observed catch and effort data, as well as total effort data for their surface longline fisheries operating in the southern hemisphere regardless of target species. Indonesia participated in the ERS Tech meeting, but were unable to provide input data for use in the 2025 risk assessment.

Summaries of observed and total effort by Members and fishery group are provided in Table 9 and Figure 1. Additionally, summaries of observed seabird captures are provided in Table 9, Table 10 and Table 11.

Onboard observer programs were impacted by movement constraints during the COVID-19 pandemic, resulting in reduced observer coverage from 2020 to 2022, particularly for fleets operating in the high seas.

Summaries of each Member's dataset

Australia

For Australia, seabird bycatch and effort data from longline vessels were sourced from 1) observer records for seabird bycatch and observed effort from 2012 to 2015, 2) electronic monitoring records for seabird bycatch and observed effort from 2016 to 2023, and 3) logbooks for total fishing effort from 2012 to 2023. All Australian tuna longline vessels were included in the same AU fleet. Electronic monitoring identification of seabird bycatch was coarser, and mostly to a family or higher taxonomic level, compared to observer identification which was mostly to a species level.

Japan

The input data for SEFRA is produced from Japanese observer data. The observer data from 2012 to 2023 were used; however, the data for 2021 and 2022 are absent due to the COVID-19 pandemic. Observed hooks, total number of bycaught seabirds, and number of seabird bycatch by species were used for the SEFRA input data. The observer usually starts observation from the beginning of the hauling operation and continues till that the observation duration becomes 80 % of the total hauling operation. Observed hooks were estimated from the ratio of research duration to duration of hauling operation. While the individuals with a DNA sample were identified by DNA, others were identified from a photo. The individual that was not identified till species was identified as a species group. The fate of individuals was also collected for each species. The data was aggregated by year, month/quarter, and 5x5 degree strata. The total number of bycaught seabirds and the number of seabird bycatch by species were aggregated additionally by fate. Total effort data were extracted from logbook data using the same time period and resolution as the observer data.

Korea

[Paragraph to be provided by Korea]

New Zealand

Assessments of the capture of protected species in New Zealand commercial fisheries rely on observer and fisher-reported data. Fisheries observers document the captures of protected species, and these observer records are linked to fisher-reported effort data. To improve species resolution all captures were first identified by the observer, and some captures were subsequently necropsied. If a bird has been necropsied, then this identification was used in preference. For birds that were not necropsied, an expert identification based on a photograph was used in preference. Finally, for birds that were neither photographed nor necropsied, an imputation process was used (Thompson et al. 2017). New Zealand data comprised that of both domestic fisheries and that undertaken by the Japanese joint venture fleet. A total of 611 observed captures that occurred during the 2012–23 calendar year were included in the New Zealand reporting reporting tables. Of these captures, 412 were Thalassarche, 152 were Procellaria, 47 were Diomedia, and none were Phoebetria.

South Africa

Observed seabird bycatch and effort data were provided from human observer records along with total effort for the fleet, for the period 2012 to 2023. Scientific observers report on all seabird interactions during fishing operations to the species level where possible and provide a description of the fate of each seabird. South Africa's observer coverage in recent years has typically been around 20% of hooks set for operations covering the entire coastline, i.e. CCSBT areas 9, 14 and 15. Actual hooks observed is reported to be around 65%, improving to 82% in the last six (6) years. The data comes from the local-flagged pelagic longline vessels and Joint Venture Japanese vessels, with on average 21 and three (3) vessels, respectively, active each year. South Africa reported on 1101 observed captures, dominated by Procellaria (white-chinned petrels) and Thalassarche (shy, yellow-nosed and black-browed albatrosses).

Taiwan

The seabird bycatch and effort data from Taiwanese longline vessels spanned 2012 to 2023, and were sourced from two datasets: 1) observer records for seabird bycatch and observed effort, and, 2) logbooks and e-logbooks documenting fishing effort. All Taiwanese tuna longline vessels, regardless of size or target species, were considered the same fleet (TW). While the observer data aimed to identify seabird bycatch to the species level, Gibson's albatross was not differentiated from other species, likely resulting in being recorded as Antipodean albatross or similar species. Observers were restricted to a maximum of eight working hours during hauling, resulting in incomplete hook observations. Hence, the observed number of hooks were provided. Fishing effort data consisted of logbook-recorded number of hooks set from 2012-2016, while e-logbook data provided effort information for 2017 onwards following e-logbook implementation in 2017.

5. RESULTS

The approach taken for the 2025 risk assessment was to first explore alternative modelling approaches fitted to 2024 biological and fishery inputs. This allowed separation of the impacts of changing the modelling approach from the impacts of updating the data inputs to the risk assessment, including the incorporation of the data inputs from Members that contributed data to the 2024 risk assessment.

The 2024 risk assessment was hampered by biologically implausible posterior updates to the number of breeding pairs and the probability of adults breeding for some taxa, with particularly strong updates for a number of mollymawk species (Anon., 2024). These posterior updates allowed the model to fit to captures data by changing the estimated availability of birds. These updates were required because taxa within a species group share estimated catchability terms ($q_{f,z}$), so improvements to model fits for taxa within a species group can only be achieved through changes in the availability of birds, i.e., by increasing $\mathbb{O}_{f,s}$. As such, a particular focus of developments to the risk assessment model was reviewing data inputs to identify potential causes for the strong posterior updates, and testing approaches intended to reduce the strength of these posterior updates.

5.1 Initial model runs and exploratory analyses with inputs to the 2024 risk assessment

The working group selected five one-off changes to the 2024 risk assessment model, with each applied to the data inputs to the 2024 risk assessment. These model runs are described below.

a) Fitting the model to empirical captures

Fitting the model to empirical captures substantially improved the model fit to captures data, most notably reducing the over-estimation of captures identified at coarse taxonomic resolutions, i.e., captures identified to a family level, or recorded as an unspecified bird. Fitting to empirical captures is preferred from a theoretical basis, as there is no need for pseudo-replication of captures data. However, there was no material change in the strength of posterior updates to the number of breeding pairs (N_s^{BP}) or the probability of breeding (${P_s}^{\mathrm{B}}$), and the estimated catchabilities were insensitive to the change.

b) Composite density maps based on the weighted average of the 2024 density maps and range maps

These composite maps can be interpreted as the use of the density maps for colonies which contributed tracking data in the modelled datasets used to estimate density maps, and the use of range maps for colonies with no available tracking data. The use of the composite maps reduced the prevalence of "zero overlap captures" but did not reduce the strong posterior updates to the number of breeding pairs (N_s^{BP}) or the probability of breeding (${P_s}^{\mathrm{B}}$).

c) Use a single species group for catchabilities for great albatross species

In the 2024 risk assessment, the great albatrosses were split into two species groups, a wandering albatross group, and a royal albatross group. Fitting to genus-level capture data was identified as an avenue of exploration in the 2025 risk assessment (run d). This would assume that there is no information in the captures data to support estimation of sub-genus catchabilities. Model run c was used to assess the impact of collapsing the great albatross species groups into one (in isolation). There were minor changes to the estimated catchabilities with the change, but no material degradation of model fits. This likely reflects the limited captures of royal albatrosses in the 2024 dataset (36 individuals).

d) Fitting to genus-level captures data

Capture data identified to a species or complex level were reassigned to genus-level capture codes. This resulted in 7 capture codes (Table 4) and a truncated $\boldsymbol{\pi}$ vector:

$$\boldsymbol{\pi} = \{\pi_{\text{genus}}, \pi_{\text{family}}, \pi_{\text{class}}\}$$

The conversion matrix for calculation of cumulative captures is provided in Table 12. As described above, the two great albatross species groups were also combined, resulting in four genus-level species groups, i.e., great albatrosses, mollymawks, sooty albatrosses, and medium petrels. Fitting the model to genus-level captures data greatly reduced the strength of posterior updates to N_s^{BP} and ${P_s}^{\mathrm{B}}$, with no updates that were considered to be biologically implausible. There was an increase in catchabilities for the mollymawk group, which appeared to compensate for the reduction in density overlap in the absence of the artificial increases in population size from updates to N_s^{BP} and ${P_s}^{\mathrm{B}}$.

e) Genus-specific $\boldsymbol{\pi}$ vectors

In the 2024 risk assessment, the $\boldsymbol{\pi}$ vectors were specific to a fishery group, but were shared among all 25 taxa. This assumption may not be appropriate if some taxa are more difficult to identify to finer taxonomic resolutions than others, e.g., similar physical characteristics, rarity of interaction with vessels and so a lack of familiarity on the part of observers, etc. The model was refitted with genus (and fishery group) specific $\boldsymbol{\pi}$ vectors. There were relatively minor changes to estimated catchabilities, but there was some evidence for differences in the identifiability of captures between genera, with a higher probability of sub-genus identifications for mollymawks and medium petrels compared with great albatrosses and sooty albatrosses. This had the added benefit of being a useful tool for assessing improvements in species identification between time periods for each of the fishing groups.

f) Other trials

Preliminary model runs with species-fishery group interaction terms in the catchability equation were also explored, i.e. with:

$$\log\left(q_{f,z}\right) = \beta_0 + \beta_f + \beta_z + b_{f,s}$$

where $b_{f,s} \sim N(0, \sigma)$. This approach allows for variation in catchabilities among taxa within a fishery group. These deviations can also account for errors in estimated overlap resulting from inaccuracies in density maps, and should not result in biased estimates of total catch if observed effort is representative of total effort (spatially and temporally). The introduction of species-fishery group interaction terms in the catchability equation resolved the strong posterior updates to the number of breeding pairs (N_s^{BP}) and probability of breeding (${P_s}^{\mathrm{B}}$). However, this approach is also susceptible to bias resulting from errors in identifications of captures. In this context, the working group preferred the approach of fitting to genus-level captures data.

5.2 Exploratory analyses of data inputs to the 2024 risk assessment

Targeted examination of data inputs to the 2024 risk assessment was conducted concurrently with the initial model runs, to explore potential drivers for the strong updates to demographic parameters encountered in 2024. The working group noted that there were observed captures for a range of taxa that occurred in areas with zero density overlap. These “zero overlap captures” reflect an inconsistency between the capture data and the assumed adult distribution of the relevant populations. Errors in identifications, captures of sub-adults, and errors in the assumed spatial distributions both have the potential to drive posterior updates to the number of breeding pairs (N_s^{BP}) or the probability of breeding (${P_s}^{\mathrm{B}}$), as errors in observed catch and observed overlap (Equation 8) both influence the estimation of catchabilities.

Composite density maps were created by taking the weighted average of the 2024 density maps and range maps (BirdLife International & Handbook of the Birds of the World, 2024), with the density maps weighted by the proportion of breeding pairs from colonies with modelled tracking data. This reduced the prevalence of “zero overlap captures”, from 418 to 72 individuals out of a total of 7,537. However, the use of the composite maps did not materially reduce the strength of posterior updates to N_s^{BP} and $P_s{}^{\mathrm{B}}$ by itself.

The 2024 risk assessment model was rerun with the updated density maps prepared for the 2025 risk assessment. This resulted in reductions in posterior updates for a range of taxa: Indian yellow-nosed albatrosses (primarily $P_s{}^{\mathrm{B}}$), black-browed albatross (N_{BP} and $P_s{}^{\mathrm{B}}$), New Zealand white-capped albatross (N_s^{BP} and $P_s{}^{\mathrm{B}}$), Westland petrel ($P_s{}^{\mathrm{B}}$) and spectacled petrel ($P_s{}^{\mathrm{B}}$). More modest reductions in posterior updates were observed for Campbell black-browed albatross ($P_s{}^{\mathrm{B}}$), Southern Buller’s albatross ($P_s{}^{\mathrm{B}}$), grey petrel ($P_s{}^{\mathrm{B}}$), with a modest increase in posterior updates to N_s^{BP} and $P_s{}^{\mathrm{B}}$ for Salvin’s albatross. However, biologically implausible posterior updates remained for white-chinned petrel, Campbell black-browed albatross, grey-headed albatross, southern Buller’s albatross, light-mantled sooty albatross and Westland petrel, with more modest updates for grey petrel and spectacled petrel.

For the taxa with remaining biologically implausible posterior updates, additional sources of information on spatial distributions were examined to assess consistency with the estimated density maps, including eBird sightings data (Sullivan et al. 2019) and tracking datasets in Birdlife’s Seabird Tracking Database that were not available for use in the estimation of density maps. In general, there was no clear evidence of inconsistencies in the density maps when compared with the sightings data and additional tracking data. However, there was some evidence of an underestimation of grey-headed albatross in the Tasman Sea and further south. Additional tracking at Campbell Island and the larger Indian Ocean colonies may address this in the future.

The working group noted that the apparent inconsistency between capture data and the assumed spatial distributions could reflect captures of juveniles and immatures, given that the density maps are for adults only (Section 4.2).

5.3 Selected model

Based on the exploratory analyses and initial model runs using data inputs to the 2024 risk assessment, the working group decided that:

- Fitting to empirical captures was preferred to fitting to cumulative captures, due to superior model fits and the lack of pseudo-replication in captures data.
- Density maps should be combined with range maps (BirdLife International and Handbook of the Birds of the World, 2024) to account for colonies with no available tracking data.
- Models should be fitted to genus-level captures data. Identification of seabirds to a species level at-sea is difficult, particularly if the individual is waterlogged or damaged. It was considered likely that there are errors in identifications in the analysed dataset, particularly when based on at-sea identifications rather than those based on photos or necropsies by experts. Fitting to genus-level captures data is a compromise, in mitigating against bias from errors in identifications at fine taxonomic resolutions, whilst still providing sufficient information to account for variability in catchabilities between taxa.
- As a result of the aggregation of captures data to a genus resolution, the great albatross species groups should be combined, giving four genus level species groups.
- Genus (and species group) specific $\boldsymbol{\pi}$ vectors should be preferred, subject to confirmation that the updated 2025 dataset provided sufficient information for robust

estimation of genus-specific $\boldsymbol{\pi}$ vectors for all fishery groups.

This model is referred to throughout this report as the "selected 2025 risk assessment model". The use of genus-level captures data, in combination with composite maps based on density maps and range maps, reduced the prevalence of "zero overlap captures" (6 from a total 9,815 captures; Table 13). Overlap from observed and total effort per species and fishery group is provided in Table 14 and Table 15 respectively.

MCMC trace diagnostics (e.g., Figure 2), and $\hat{r}$ (< 1.05)were acceptable for model parameters with minimal posterior updates to both the number of breeding pairs (N_s^{BP}; Figure 3) and the probability of breeding (P_s^{B}; Figure 4). Model fits to empirical captures were acceptable (Figure 5, Figure 6, Table 17), and comparisons of cumulative captures indicated that the model was also accurately predicting total observed captures.

Estimated catchabilities demonstrated strong variability between fishery and species groups (Table 18, Figure 7), with wide credible intervals for fishery group and species group combinations with no, or less frequent, captures, e.g. sooty albatrosses.

Estimated $\boldsymbol{\pi}$ vectors demonstrated strong differences between fishery groups (Figure 8), which may reflect differences in sources of identifications. For example, New Zealand's fishery groups have relatively high probability of genus-level identifications for genera with observed captures, which may reflect the use of necropsy-based identifications. In contrast, the probabilities of genus-level identifications for the Australian fishery group were relatively low, which reflects difficulties in acquiring more resolved species identifications based on electronic monitoring footage alone. Across the fishery groups, there was also a tendency for higher probabilities of genus-level identifications for *Thalassarche* and *Procellaria* species.

Estimated total mean annual deaths, cryptic deaths, and relative mortalities are provided in Table 19. Estimated relative mortality were typically highest for *Diomedea* species, and lowest for the *Procellaria* species (Figure 9). The species with the highest estimated relative mortality were (in descending order): Gibson's albatross (0.72, 95% CI 0.48–1.14), Amsterdam albatross (0.38, 0.25–0.60), Tristan albatross (0.36, 0.24–0.55), Sooty albatross (0.32, 0.20–0.49) and New Zealand white-capped albatross (0.24, 0.16–0.38). Cryptic mortality rates were effectively the same for all species, given the assumption that all birds were assumed to be dead at-vessel, and so relative mortality rankings were equivalent when considering relative mortality from "observable" deaths only (Figure 10).

The spatial distribution of total estimated deaths per species group is provided in Figure 13, with further breakdowns by fishery group provided in Figure 14. The spatial distribution of the mean relative mortality across all species is provided in Figure 15, with species-group specific mean relative mortality available in Figure 16. These maps identify a number of relatively small regions that contribute a high proportion of both estimated deaths and relative mortality, including the Tasman Sea for great albatrosses, mollymawks and sooty albatrosses, as well as the southeast Atlantic for Sooty albatrosses and the east Pacific for petrels.

5.4 Sensitivity run, with family-specific π vectors

A sensitivity run was undertaken based on the selected 2025 risk assessment model but with family-specific $\boldsymbol{\pi}$ vectors (rather than genus-specific) to assess the sensitivity of outputs to this decision. The quality of model fit was similar to the selected risk assessment model, with no material degradation in model fits resulting from the simplification of the $\boldsymbol{\pi}$ vector specification. Estimated catchabilities were insensitive to the change in the $\boldsymbol{\pi}$ vector specification (not shown). Estimated deaths for *Procellaria* petrels were least impacted by the change in $\boldsymbol{\pi}$ vector specification (Table 20). Estimated mean annual deaths for the great albatrosses and sooty albatrosses were slightly reduced with family-specific $\boldsymbol{\pi}$ vectors, with a slight increase in estimated deaths for mollymawks. However, these changes to estimated deaths did not materially impact the rankings of estimated relative mortality.

5.5 Selected model fitted to data from 2012 to 2019

To provide a more direct comparison with the 2024 risk assessment model, the selected 2025 risk assessment model was also fitted to data from 2012 to 2019, to match the time series used in 2024. Using this restricted data set, the quality of model fit was similar to the selected risk assessment model but the estimated mean annual deaths and relative mortality increased for all taxa (Table 21). It seems most likely that the higher estimates of mean annual deaths using the restricted data set were driven by differences in catchabilities for some fleets (see Section 5.6).

5.6 Model with temporally varying catchabilities and π vectors

The selected 2025 risk assessment model was also refitted with time-blocked catchability parameters and π vectors, to assess evidence for potential temporal changes in capture rates. Three time periods were assumed: 2012 to 2016; 2017 to 2019; and 2020 to 2023.

There was evidence for increased probabilities of identifications to a finer taxonomic resolution through time (Figure 17), which may reflect increasing seabird-related training for at-sea observers, as well as a move to photo-based identifications by experts (e.g., for the Japanese fishery group). There were also reductions in estimated catchabilities through time for a number of fishery groups (Figure 18), including: mollymawk catchabilities for the domestic New Zealand fishery group, and South African domestic and Joint Venture fishery groups; Japan's fishery group catchabilities for all species groups, particularly in the period 2020 to 2023. There were also increasing temporal trends through time, including *Procellaria* petrel catchabilities for New Zealand's domestic and South Africa's Joint Venture fishery groups. The working group did note that interpretation of temporal changes in catchability effects is complicated by the time-invariant nature of the biological inputs, as catchabilities are confounded with the size of population available for capture in fisheries.

5.7 Comparisons of model results with previous risk assessments

It is difficult to make direct comparisons between the 2024 and 2025 risk assessments, given the differences in the modelling approach and data inputs. However, the outputs of the two risk assessments are broadly consistent with each other, in terms of the species rankings of estimated risk ratios from the 2025 risk assessment and the 'relative mortalities' from the 2024 risk assessment (Table 22).

The most influential change implemented in the 2025 risk assessment was fitting the model to captures data with genus-level (or higher) taxonomic resolutions. This removed the biologically implausible posterior updates to the number of breeding pairs and probability of breeding that were observed in the 2024 risk assessment, with a corresponding improvement in estimates of relative mortality. This can most clearly be seen for a number of mollymawk species, including Campbell black-browed albatross, grey-headed albatross and southern Buller's albatross (Table 22). The estimated deaths are also markedly different for some species, e.g., the order of magnitude decrease for grey-headed albatross in the absence of the (artificial) increase in adult population size through posterior updates to biological parameters, and the order of magnitude increase for Atlantic yellow-nosed albatross driven by increased overlap with the updated density maps.

More generally, the results of the 2025 risk assessment results are also consistent with previous iterations (Abraham et al. 2019; Anon et al. 2024, Peatman et al. WCPFC report), and other studies (Richard et al. 2024), including the 1) relatively high risk to species from the wandering albatross complex, 2) the higher risk in the Tasman Sea, and 3) the consistent assessment of Gibson's albatross, Amsterdam albatross, Tristan albatross and Sooty albatross as being among the taxa at highest risk.

6. CONCLUSIONS, REMAINING ISSUES and NEXT STEPS

6.1 Progress since the 2024 SEFRA

- This report summarises a quantitative risk assessment for 25 taxa of seabirds caught in surface longline fisheries (no matter the target species) by six participating Members of the Commission for the Conservation of Southern Bluefin Tuna.
- This assessment is based on the Spatially Explicit Fisheries Risk Assessment (SEFRA) approach and builds on the SEFRA model developed collaboratively by Members and discussed by the CCSBT's ERSWG15 in April 2024. Diagnostics suggest that the 2025 SEFRA model had converged, fitted the data very well, and did not appreciably update any of the priors for biological inputs.
- The key concerns raised about the 2024 iteration have been resolved in the 2025 iteration in that: conflicts between estimated overlap of fishing and seabirds and the observed captures (i.e., the presence of observed captures where the estimated overlap was zero) have been resolved; and the fitted models no longer require implausible updates to the priors on population size or the probability of breeding in a year.
- Modifications to the 2024 SEFRA model were made one at a time such that the impact of each change to data and model structure could be assessed.
- Updating the available information on seabird distributions reduced the number of "zero overlap captures" somewhat but fitting to genus-level (or higher) capture data (as opposed to species-level, where available) was by far the most influential change.
- The broad patterns of estimated risk were similar in the 2024 and 2025 SEFRA models; Gibson's albatross, Amsterdam albatross, Tristan albatross and Sooty albatross were the taxa estimated to be at highest risk in both model iterations. However, the estimated risk for many seabird taxa was higher in the 2025 SEFRA than in the 2024 SEFRA. The lower risk for many taxa in the 2024 SEFRA is thought to be largely an artefact caused by the updates to biological priors.
- At the scale of 5-degree squares, estimated annual deaths of great albatrosses and mollymawks were highest in the Tasman Sea although there were other higher-catch areas in the south-eastern Indian Ocean and the south-eastern Atlantic Ocean. Sooty albatross deaths were highest in the south-eastern Atlantic Ocean and, to a lesser extent, in the Tasman Sea. Deaths of medium petrels were highest around South Africa and off Namibia, and in the south-eastern Pacific Ocean. Spatial patterns vary among taxa finer than these four groups.
- The 2025 SEFRA was not very sensitive to fitting to family-level (or higher) capture data (as opposed to genus-level in the base case or species-level, where available, in 2024); the average absolute change to the estimated risk ratios was <10% (compared with ~40% for the change between the 2024 and 2025 SEFRA models).
- The 2025 SEFRA fitted to data from 2012 to 2019 (as for the 2024 SEFRA) had consistently higher estimates of risk (averaging about 20% higher) than the model fitted to the whole time series 2012 to 2023. This is thought to be due to lower catchability in more recent years.
- Diagnostics and inspection of results suggested that a SEFRA model with different time blocks (among which catchability was allowed to vary) had converged, fitted the data very well and provided useful estimates of the taxonomic level of identification of captured birds and catchability / total deaths. Catchability for great albatrosses and mollymawks was somewhat lower in the latest time block (2020 to 2023) for New Zealand domestic and Japanese fleets although there were mixed results for the other fleets and seabird taxa with few clear trends.

6.2 Uncertainties and caveats for the 2025 SEFRA model

- All SEFRA models are highly reliant on information on the distribution of seabirds. Better distributions than were available in 2024 were used but these are not perfect. Some recorded captures occur outside the predicted distributions, mostly at a sub-genus level. This was interpreted as an indication that the overlap estimates were inconsistent with the captures at a sub-genus level, which could explain the strong updates to biological inputs observed in the 2024 SEFRA. This inconsistency could come from incorrect bird identifications, captures of sub-adults, or poor distribution maps, both of which may remain as issues.
- The 2025 SEFRA uses captures aggregated to genus level. This mitigates against potential bias due to misidentification of seabirds at finer taxonomic resolutions, and substantially reduces the number of captures outside of predicted distributions. The estimated captures are then disaggregated to species level based on the estimated overlap, relying heavily on the distribution of individual bird species and the quantum and distribution of total fishing effort. There may be some potential to use verified identifications of captures to enhance disaggregation in future.
- Juveniles, immature birds and pre-breeding birds may have different spatio-temporal distributions to adults and are likely to have higher catchability than adults, although data are not available to split captures by life stage. A precautionary approach has been adopted by assuming all captures are adults and captures are compared with the adult population size.
- The model is highly reliant on observer (or electronic monitoring) data, including bird identifications being correct at the genus level and accurate recording of captures and observed effort. Calculating total deaths assumes there is no "observer effect" on fisher behaviour.
- Catchability is assumed constant in space and (except for time-blocked model) in time, and within genus. There is limited data to explore this in relation to both yearly estimates of population for all seabirds included in the model and sufficient capture information for all fisheries groups. As such, we have not explored this but, if there were broad-scale differences in catchability, this would cause bias. Gaps in observer coverage were found to degrade precision of estimates on the 2024 SEFRA but were not assessed to cause bias.
- Although cryptic mortality is known to occur, the available information to calculate appropriate scalars is relatively sparse and relates only to birds hooked during setting. Similarly, the survival of birds that escape or are released alive is relatively poorly understood; as a precautionary approach, all captures are assumed dead.
- The time-blocked models assume constant biological inputs (population size and productivity) across all time blocks. In reality, population size, productivity or distribution may vary, leading to some potential bias in estimates of catchability or captures.

6.3 Next steps

The transition to phase 2, the global (southern hemisphere) risk assessment under the CCSBT Seabird Project, funded by FAO/GEF Common Oceans Program, started immediately following the ERS-Tech meeting in April 2025. In practice, it is expected that the global southern hemisphere assessment will use the model finalised at that meeting without any modifications.

Data would be sought from other nations fishing in the southern hemisphere in a process led by the Project Manager of the CCSBT Seabird Project, Dr Ross Wanless, coordinating with interested Members and the project partner BirdLife International.

An update on progress with the CCSBT SEFRA, and the transition to the global assessment, will be reported to the Extended Commission of the Thirty-Second Annual Meeting of the Commission (6–9 October 2025), although the format for this update has yet to be determined. Therefore, formally, this technical report and description of the 2025 SEFRA will be made available outside CCSBT only after the completion of the Extended Commission. However, this does not prevent the CCSBT Seabird Project Manager from engaging with potential data-contributing, non-CCSBT Members immediately, noting data confidentiality arrangements within CCSBT. The agreed 2024 SEFRA Technical Report (Attachment 4 of ERSWG 15 report) can be used as the base material, noting the substantial progress made during the 2025 ERS-Tech process.

The SEFRA model can be updated at any time when new information becomes available. No timetable for such updates is presented here although it is anticipated that the risk assessment will be updated periodically as may be required by the CCSBT Multi-year Seabird Strategy.

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Tables

Table 1: Glossary of model terms.

Notation	Description
Subscripts	
f	Fishery group
s	Species
z	Species group
k	Capture code
m	Month
x	Spatial location or grid cell
Estimated parameters	
N_s^{BP}	Number of breeding pairs
P_s^{B}	Annual probability of breeding
S_s^{opt}	Annual optimum survivorship
A_s^{curr}	Current age at first breeding
$\beta_0, \beta_f, \beta_{z\vert f}$	$q_{f,z}$ regression coefficients
$\gamma_0, \gamma_f, \gamma_{z\vert f}$	$\Psi_{f,z}$ regression coefficients
$\boldsymbol{\pi}_f$	Vector of capture assignment probabilities
Derived parameters	
N_s^{adults}	Total number of adults
$N_{s,m}$	Number of adults available to fishing
N_s	$N_{s,m}$ summed across months
$\mathbb{D}_{s,m,x}$	Density of adults available to fishing
$q_{f,z}$	Catchability
$\Psi_{f,z}$	Probability of capture being alive
$C_{f,s}$	Number of captures per species
$C_{f,k}$	Number of captures per capture code
$\kappa_{f,z}$	Mortality multiplier
$D_{f,s}$	Number of deaths
Inputs covariates	
$P_{s,m}^{\mathrm{SH}}$	Probability of an adult being in the southern hemisphere
$P_{s,m}^{\mathrm{nest}}$	Probability of a breeding adult being on the nest
$d_{s,m,x}$	Relative density of adults per square kilometre
$a_{f,m,x}$	Fishing effort
K	Cryptic mortality multiplier
ω	Probability of post-release survivorship
Derived covariates	
$\mathbb{O}_{f,s}$	Density overlap

Table 2: Species and species groups used in the southern hemisphere risk assessment model. Species codes are from the FAO-ASFIS species list where possible (https://www.fao.org/fishery/en/species/search). The species group definitions provide a covariate input for estimation of the catchability.

Code	Common name	Scientific name	Species group
DIW	Gibson's albatross	*Diomedea antipodensis gibsoni*	Great albatross
DQS	Antipodean albatross	*Diomedea antipodensis antipodensis*	Great albatross
DIX	Wandering albatross	*Diomedea exulans*	Great albatross
DBN	Tristan albatross	*Diomedea dabbenena*	Great albatross
DAM	Amsterdam albatross	*Diomedea amsterdamensis*	Great albatross
DIP	Southern royal albatross	*Diomedea epomophora*	Great albatross
DIQ	Northern royal albatross	*Diomedea sanfordi*	Great albatross
DCR	Atlantic yellow-nosed albatross	*Thalassarche chlororhynchos*	Mollymawk
TQH	Indian yellow-nosed albatross	*Thalassarche carteri*	Mollymawk
DIM	Black-browed albatross	*Thalassarche melanophris*	Mollymawk
TQW	Campbell black-browed albatross	*Thalassarche impavida*	Mollymawk
DCU	Shy albatross	*Thalassarche cauta*	Mollymawk
TWD	New Zealand white-capped albatross	*Thalassarche cauta steadi*	Mollymawk
DKS	Salvin's albatross	*Thalassarche salvini*	Mollymawk
DER	Chatham Island albatross	*Thalassarche eremita*	Mollymawk
DIC	Grey-headed albatross	*Thalassarche chrysostoma*	Mollymawk
DSB	Southern Buller's albatross	*Thalassarche bulleri bulleri*	Mollymawk
DNB	Northern Buller's albatross	*Thalassarche bulleri platei*	Mollymawk
PHU	Sooty albatross	*Phoebetria fusca*	Sooty albatross
PHE	Light-mantled sooty albatross	*Phoebetria palpebrata*	Sooty albatross
PCI	Grey petrel	*Procellaria cinerea*	Medium petrel
PRK	Black petrel	*Procellaria parkinsoni*	Medium petrel
PCW	Westland petrel	*Procellaria westlandica*	Medium petrel
PRO	White-chinned petrel	*Procellaria aequinoctialis*	Medium petrel
PCN	Spectacled petrel	*Procellaria conspicillata*	Medium petrel

Table 3: Capture codes used in the preparation of data inputs for the 2025 southern hemisphere risk assessment model.

Code	Common name	Scientific name	Taxonomic resolution
DKS	Salvin's albatross	*Thalassarche salvini*	Species
DER	Chatham Island albatross	*Thalassarche eremita*	Species
DIC	Grey-headed albatross	*Thalassarche chrysostoma*	Species
PHU	Sooty albatross	*Phoebetria fusca*	Species
PHE	Light-mantled sooty albatross	*Phoebetria palpebrata*	Species
PCI	Grey petrel	*Procellaria cinerea*	Species
PCN	Spectacled petrel	*Procellaria conspicillata*	Species
DRA	Royal albatrosses	*Diomedea epomophora* & *D. sanfordi*	Complex
DYN	Yellow-nosed albatrosses	*Thalassarche chlororhynchos* & *T. carteri*	Complex
DST	Shy-type albatross	*Thalassarche cauta* & *T. c. steadi*	Complex
DBB	Black-browed albatrosses	*Thalassarche melanophris* & *T. impavida*	Complex
DIB	Buller's albatross	*Thalassarche bulleri bulleri* & *T. bulleri platei*	Complex
DWC	Wandering albatross complex	*Diomedea exulans, D. dabbenena, D. amsterdamensis, D. antipodensis gibsoni & D. a. antipodensis*	Complex
PRZ	*Procellaria* petrel complex	*Procellaria parkinsoni, P. westlandica* & *P. aequinoctialis*	Complex
DIZ	*Diomedea* spp.	*Diomedea* spp.	Genus
THZ	*Thalassarche* spp.	*Thalassarche* spp.	Genus
PHZ	*Phoebetria* spp.	*Phoebetria* spp.	Genus
PTZ	*Procellaria* spp.	*Procellaria* spp.	Genus
ALZ	Diomedeidae	Diomedeidae	Family
PRX	Procellariidae	Procellariidae	Family
BLZ	Bird	–	Class

Table 4: Capture codes used in the 2025 southern hemisphere risk assessment model.

Code	Common name	Scientific name	Taxonomic resolution
DIZ	*Diomedea* spp.	*Diomedea* spp.	Genus
THZ	*Thalassarche* spp.	*Thalassarche* spp.	Genus
PHZ	*Phoebetria* spp.	*Phoebetria* spp.	Genus
PTZ	*Procellaria* spp.	*Procellaria* spp.	Genus
ALZ	Diomedeidae	Diomedeidae	Family
PRX	Procellariidae	Procellariidae	Family
BLZ	Bird	-	Class

Table 5: Probability of a breeding adult being on nest by month ($P_{s,m}^{nest}$). Darker shaded cells indicate a higher probability.

Common name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gibson's albatross	0.50	0.50	0.50	0.40	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.22
Antipodean albatross	0.40	0.50	0.45	0.45	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.20
Wandering albatross	0.50	0.50	0.40	0.20	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.40
Tristan albatross	0.60	0.50	0.50	0.50	0.30	0.30	0.05	0.05	0.05	0.05	0.05	0.40
Amsterdam albatross	0.05	0.40	0.50	0.50	0.40	0.30	0.05	0.05	0.05	0.05	0.05	0.05
Southern royal albatross	0.50	0.50	0.40	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0.40	0.50
Northern royal albatross	0.50	0.40	0.30	0.05	0.05	0.05	0.05	0.05	0.00	0.40	0.50	0.50
Atlantic yellow-nosed albatross	0.30	0.20	0.10	0.05	0.00	0.00	0.00	0.50	0.60	0.50	0.50	0.50
Indian yellow-nosed albatross	0.20	0.10	0.05	0.05	0.00	0.00	0.00	0.10	0.50	0.50	0.40	0.40
Black-browed albatross	0.20	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.40	0.50	0.50	0.40
Campbell black-browed albatross	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.20	0.50	0.50	0.40	0.30
Shy albatross	0.10	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.50	0.50	0.40	0.40
New Zealand white-capped albatross	0.40	0.10	0.05	0.05	0.05	0.05	0.05	0.00	0.00	0.25	0.50	0.50
Salvin's albatross	0.05	0.05	0.05	0.00	0.00	0.00	0.10	0.30	0.50	0.50	0.40	0.10
Chatham Island albatross	0.10	0.05	0.05	0.05	0.00	0.00	0.20	0.40	0.50	0.50	0.40	0.30
Grey-headed albatross	0.30	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.10	0.50	0.50	0.40
Southern Buller's albatross	0.20	0.50	0.45	0.30	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00
Northern Buller's albatross	0.45	0.40	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.40	0.50
Sooty albatross	0.20	0.05	0.05	0.05	0.05	0.00	0.00	0.50	0.70	0.70	0.50	0.50
Light-mantled sooty albatross	0.40	0.10	0.05	0.05	0.05	0.05	0.00	0.00	0.10	0.50	0.50	0.40
Grey petrel	0.00	0.50	0.50	0.50	0.40	0.30	0.05	0.05	0.05	0.05	0.05	0.00
Black petrel	0.50	0.40	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.05	0.30	0.50
Westland petrel	0.00	0.15	0.30	0.40	0.50	0.50	0.45	0.40	0.05	0.05	0.05	0.00
White-chinned petrel	0.40	0.30	0.05	0.05	0.00	0.00	0.00	0.00	0.30	0.40	0.50	0.50
Spectacled petrel	0.10	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.40	0.30

Table 6: Probability of an adult being in the southern hemisphere by month ($P_{s,m}^{\mathrm{SH}}$). Darker shaded cells indicate a higher probability.

Common name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gibson's albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Antipodean albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Wandering albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Tristan albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Amsterdam albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Southern royal albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Northern royal albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Atlantic yellow-nosed albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Indian yellow-nosed albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Black-browed albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Campbell black-browed albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Shy albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
New Zealand white-capped albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Salvin's albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Chatham Island albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Grey-headed albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Southern Buller's albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Northern Buller's albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sooty albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Light-mantled sooty albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Grey petrel	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Black petrel	1.00	1.00	1.00	1.00	1.00	0.80	0.80	0.80	0.80	0.80	1.00	1.00
Westland petrel	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
White-chinned petrel	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Spectacled petrel	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 7: Prior values for the annual number of breeding pairs (N_s^{BP}), proportion of adults breeding (P_s^{B}), age at first reproduction (A_s^{curr}), and optimum survivorship (S_s^{opt}).

		N_s^{BP}		P_s^B		A_s^{curr}		S_s^{opt}	
Code	Common name	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
DIW	Gibson's albatross	4 421	4 000-4 864	0.60	0.52-0.67	11.9	8.5-16.1	0.96	0.95-0.98
DQS	Antipodean albatross	3 381	3 065-3 725	0.45	0.35-0.55	13.9	10.5-18.2	0.97	0.95-0.98
DIX	Wandering albatross	10 131	9 175-11 134	0.49	0.40-0.59	9.9	7.3-13.3	0.97	0.95-0.98
DBN	Tristan albatross	1 623	1 146-1 973	0.35	0.23-0.48	9.2	6.5-12.7	0.96	0.95-0.98
DAM	Amsterdam albatross	60	49-73	0.60	0.50-0.69	9.9	7.3-13.2	0.96	0.95-0.98
DIP	Southern royal albatross	5 818	5 043-6 653	0.53	0.33-0.72	9.2	6.2-13.0	0.96	0.95-0.98
DIQ	Northern royal albatross	4 257	3 413-5 239	0.53	0.33-0.73	8.9	8.5-9.3	0.97	0.95-0.98
DCR	Atlantic yellow-nosed albatross	26 808	22 001-32 403	0.60	0.58-0.61	8.9	6.4-12.2	0.95	0.93-0.97
TQH	Indian yellow-nosed albatross	34 002	27 855-41 039	0.60	0.49-0.69	8.9	6.3-12.1	0.95	0.93-0.97
DIM	Black-browed albatross	671 369	607 619-738 568	0.84	0.79-0.89	9.9	7.3-13.1	0.95	0.93-0.97
TQW	Campbell black-browed albatross	14 119	12 768-15 549	0.89	0.75-0.96	9.2	6.2-13.1	0.95	0.93-0.97
DCU	Shy albatross	15 339	12 529-18 518	0.74	0.64-0.83	8.8	5.8-13.0	0.95	0.94-0.97
TWD	New Zealand white-capped albatross	85 808	67 480-107 569	0.68	0.56-0.79	8.8	5.8-13.0	0.95	0.94-0.97
DKS	Salvin's albatross	35 238	31 960-38 794	0.82	0.67-0.94	11.2	8.4-14.7	0.95	0.94-0.97
DER	Chatham Island albatross	5 294	5 188-5 400	0.77	0.66-0.86	9.9	7.8-12.3	0.96	0.94-0.97
DIC	Grey-headed albatross	63 034	57 057-69 504	0.41	0.19-0.63	12.9	10.2-16.1	0.96	0.95-0.98
DSB	Southern Buller's albatross	13 499	12 211-14 878	0.80	0.66-0.92	11.9	9.2-15.1	0.95	0.93-0.97
DNB	Northern Buller's albatross	19 362	17 529-21 341	0.80	0.69-0.88	11.9	9.3-15.1	0.95	0.93-0.97
PHU	Sooty albatross	13 359	11 705-14 451	0.73	0.62-0.82	9.2	6.3-13.1	0.97	0.95-0.98
PHE	Light-mantled sooty albatross	20 905	17 136-25 231	0.73	0.49-0.91	9.2	6.3-13.1	0.97	0.95-0.98
PCI	Grey petrel	105 660	77 870-140 105	0.89	0.75-0.96	6.9	5.2-9.0	0.94	0.92-0.95
PRK	Black petrel	5 458	4 873-6 083	0.61	0.53-0.69	7.4	7.0-7.9	0.93	0.92-0.95
PCW	Westland petrel	6 225	5 514-6 987	0.48	0.34-0.63	7.0	5.0-9.4	0.95	0.93-0.96
PRO	White-chinned petrel	1 316 786	1 074 335-1 593 474	0.75	0.64-0.83	6.6	4.6-9.2	0.93	0.92-0.95
PCN	Spectacled petrel	41 988	34 447-50 333	0.79	0.68-0.88	6.6	4.6-9.1	0.94	0.92-0.95

Table 8: Prior values for the total number of adults (N_s) and the theoretical unconstrained maximum population growth rate (r_s) .

		N_s (thousand)		r_s	
Code	Common name	Mean	95% CI	Mean	95% CI
DIW	Gibson's albatross	14 909	12 750-17 458	0.04	0.03-0.05
DQS	Antipodean albatross	15 263	11 956-19 727	0.04	0.03-0.05
DIX	Wandering albatross	41 429	33 352-51 892	0.05	0.03-0.06
DBN	Tristan albatross	9 690	5 900-15 107	0.05	0.04-0.06
DAM	Amsterdam albatross	202	156-260	0.05	0.03-0.06
DIP	Southern royal albatross	22 877	15 534-36 179	0.05	0.04-0.07
DIQ	Northern royal albatross	16 704	10 850-27 135	0.05	0.04-0.06
DCR	Atlantic yellow-nosed albatross	89 992	73 818-108 954	0.06	0.04-0.07
TQH	Indian yellow-nosed albatross	115 030	88 811-147 884	0.06	0.04-0.07
DIM	Black-browed albatross	1 593 207	1 422 033-1 791 582	0.05	0.04-0.07
TQW	Campbell black-browed albatross	31 907	27 687-38 369	0.06	0.04-0.07
DCU	Shy albatross	41 464	32 765-52 255	0.06	0.04-0.08
TWD	New Zealand white-capped albatross	254 551	189 506-338 493	0.06	0.04-0.08
DKS	Salvin's albatross	86 384	72 536-107 411	0.05	0.04-0.06
DER	Chatham Island albatross	13 835	12 342-16 052	0.05	0.04-0.06
DIC	Grey-headed albatross	340 458	195 740-648 759	0.04	0.03-0.05
DSB	Southern Buller's albatross	33 852	28 455-41 829	0.05	0.04-0.06
DNB	Northern Buller's albatross	48 877	41 987-58 026	0.05	0.04-0.06
PHU	Sooty albatross	36 871	30 880-44 041	0.05	0.04-0.07
PHE	Light-mantled sooty albatross	58 790	42 233-88 017	0.05	0.04-0.07
PCI	Grey petrel	238 644	172 197-326 322	0.07	0.06-0.09
PRK	Black petrel	17 981	15 118-21 433	0.07	0.06-0.08
PCW	Westland petrel	26 630	19 309-37 730	0.07	0.05-0.09
PRO	White-chinned petrel	3 543 560	2 799 132-4 491 550	0.08	0.06-0.10
PCN	Spectacled petrel	106 495	84 283-133 438	0.08	0.06-0.10

Table 9: Total observed captures (Obs n; individuals), observed effort (Obs eff; 1000 hooks) and total effort (Tot eff; 1000 hooks) by fishery group and year, for a) NZL (DOM), NZL (JV), ZAF (DOM), ZAF (JV) and AUS), and b) (continued on next page) JPN, TWN and KOR. DOM denotes domestic fleet, and JV Joint Venture operations.

a) NZL (DOM), NZL (JV), ZAF (DOM), ZAF (JV) and AUS

	NZL (DOM)			NZL (JV)			ZAF (DOM)			ZAF (JV)			AUS		
Year	Obs n	Obs eff	Tot eff	Obs n	Obs eff	Tot eff	Obs n	Obs eff	Tot eff	Obs n	Obs eff	Tot eff	Obs n	Obs eff	Tot eff
2012	24	148	2 510	33	555	551	0	0	1 572	126	337	2 742	3	487	7 369
2013	24	88	2 287	5	488	488	0	0	1 745	267	719	3 094	0	401	7 312
2014	18	126	1 868	16	653	653	20	23	1 767	170	475	1 265	1	222	7 341
2015	23	122	1 808	22	619	622	18	23	1 878	120	309	978	2	172	8 560
2016	128	332	2 358	0	0	0	0	0	1 573	37	101	668	3	771	8 094
2017	55	333	2 119	0	0	0	6	7	1 783	77	206	890	6	949	9 098
2018	95	301	2 317	0	0	0	6	7	2 230	15	38	651	14	907	8 249
2019	54	165	2 042	0	0	0	14	18	2 176	24	64	724	10	1 048	8 905
2020	18	197	1 974	0	0	0	77	95	1 661	0	0	0	6	862	8 392
2021	48	184	1 546	0	0	0	9	12	2 116	11	31	197	10	777	8 009
2022	56	68	1 280	0	0	0	10	15	2 356	4	12	163	3	693	7 124
2023	18	50	1 497	0	0	0	38	59	2 932	0	0	0	8	711	7 463
Total	561	2 114	23 604	76	2 314	2 315	198	260	23 789	851	2 292	11 370	66	8 000	95 914

Table 9 continued.

b) JPN, TWN, KOR, and total across fishery groups

		JPN			TWN			KOR			Total	
Year	Obs n	Obs eff	Tot eff	Obs n	Obs eff	Tot eff	Obs n	Obs eff	Tot eff	Obs n	Obs eff	Tot eff
2012	120	2 921	139 354	162	11 542	195 190	0	0	52 674	468	15 990	401 962
2013	423	4 745	121 815	355	11 424	232 556	0	0	61 178	1 074	17 864	430 473
2014	746	6 540	105 885	123	9 954	229 415	0	0	54 717	1 094	17 992	402 912
2015	946	5 175	94 939	26	8 554	201 169	0	0	53 628	1 157	14 974	363 581
2016	1 559	6 344	93 383	59	9 229	225 181	0	0	59 769	1 786	16 777	391 026
2017	121	5 164	91 530	42	13 316	281 430	0	0	43 958	307	19 976	430 807
2018	355	5 304	88 059	76	15 005	266 056	0	0	43 974	561	21 563	411 535
2019	1 857	5 265	70 012	71	15 340	301 488	26	530	2 427	2 056	22 431	387 773
2020	136	2 302	65 604	48	12 929	316 198	0	0	0	285	16 385	393 830
2021	0	0	59 565	80	11 581	192 956	0	0	0	158	12 586	264 388
2022	0	0	53 050	266	14 215	249 051	28	386	2 413	367	15 389	315 437
2023	151	3 042	41 394	269	14 246	265 050	18	501	2 478	502	18 609	320 814
Total	6 414	46 804	1 024 590	1 577	147 334	2 955 740	72	1 417	377 216	9 815	210 534	4 514 537

Table 10: Observed captures per capture code and fishery group. DOM denotes domestic fleet, and JV Joint Venture operations.

Code	Common name	NZL (DOM)	NZL (JV)	JPN	TWN	ZAF (DOM)	ZAF (JV)	AUS	KOR	Total
DIZ	*Diomedea* spp	51	0	430	106	2	0	1	3	593
THZ	*Thalassarche* spp	358	74	3 853	734	148	316	7	59	5 549
PHZ	*Phoebetria* spp	0	0	267	115	0	0	0	10	392
PTZ	*Procellaria* spp	152	2	650	435	43	520	0	0	1 802
ALZ	Diomedeidae	0	0	824	172	5	15	33	0	1 049
PRX	Procellariidae	0	0	167	7	0	0	16	0	190
BLZ	Bird	0	0	223	8	0	0	9	0	240
	Total	561	76	6 414	1 577	198	851	66	72	9 815

Table 11: Observed captures by at-vessel status, per capture code and fishery group. DOM denotes domestic fleet, and JV Joint Venture operations.

		NZL (DOM)		NZL (JV)		JPN		TWN		ZAF (DOM)		ZAF (JV)		AUS		KOR	
Code	Common name	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead
DIZ	*Diomedea* spp	13	38	0	0	58	369	2	100	0	2	0	0	1	0	0	3
THZ	*Thalassarche* spp	42	316	33	41	60	3785	28	689	24	121	213	68	3	4	0	59
PHZ	*Phoebetria* spp	0	0	0	0	1	266	0	115	0	0	0	0	0	0	0	10
PTZ	*Procellaria* spp	19	133	0	2	4	646	20	404	0	41	53	458	0	0	0	0
ALZ	Diomedeidae	0	0	0	0	17	461	10	159	3	2	8	6	11	21	0	0
PRX	Procellariidae	0	0	0	0	4	117	2	2	0	0	0	0	7	8	0	0
BLZ	Bird	0	0	0	0	6	204	1	7	0	0	0	0	3	6	0	0
Total		74	487	33	43	150	5848	63	1476	27	166	274	532	25	39	0	72

Table 12: Conversion matrix for calculation of cumulative captures per capture code.

Code	DIZ	THZ	PHZ	PTZ	ALZ	PRX	BLZ
DIZ	1	0	0	0	0	0	0
THZ	0	1	0	0	0	0	0
PHZ	0	0	1	0	0	0	0
PTZ	0	0	0	1	0	0	0
ALZ	1	1	1	0	1	0	0
PRX	0	0	0	1	0	1	0
BLZ	1	1	1	1	1	1	1

Table 13: Observed captures per capture code from cells with zero densities in all months. DOM denotes domestic fleet, and JV Joint Venture operations.

Code	NZL (DOM)	NZL (JV)	JPN	TWN	ZAF (DOM)	ZAF (JV)	AUS	KOR	Total
DIZ	0	0	0	0	0	0	0	0	0
THZ	0	0	0	0	0	0	0	0	0
PHZ	0	0	0	1	0	0	0	0	1
PTZ	0	0	0	0	0	2	0	0	2
ALZ	0	0	0	0	0	0	0	0	0
PRX	0	0	0	0	0	0	0	0	0
BLZ	0	0	0	3	0	0	0	0	3
Total	0	0	0	4	0	2	0	0	6

Table 14: Estimated observed overlap by species and fishery group, with units hooks km^{-2}. DOM denotes domestic fleet, and JV Joint Venture operations.

Code	Common name	NZL (DOM)	NZL (JV)	JPN	TWN	ZAF (DOM)	ZAF (JV)	AUS	KOR	Total
DIW	Gibson's albatross	0.19	0.59	1.20	0.44	0.00	0.00	0.30	0.00	2.72
DQS	Antipodean albatross	0.13	0.11	0.09	0.18	0.00	0.00	0.02	0.00	0.54
DIX	Wandering albatross	0.01	0.01	0.09	0.36	<0.01	0.01	0.01	<0.01	0.50
DBN	Tristan albatross	0.00	0.00	0.71	0.61	0.01	0.03	<0.01	0.18	1.54
DAM	Amsterdam albatross	0.00	0.00	0.13	2.84	<0.01	0.02	<0.01	<0.01	2.99
DIP	Southern royal albatross	0.14	0.28	0.20	0.08	<0.01	<0.01	0.02	<0.01	0.72
DIQ	Northern royal albatross	0.12	0.03	0.04	0.08	<0.01	<0.01	<0.01	<0.01	0.28
DCR	Atlantic yellow-nosed albatross	0.00	0.00	0.37	0.62	0.01	0.03	0.00	0.06	1.09
TQH	Indian yellow-nosed albatross	<0.01	<0.01	0.40	0.96	<0.01	0.01	0.05	<0.01	1.43
DIM	Black-browed albatross	0.01	<0.01	0.04	0.13	<0.01	0.01	0.01	<0.01	0.19
TQW	Campbell black-browed albatross	0.07	0.09	0.35	0.30	0.00	0.00	0.10	0.00	0.90
DCU	Shy albatross	0.00	0.00	0.29	0.19	<0.01	0.01	0.14	<0.01	0.63
TWD	New Zealand white-capped albatross	0.18	0.41	0.59	0.46	<0.01	0.03	0.12	<0.01	1.79
DKS	Salvin's albatross	0.10	0.07	0.06	0.11	<0.01	<0.01	0.02	<0.01	0.36
DER	Chatham Island albatross	0.04	<0.01	0.08	0.08	0.00	0.00	<0.01	0.00	0.20
DIC	Grey-headed albatross	0.01	0.01	0.08	0.10	<0.01	<0.01	<0.01	0.01	0.21
DSB	Southern Buller's albatross	0.14	0.26	0.60	0.21	0.00	0.00	0.14	0.00	1.36
DNB	Northern Buller's albatross	0.08	0.05	0.10	0.07	0.00	0.00	0.01	0.00	0.31
PHU	Sooty albatross	0.00	0.00	0.40	0.71	<0.01	0.01	<0.01	0.07	1.19
PHE	Light-mantled sooty albatross	0.01	0.04	0.09	0.05	<0.01	<0.01	<0.01	<0.01	0.20
PCI	Grey petrel	0.05	0.06	0.10	0.11	<0.01	<0.01	<0.01	0.02	0.34
PRK	Black petrel	0.07	0.03	0.16	0.19	0.00	0.00	0.06	0.00	0.51
PCW	Westland petrel	0.29	0.63	0.39	0.21	0.00	0.00	0.04	0.00	1.57
PRO	White-chinned petrel	<0.01	<0.01	0.07	0.20	<0.01	0.02	0.01	0.01	0.30
PCN	Spectacled petrel	0.00	0.00	0.05	0.60	<0.01	<0.01	0.00	0.01	0.65
Total		1.64	2.67	6.68	9.90	0.04	0.18	1.05	0.37	22.52

Table 15: Estimated total overlap by species and fishery group, with units hooks km^{-2}. DOM denotes domestic fleet, and JV Joint Venture operations.

Code	Common name	NZL (DOM)	NZL (JV)	JPN	TWN	ZAF (DOM)	ZAF (JV)	AUS	KOR	Total
DIW	Gibson's albatross	1.7	0.6	13.4	3.5	0.0	0.0	3.5	<0.1	22.6
DQS	Antipodean albatross	1.4	0.1	1.6	2.0	0.0	0.0	0.3	<0.1	5.4
DIX	Wandering albatross	0.1	<0.1	1.4	6.6	0.1	0.1	0.1	0.2	8.5
DBN	Tristan albatross	0.0	0.0	6.3	6.0	0.5	0.2	<0.1	2.8	15.7
DAM	Amsterdam albatross	0.0	0.0	2.4	28.4	0.1	0.1	<0.1	0.2	31.1
DIP	Southern royal albatross	1.5	0.3	2.6	0.6	<0.1	<0.1	0.2	<0.1	5.3
DIQ	Northern royal albatross	1.7	<0.1	0.6	0.6	<0.1	<0.1	<0.1	0.1	3.0
DCR	Atlantic yellow-nosed albatross	0.0	0.0	6.8	8.6	0.8	0.1	0.0	1.1	17.4
TQH	Indian yellow-nosed albatross	<0.1	<0.1	6.5	9.0	0.2	0.1	0.6	0.4	16.8
DIM	Black-browed albatross	0.1	<0.1	0.8	1.3	0.2	<0.1	0.1	0.1	2.6
TQW	Campbell black-browed albatross	0.7	0.1	4.5	2.2	0.0	0.0	1.1	0.1	8.7
DCU	Shy albatross	0.0	0.0	2.1	2.8	0.1	<0.1	1.1	0.1	6.2
TWD	New Zealand white-capped albatross	1.8	0.4	7.6	5.5	0.3	0.1	1.4	0.1	17.2
DKS	Salvin's albatross	1.1	0.1	1.7	1.2	<0.1	<0.1	0.2	<0.1	4.3
DER	Chatham Island albatross	0.4	<0.1	2.0	1.0	0.0	0.0	<0.1	0.1	3.6
DIC	Grey-headed albatross	0.1	<0.1	0.7	1.1	<0.1	<0.1	<0.1	0.2	2.1
DSB	Southern Buller's albatross	1.5	0.3	7.3	2.3	0.0	0.0	1.6	<0.1	13.0
DNB	Northern Buller's albatross	1.1	<0.1	2.8	1.0	0.0	0.0	0.1	0.0	5.1
PHU	Sooty albatross	0.0	0.0	3.5	8.6	0.3	0.1	<0.1	1.3	13.9
PHE	Light-mantled sooty albatross	0.1	<0.1	1.0	0.7	<0.1	<0.1	<0.1	0.1	2.0
PCI	Grey petrel	0.5	0.1	1.0	1.1	<0.1	<0.1	<0.1	0.3	3.0
PRK	Black petrel	1.0	<0.1	3.6	4.3	0.0	0.0	0.7	0.6	10.1
PCW	Westland petrel	2.6	0.6	5.6	1.9	0.0	0.0	0.5	0.0	11.2
PRO	White-chinned petrel	0.1	<0.1	1.6	2.8	0.2	0.1	0.1	0.2	5.0
PCN	Spectacled petrel	0.0	0.0	1.0	11.9	0.2	<0.1	0.0	0.1	13.2
Total		17.4	2.7	88.3	114.9	2.9	1.0	11.6	8.2	247.0

Table 16: The mean of the year and month specific proportions of each population from 5° cells that overlapped with fishing effort.

Code	Common name	NZL (DOM)	NZL (JV)	JPN	TWN	ZAF (DOM)	ZAF (JV)	AUS	KOR	Total
DIW	Gibson's albatross	0.076	0.109	0.156	0.051	0.000	0.000	0.099	0.002	0.276
DQS	Antipodean albatross	0.059	0.018	0.037	0.033	0.000	0.000	0.008	0.000	0.111
DIX	Wandering albatross	0.003	0.002	0.033	0.043	0.006	0.004	0.003	0.007	0.079
DBN	Tristan albatross	0.000	0.000	0.099	0.080	0.028	0.011	0.001	0.040	0.188
DAM	Amsterdam albatross	0.000	0.000	0.044	0.191	0.005	0.004	0.001	0.015	0.224
DIP	Southern royal albatross	0.061	0.053	0.029	0.009	0.000	0.000	0.008	0.001	0.092
DIQ	Northern royal albatross	0.089	0.004	0.010	0.008	0.001	0.001	0.001	0.002	0.102
DCR	Atlantic yellow-nosed albatross	0.000	0.000	0.107	0.145	0.046	0.011	0.000	0.034	0.256
TQH	Indian yellow-nosed albatross	0.002	0.001	0.070	0.086	0.013	0.006	0.023	0.022	0.168
DIM	Black-browed albatross	0.007	0.001	0.020	0.013	0.008	0.002	0.002	0.002	0.039
TQW	Campbell black-browed albatross	0.031	0.018	0.051	0.029	0.000	0.000	0.030	0.010	0.108
DCU	Shy albatross	0.000	0.000	0.017	0.017	0.005	0.003	0.143	0.003	0.175
TWD	New Zealand white-capped albatross	0.076	0.084	0.079	0.039	0.015	0.009	0.042	0.007	0.214
DKS	Salvin's albatross	0.049	0.010	0.057	0.011	0.002	0.001	0.008	0.001	0.117
DER	Chatham Island albatross	0.026	0.001	0.075	0.020	0.000	0.000	0.001	0.002	0.117
DIC	Grey-headed albatross	0.002	0.001	0.013	0.010	0.001	0.001	0.001	0.004	0.026
DSB	Southern Buller's albatross	0.064	0.052	0.100	0.032	0.000	0.000	0.043	0.000	0.195
DNB	Northern Buller's albatross	0.050	0.008	0.111	0.020	0.000	0.000	0.005	0.000	0.155
PHU	Sooty albatross	0.000	0.000	0.062	0.061	0.020	0.007	0.001	0.021	0.132
PHE	Light-mantled sooty albatross	0.004	0.009	0.011	0.007	0.002	0.001	0.001	0.004	0.022
PCI	Grey petrel	0.018	0.012	0.012	0.011	0.001	0.001	0.000	0.005	0.041
PRK	Black petrel	0.054	0.006	0.095	0.092	0.000	0.000	0.022	0.014	0.246
PCW	Westland petrel	0.107	0.112	0.081	0.029	0.000	0.000	0.017	0.000	0.177
PRO	White-chinned petrel	0.003	0.001	0.041	0.024	0.010	0.005	0.002	0.005	0.068
PCN	Spectacled petrel	0.000	0.000	0.057	0.209	0.013	0.001	0.000	0.006	0.236

Table 17 Comparison of predicted vs observed captures per capture code from the selected 2025 risk assessment model, for a) NZL (DOM), NZL (JV), ZAF (DOM), ZAF (JV) and AUS), and b) (continued on next page) JPN, TWN and KOR. DOM denotes domestic fleet, and JV Joint Venture operations. 95% CIs are provided in parentheses.

a) NZL (DOM), NZL (JV), ZAF (DOM), ZAF (JV) and AUS

		NZL (DOM)		NZL (JV)		ZAF (DOM)		ZAF (JV)		AUS	
Code	Common name	Obs	Est	Obs	Est	Obs	Est	Obs	Est	Obs	Est
DIZ	*Diomedea* spp	4.2	3.6 (2.2-5.3)	0	0 (0-0.2)	0.2	0.1 (0-0.2)	0	0 (0-0.2)	0.1	0.1 (0-0.4)
THZ	*Thalassarche* spp	29.8	29 (24.7-33.7)	6.2	5.5 (3.8-7.6)	12.3	11.6 (8.9-14.7)	26.3	25.6 (21.5-29.8)	0.6	0.7 (0.2-1.5)
PHZ	*Phoebetria* spp	0	0 (0-0.2)	0	0 (0-0.1)	0	0 (0-0.1)	0	0 (0-0.2)	0	0 (0-0.1)
PTZ	*Procellaria* spp	12.7	12 (9.5-14.9)	0.2	0.1 (0-0.4)	3.6	3.1 (1.8-4.6)	43.3	42.3 (37.2-47.7)	0	0.2 (0-0.6)
ALZ	Diomedeidae	0	0.7 (0.2-1.4)	0	0.3 (0-0.8)	0.4	0.7 (0.2-1.5)	1.2	1.5 (0.7-2.5)	2.8	2.4 (1.2-3.7)
PRX	Procellariidae	0	0.3 (0-0.8)	0	0.1 (0-0.3)	0	0.3 (0-0.7)	0	0.4 (0.1-1)	1.3	1 (0.3-1.9)
BLZ	Bird	0	1 (0.3-1.8)	0	0.4 (0.1-1)	0	0.6 (0.2-1.3)	0	0.9 (0.2-1.7)	0.8	1.1 (0.4-2.1)

b) JPN, TWN and KOR

		JPN		TWN		KOR	
Code	Common name	Obs	Est	Obs	Est	Obs	Est
DIZ	*Diomedea* spp	35.8	35.4 (30.7-40)	8.8	8.4 (6.2-10.8)	0.2	0.1 (0-0.4)
THZ	*Thalassarche* spp	321.1	320.8 (307.2-334.8)	61.2	60.5 (54.3-66.8)	4.9	4.3 (2.8-5.9)
PHZ	*Phoebetria* spp	22.2	21.9 (18.4-25.5)	9.6	9.1 (6.8-11.5)	0.8	0.5 (0.1-1.1)
PTZ	*Procellaria* spp	54.2	53.8 (48.1-59.6)	36.2	35.7 (31.1-40.7)	0	0.1 (0-0.2)
ALZ	Diomedeidae	68.7	69.1 (62.6-76.2)	14.3	14.8 (11.8-17.8)	0	0.5 (0.1-1.2)
PRX	Procellariidae	13.9	14.1 (11.4-17.2)	0.6	0.9 (0.2-1.8)	0	0.1 (0-0.2)
BLZ	Bird	18.6	19.5 (16.3-23)	0.7	2.1 (1.1-3.2)	0	0.5 (0.1-1.2)

Table 18: Catchability coefficients estimated from the selected 2025 risk assessment model. DOM denotes domestic fleet, and JV Joint Venture operations. 95% CIs are provided in parentheses.

Species group	NZL (DOM)	NZL (JV)	JPN	TWN	ZAF (DOM)	ZAF (JV)	AUS	KOR
Great albatross	5.23 (3.71-7.2)	0.07 (0.01-0.23)	20.15 (15.82-25.9)	4.63 (3.22-6.35)	15.39 (2.2-44.03)	1.88 (0.18-6.48)	0.94 (0.13-3.16)	1.74 (0.4-4.41)
Mollymawk	4.4 (3.53-5.33)	0.57 (0.4-0.79)	12.1 (10.23-13.87)	1.53 (1.33-1.76)	20.07 (16.54-23.9)	16.83 (14.07-19.78)	0.77 (0.47-1.07)	4.12 (2.91-5.41)
Sooty albatross	1.29 (0.16-4.2)	0.23 (0.02-0.86)	23.99 (16.3-34.06)	5.81 (4.18-8.13)	4.93 (0.35-19.64)	2.22 (0.21-8.05)	2.36 (0.12-11.62)	3.6 (1.62-6.17)
Medium petrel	5.38 (4.21-6.77)	0.1 (0.03-0.24)	3.4 (2.72-4.2)	0.59 (0.46-0.75)	4.68 (3-6.76)	9.58 (7.36-12.15)	1.3 (0.74-2.09)	0.09 (0.02-0.24)

Table 19: Estimated total deaths (D_s), cryptic deaths, maximum theoretical growth rate ($r_s \cdot N_s$) and relative mortalities (deaths relative to $r_s \cdot N_s$) from the selected 2025 risk assessment model. 95% CIs are provided in parentheses.

Common name	Total deaths	Cryptic deaths	$r_s \cdot N_s$	Relative mortalities
Gibson's albatross	438 (305-646)	110 (6-280)	598 (450-800)	0.72 (0.48-1.14)
Antipodean albatross	78 (53-115)	20 (5-45)	551 (407-782)	0.14 (0.10-0.21)
Wandering albatross	265 (187-393)	72 (14-158)	1,879 (1,418-2,513)	0.14 (0.10-0.22)
Tristan albatross	166 (102-270)	43 (8-104)	459 (269-770)	0.36 (0.24-0.55)
Amsterdam albatross	3 (2-6)	1 (0-2)	9 (7-13)	0.38 (0.25-0.60)
Southern royal albatross	149 (93-251)	37 (5-101)	1,049 (685-1,810)	0.14 (0.09-0.21)
Northern royal albatross	41 (24-70)	10 (3-24)	804 (524-1,383)	0.05 (0.04-0.07)
Atlantic yellow-nosed albatross	1,071 (771-1,532)	297 (69-657)	5,130 (3,741-7,061)	0.21 (0.15-0.30)
Indian yellow-nosed albatross	1,299 (868-1,897)	361 (56-836)	6,476 (4,542-9,190)	0.20 (0.14-0.30)
Black-browed albatross	2,936 (2,275-3,861)	802 (241-1,634)	83,375 (65,879-106,184)	0.04 (0.03-0.05)
Campbell black-browed albatross	226 (158-338)	65 (6-154)	1,751 (1,309-2,439)	0.13 (0.09-0.20)
Shy albatross	149 (103-226)	42 (7-98)	2,257 (1,547-3,327)	0.07 (0.04-0.10)
New Zealand white-capped albatross	3,445 (2,457-4,820)	965 (158-2,178)	14,038 (9,405-20,602)	0.24 (0.16-0.38)
Salvin's albatross	260 (186-379)	73 (13-163)	3,929 (2,963-5,390)	0.07 (0.05-0.10)
Chatham Island albatross	41 (29-62)	12 (1-29)	698 (572-868)	0.06 (0.04-0.09)
Grey-headed albatross	452 (263-949)	125 (25-347)	12,616 (7,323-27,748)	0.04 (0.03-0.05)
Southern Buller's albatross	344 (236-526)	97 (6-232)	1,541 (1,220-2,001)	0.23 (0.15-0.33)
Northern Buller's albatross	227 (155-330)	64 (6-154)	2,273 (1,781-2,920)	0.10 (0.07-0.15)
Sooty albatross	567 (402-825)	166 (37-340)	1,780 (1,326-2,453)	0.32 (0.20-0.49)
Light-mantled sooty albatross	169 (99-287)	48 (5-127)	2,687 (1,782-4,198)	0.06 (0.04-0.11)
Grey petrel	141 (94-213)	39 (11-83)	17,819 (12,545-26,541)	0.01 (0.01-0.01)
Black petrel	36 (25-52)	10 (3-21)	1,264 (1,073-1,538)	0.03 (0.02-0.04)
Westland petrel	82 (52-131)	23 (5-53)	1,782 (1,214-2,635)	0.05 (0.03-0.07)
White-chinned petrel	3,562 (2,829-4,610)	1,011 (292-2,036)	263,270 (186,430-382,655)	0.01 (0.01-0.02)
Spectacled petrel	132 (88-197)	36 (8-80)	8,140 (5,857-11,532)	0.02 (0.01-0.02)

Table 20: Estimated total deaths (D_s), maximum theoretical growth rate ($r_s \cdot N_s$) and relative mortalities (deaths relative to $r_s \cdot N_s$) for: the selected 2025 risk assessment model; and, the sensitivity run with family-specific π. 95% CIs are provided in parentheses.

	2025 risk assessment model			Sensitivity – family-specific $\boldsymbol{\pi}$		
Common name	Total deaths	$r_s \cdot N_s$	Relative mortalities	Total deaths	$r_s \cdot N_s$	Relative mortalities
Gibson's albatross	438 (305-646)	598 (450-800)	0.72 (0.48-1.14)	361 (263-514)	604 (450-817)	0.60 (0.39-0.89)
Antipodean albatross	78 (53-115)	551 (407-782)	0.14 (0.10-0.21)	66 (46-96)	550 (391-764)	0.12 (0.08-0.17)
Wandering albatross	265 (187-393)	1,879 (1,418-2,513)	0.14 (0.10-0.22)	223 (159-310)	1,896 (1,427-2,550)	0.12 (0.08-0.17)
Tristan albatross	166 (102-270)	459 (269-770)	0.36 (0.24-0.55)	136 (87-222)	464 (282-766)	0.30 (0.21-0.43)
Amsterdam albatross	3 (2-6)	9 (7-13)	0.38 (0.25-0.60)	3 (2-4)	9 (7-13)	0.32 (0.21-0.47)
Southern royal albatross	149 (93-251)	1,049 (685-1,810)	0.14 (0.09-0.21)	126 (80-203)	1,049 (695-1,754)	0.12 (0.08-0.18)
Northern royal albatross	41 (24-70)	804 (524-1,383)	0.05 (0.04-0.07)	37 (23-62)	807 (551-1,401)	0.04 (0.03-0.06)
Atlantic yellow-nosed albatross	1,071 (771-1,532)	5,130 (3,741-7,061)	0.21 (0.15-0.30)	1,110 (799-1,546)	5,132 (3,739-6,851)	0.22 (0.15-0.32)
Indian yellow-nosed albatross	1,299 (868-1,897)	6,476 (4,542-9,190)	0.20 (0.14-0.30)	1,338 (926-1,951)	6,466 (4,559-9,223)	0.21 (0.14-0.31)
Black-browed albatross	2,936 (2,275-3,861)	83,375 (65,879-106,184)	0.04 (0.03-0.05)	3,019 (2,339-3,938)	82,522 (65,404-105,457)	0.04 (0.03-0.05)
Campbell black-browed albatross	226 (158-338)	1,751 (1,309-2,439)	0.13 (0.09-0.20)	238 (165-336)	1,799 (1,354-2,432)	0.13 (0.09-0.20)
Shy albatross	149 (103-226)	2,257 (1,547-3,327)	0.07 (0.04-0.10)	155 (109-232)	2,235 (1,580-3,387)	0.07 (0.04-0.10)
New Zealand white-capped albatross	3,445 (2,457-4,820)	14,038 (9,405-20,602)	0.24 (0.16-0.38)	3,576 (2,556-5,067)	14,097 (9,617-20,965)	0.25 (0.17-0.39)
Salvin's albatross	260 (186-379)	3,929 (2,963-5,390)	0.07 (0.05-0.10)	271 (189-395)	3,981 (3,052-5,209)	0.07 (0.05-0.10)
Chatham Island albatross	41 (29-62)	698 (572-868)	0.06 (0.04-0.09)	43 (29-62)	699 (568-869)	0.06 (0.04-0.09)
Grey-headed albatross	452 (263-949)	12,616 (7,323-27,748)	0.04 (0.03-0.05)	466 (276-932)	12,291 (7,274-25,968)	0.04 (0.03-0.05)
Southern Buller's albatross	344 (236-526)	1,541 (1,220-2,001)	0.23 (0.15-0.33)	362 (250-539)	1,529 (1,219-2,020)	0.23 (0.16-0.35)
Northern Buller's albatross	227 (155-330)	2,273 (1,781-2,920)	0.10 (0.07-0.15)	234 (164-340)	2,250 (1,765-2,916)	0.10 (0.07-0.15)
Sooty albatross	567 (402-825)	1,780 (1,326-2,453)	0.32 (0.20-0.49)	441 (334-578)	1,782 (1,335-2,450)	0.25 (0.16-0.37)
Light-mantled sooty albatross	169 (99-287)	2,687 (1,782-4,198)	0.06 (0.04-0.11)	123 (79-194)	2,658 (1,779-4,204)	0.05 (0.03-0.07)
Grey petrel	141 (94-213)	17,819 (12,545-26,541)	0.01 (0.01-0.01)	143 (97-213)	17,949 (12,763-26,072)	0.01 (0.01-0.01)
Black petrel	36 (25-52)	1,264 (1,073-1,538)	0.03 (0.02-0.04)	37 (25-53)	1,269 (1,063-1,515)	0.03 (0.02-0.04)
Westland petrel	82 (52-131)	1,782 (1,214-2,635)	0.05 (0.03-0.07)	81 (53-132)	1,778 (1,204-2,712)	0.05 (0.03-0.07)
White-chinned petrel	3,562 (2,829-4,610)	263,270 (186,430-382,655)	0.01 (0.01-0.02)	3,599 (2,796-4,634)	259,021 (186,993-361,680)	0.01 (0.01-0.02)
Spectacled petrel	132 (88-197)	8,140 (5,857-11,532)	0.02 (0.01-0.02)	133 (92-196)	8,081 (5,787-11,187)	0.02 (0.01-0.02)

Table 21: Estimated total deaths (D_s), maximum theoretical growth rate, ($r_s \cdot N_s$) and relative mortalities (deaths relative to $r_s \cdot N_s$) for: the selected 2025 risk assessment model; and, the 2025 model fitted to data from 2012 to 2019. 95% CIs are provided in parentheses.

	2025 risk assessment model			2025 risk assessment model fitted to data from 2012-19		
Common name	Total deaths	$r_s \cdot N_s$	Relative mortalities	Total deaths	$r_s \cdot N_s$	Relative mortalities
Gibson's albatross	438 (305-646)	598 (450-800)	0.72 (0.48-1.14)	587 (395-904)	603 (459-790)	0.97 (0.62-1.60)
Antipodean albatross	78 (53-115)	551 (407-782)	0.14 (0.10-0.21)	93 (61-147)	554 (403-788)	0.17 (0.11-0.26)
Wandering albatross	265 (187-393)	1,879 (1,418-2,513)	0.14 (0.10-0.22)	279 (187-408)	1,885 (1,409-2,571)	0.15 (0.10-0.23)
Tristan albatross	166 (102-270)	459 (269-770)	0.36 (0.24-0.55)	223 (131-378)	463 (276-779)	0.47 (0.30-0.75)
Amsterdam albatross	3 (2-6)	9 (7-13)	0.38 (0.25-0.60)	4 (2-6)	9 (7-13)	0.39 (0.25-0.63)
Southern royal albatross	149 (93-251)	1,049 (685-1,810)	0.14 (0.09-0.21)	195 (116-354)	1,053 (673-1,855)	0.18 (0.12-0.30)
Northern royal albatross	41 (24-70)	804 (524-1,383)	0.05 (0.04-0.07)	46 (27-84)	811 (537-1,418)	0.06 (0.04-0.08)
Atlantic yellow-nosed albatross	1,071 (771-1,532)	5,130 (3,741-7,061)	0.21 (0.15-0.30)	1,309 (931-1,819)	5,053 (3,677-6,769)	0.26 (0.18-0.37)
Indian yellow-nosed albatross	1,299 (868-1,897)	6,476 (4,542-9,190)	0.20 (0.14-0.30)	1,514 (990-2,247)	6,488 (4,588-9,103)	0.23 (0.16-0.35)
Black-browed albatross	2,936 (2,275-3,861)	83,375 (65,879-106,184)	0.04 (0.03-0.05)	3,478 (2,557-4,613)	82,740 (66,062-105,017)	0.04 (0.03-0.06)
Campbell black-browed albatross	226 (158-338)	1,751 (1,309-2,439)	0.13 (0.09-0.20)	283 (185-413)	1,767 (1,345-2,465)	0.16 (0.10-0.25)
Shy albatross	149 (103-226)	2,257 (1,547-3,327)	0.07 (0.04-0.10)	198 (133-295)	2,276 (1,566-3,316)	0.09 (0.06-0.14)
New Zealand white-capped albatross	3,445 (2,457-4,820)	14,038 (9,405-20,602)	0.24 (0.16-0.38)	4,277 (2,989-5,971)	13,935 (9,207-21,511)	0.31 (0.20-0.47)
Salvin's albatross	260 (186-379)	3,929 (2,963-5,390)	0.07 (0.05-0.10)	337 (228-501)	3,949 (2,996-5,458)	0.09 (0.06-0.13)
Chatham Island albatross	41 (29-62)	698 (572-868)	0.06 (0.04-0.09)	56 (37-83)	695 (552-895)	0.08 (0.05-0.12)
Grey-headed albatross	452 (263-949)	12,616 (7,323-27,748)	0.04 (0.03-0.05)	524 (298-1,056)	12,231 (7,519-26,079)	0.04 (0.03-0.06)
Southern Buller's albatross	344 (236-526)	1,541 (1,220-2,001)	0.23 (0.15-0.33)	444 (288-693)	1,544 (1,177-2,071)	0.29 (0.19-0.44)
Northern Buller's albatross	227 (155-330)	2,273 (1,781-2,920)	0.10 (0.07-0.15)	301 (202-437)	2,237 (1,776-2,894)	0.13 (0.09-0.19)
Sooty albatross	567 (402-825)	1,780 (1,326-2,453)	0.32 (0.20-0.49)	630 (430-923)	1,791 (1,307-2,444)	0.35 (0.22-0.56)
Light-mantled sooty albatross	169 (99-287)	2,687 (1,782-4,198)	0.06 (0.04-0.11)	181 (108-326)	2,670 (1,770-4,326)	0.07 (0.04-0.12)
Grey petrel	141 (94-213)	17,819 (12,545-26,541)	0.01 (0.01-0.01)	142 (89-219)	17,702 (11,989-26,100)	0.01 (0.01-0.01)
Black petrel	36 (25-52)	1,264 (1,073-1,538)	0.03 (0.02-0.04)	42 (29-64)	1,258 (1,058-1,569)	0.03 (0.02-0.05)
Westland petrel	82 (52-131)	1,782 (1,214-2,635)	0.05 (0.03-0.07)	85 (54-140)	1,780 (1,224-2,737)	0.05 (0.03-0.07)
White-chinned petrel	3,562 (2,829-4,610)	263,270 (186,430-382,655)	0.01 (0.01-0.02)	4,663 (3,601-6,068)	263,870 (189,959-371,580)	0.02 (0.01-0.03)
Spectacled petrel	132 (88-197)	8,140 (5,857-11,532)	0.02 (0.01-0.02)	157 (108-232)	8,153 (5,949-11,232)	0.04 (0.03-0.06)

Table 22: Estimated total deaths (D_s), maximum theoretical growth rate, ($r_s \cdot N_s$) and relative mortalities (deaths relative to $r_s \cdot N_s$) for: the selected 2025 risk assessment model; and, the 2024 risk assessment model. 95% CIs are provided in parentheses.

	2025 risk assessment model			2024 risk assessment		
Common name	Total deaths	$r_s \cdot N_s$	Relative mortalities	Total deaths	$r_s \cdot N_s$	Relative mortalities
Gibson's albatross	438 (305-646)	598 (450-800)	0.72 (0.48-1.14)	606 (444-827)	940 (701-1 265)	0.65 (0.43-0.97)
Antipodean albatross	78 (53-115)	551 (407-782)	0.14 (0.10-0.21)	67 (48-96)	655 (499-861)	0.10 (0.07-0.15)
Wandering albatross	265 (187-393)	1,879 (1,418-2,513)	0.14 (0.10-0.22)	253 (179-354)	1 875 (1 403-2 594)	0.13 (0.09-0.19)
Tristan albatross	166 (102-270)	459 (269-770)	0.36 (0.24-0.55)	188 (113-312)	455 (274-771)	0.41 (0.28-0.62)
Amsterdam albatross	3 (2-6)	9 (7-13)	0.38 (0.25-0.60)	2 (2-4)	9 (7-13)	0.25 (0.17-0.38)
Southern royal albatross	149 (93-251)	1,049 (685-1,810)	0.14 (0.09-0.21)	74 (53-103)	1 146 (712-1 900)	0.06 (0.04-0.11)
Northern royal albatross	41 (24-70)	804 (524-1,383)	0.05 (0.04-0.07)	16 (9-26)	834 (567-1 367)	0.02 (0.01-0.03)
Atlantic yellow-nosed albatross	1,071 (771-1,532)	5,130 (3,741-7,061)	0.21 (0.15-0.30)	91 (63-133)	5 304 (3 965-7 124)	0.02 (0.01-0.02)
Indian yellow-nosed albatross*	1,299 (868-1,897)	6,476 (4,542-9,190)	0.20 (0.14-0.30)	943 (702-1,310)	13 901 (10 580-18 427)	0.07 (0.05-0.10)
Black-browed albatross*	2,936 (2,275-3,861)	83,375 (65,879-106,184)	0.04 (0.03-0.05)	1,268 (926-1,769)	56 203 (44 501-70 437)	0.02 (0.02-0.03)
Campbell black-browed albatross*	226 (158-338)	1,751 (1,309-2,439)	0.13 (0.09-0.20)	449 (332-626)	99 228 (71 446-138 500)	0.00 (0.00-0.01)
Shy albatross	149 (103-226)	2,257 (1,547-3,327)	0.07 (0.04-0.10)	128 (84-198)	2 377 (1 656-3 475)	0.05 (0.03-0.08)
New Zealand white-capped albatross*	3,445 (2,457-4,820)	14,038 (9,405-20,602)	0.24 (0.16-0.38)	2,158 (1,594-2,937)	28 743 (20 842-39 599)	0.07 (0.05-0.11)
Salvin's albatross	260 (186-379)	3,929 (2,963-5,390)	0.07 (0.05-0.10)	127 (84-194)	6 885 (4 841-9 760)	0.02 (0.01-0.03)
Chatham Island albatross	41 (29-62)	698 (572-868)	0.06 (0.04-0.09)	12 (8-18)	703 (568-894)	0.02 (0.01-0.03)
Grey-headed albatross*	452 (263-949)	12,616 (7,323-27,748)	0.04 (0.03-0.05)	3,169 (2,409-4,250)	95 090 (76 764-118 084)	0.03 (0.02-0.05)
Southern Buller's albatross*	344 (236-526)	1,541 (1,220-2,001)	0.23 (0.15-0.33)	2,110 (1,554-2,910)	23 601 (19 122-29 641)	0.09 (0.06-0.13)
Northern Buller's albatross	227 (155-330)	2,273 (1,781-2,920)	0.10 (0.07-0.15)	99 (70-142)	2 260 (1 814-2 902)	0.04 (0.03-0.06)
Sooty albatross	567 (402-825)	1,780 (1,326-2,453)	0.32 (0.20-0.49)	646 (475-857)	1 677 (1 193-2 315)	0.39 (0.25-0.58)
Light-mantled sooty albatross*	169 (99-287)	2,687 (1,782-4,198)	0.06 (0.04-0.11)	306 (220-426)	5 052 (3 505-7 424)	0.06 (0.04-0.09)
Grey petrel*	141 (94-213)	17,819 (12,545-26,541)	0.01 (0.01-0.01)	458 (337-636)	35 025 (26 669-46 892)	0.01 (0.01-0.02)
Black petrel	36 (25-52)	1,264 (1,073-1,538)	0.03 (0.02-0.04)	38 (26-54)	1 267 (1 069-1 520)	0.03 (0.02-0.04)
Westland petrel*	82 (52-131)	1,782 (1,214-2,635)	0.05 (0.03-0.07)	117 (74-181)	1 929 (1 305-2 896)	0.06 (0.04-0.09)
White-chinned petrel*	3,562 (2,829-4,610)	263,270 (186,430-382,655)	0.01 (0.01-0.02)	3,167 (2,469-4,076)	148 436 (109 106-200 975)	0.02 (0.01-0.03)
Spectacled petrel	132 (88-197)	8,140 (5,857-11,532)	0.02 (0.01-0.02)	374 (263-531)	26 760 (18 315-39 850)	0.01 (0.01-0.02)

* indicates species that had visible posterior updates to biological parameters in the 2024 risk assessment.

Figures

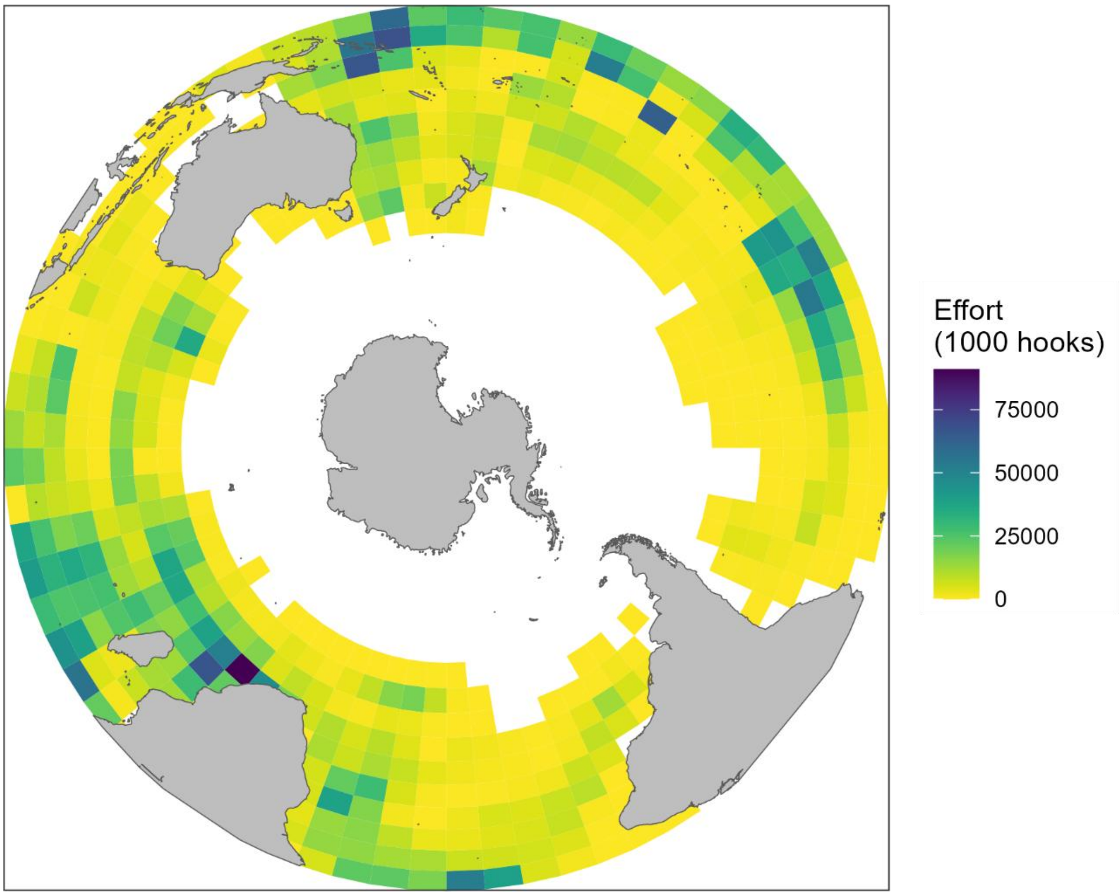


Figure 1: Map of total effort included in the risk assessment (in units of 1000 hooks).

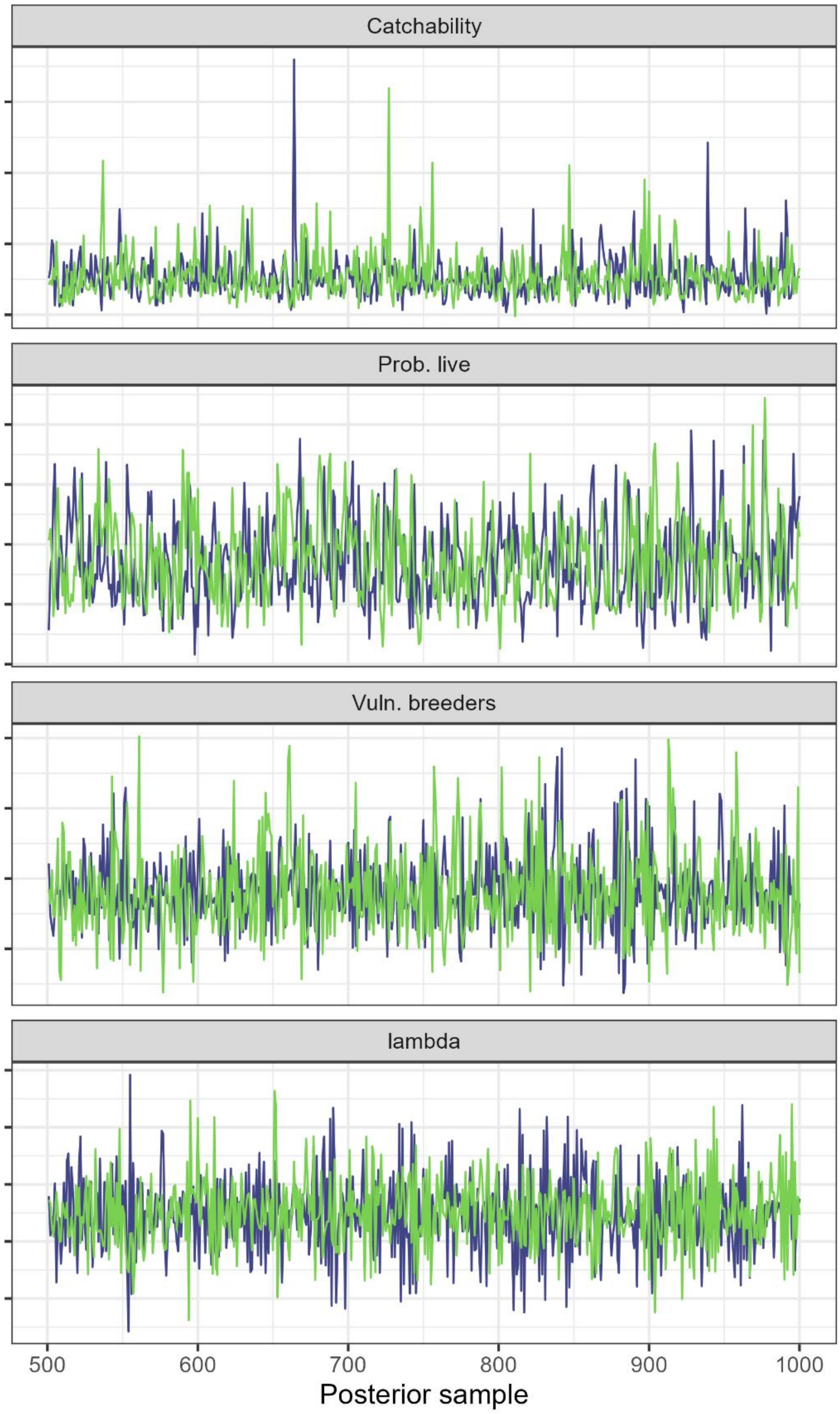


Figure 2: MCMC trace diagnostics for the 2025 risk assessment model fit. For each MCMC chain, the Euclidean norm is calculated for each parameter vector.

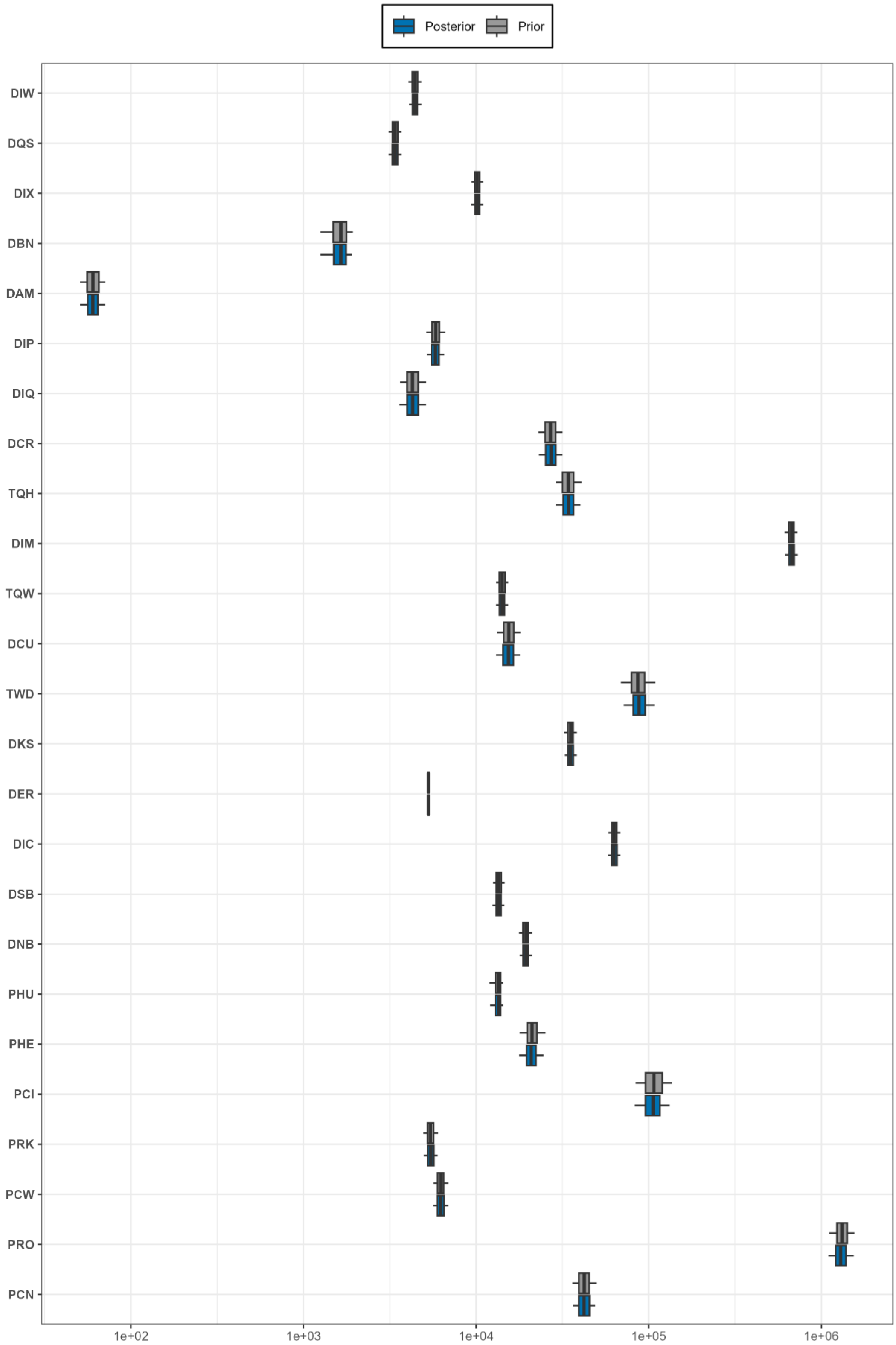


Figure 3: Prior and posterior distributions of the number of breeding pairs per species (N_s^{BP}; log-10 transformed) from the selected 2025 risk assessment model.

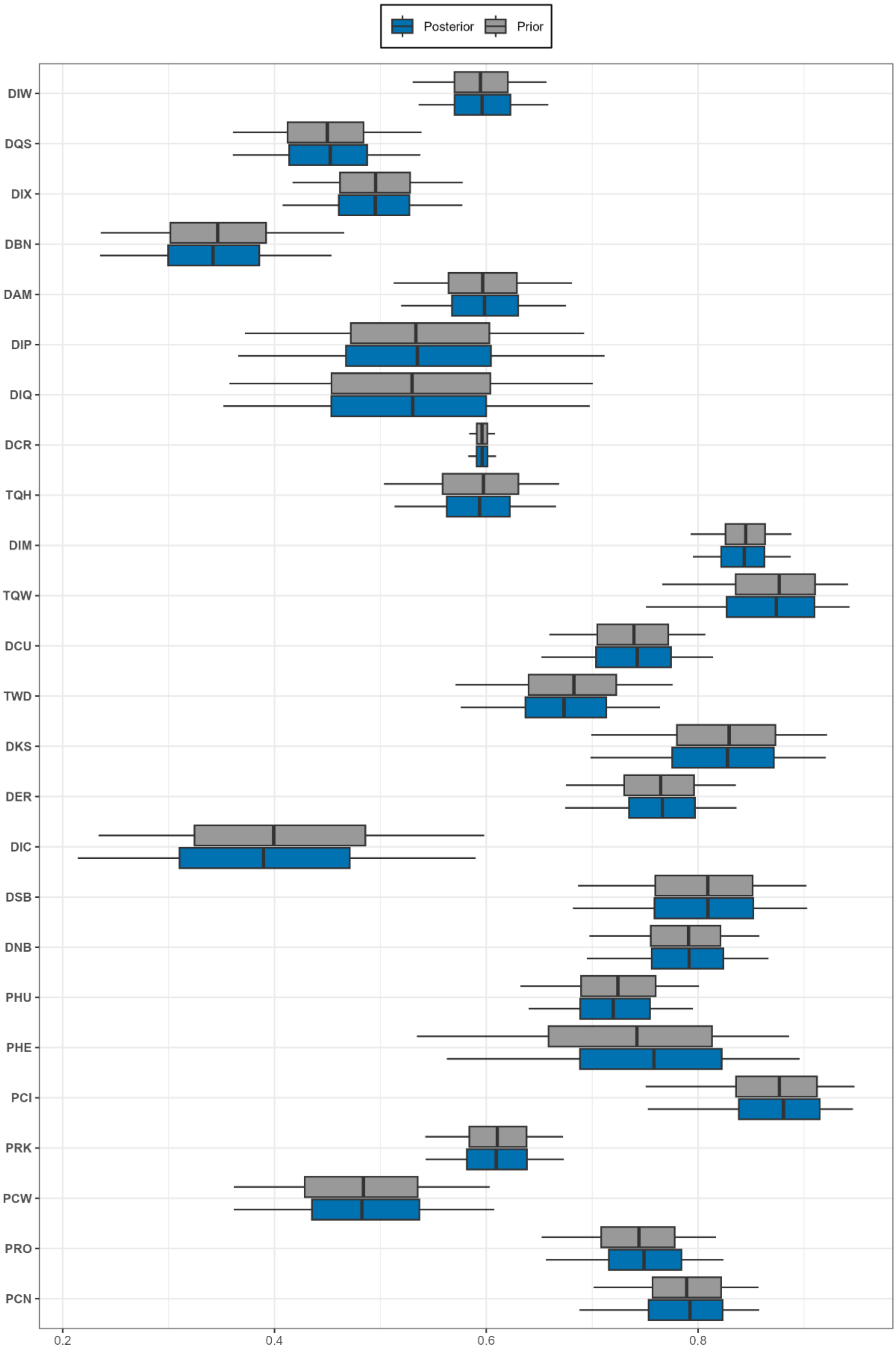


Figure 4: Prior and posterior distributions of the probability of breeding per species (P_s^B) from the selected 2025 risk assessment model.

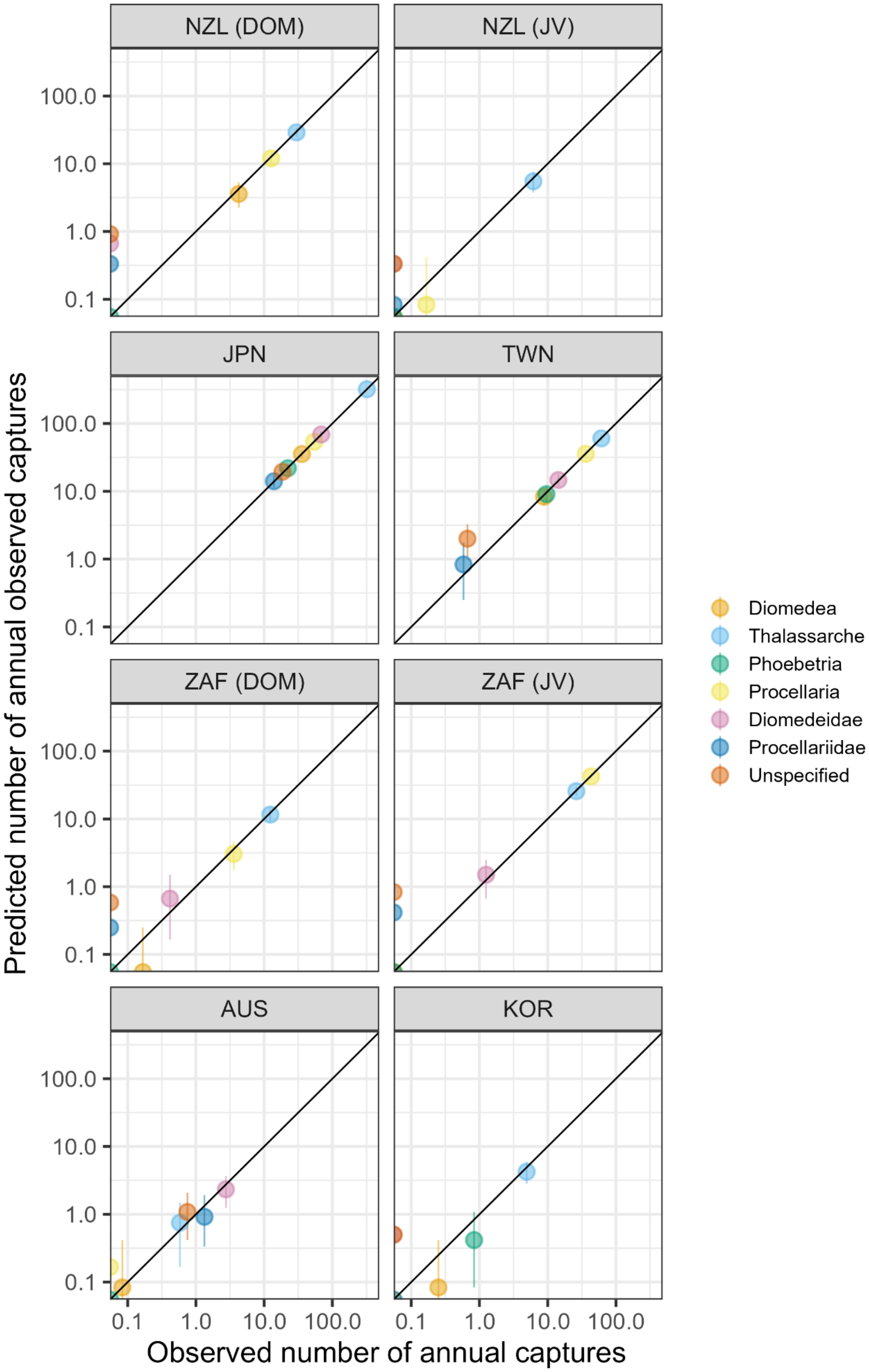


Figure 5: Fit to average annual empirical captures by capture code and fishery group (on the log-10 scale) from the selected 2025 risk assessment model. DOM denotes domestic fleet, and JV Joint Venture operations.

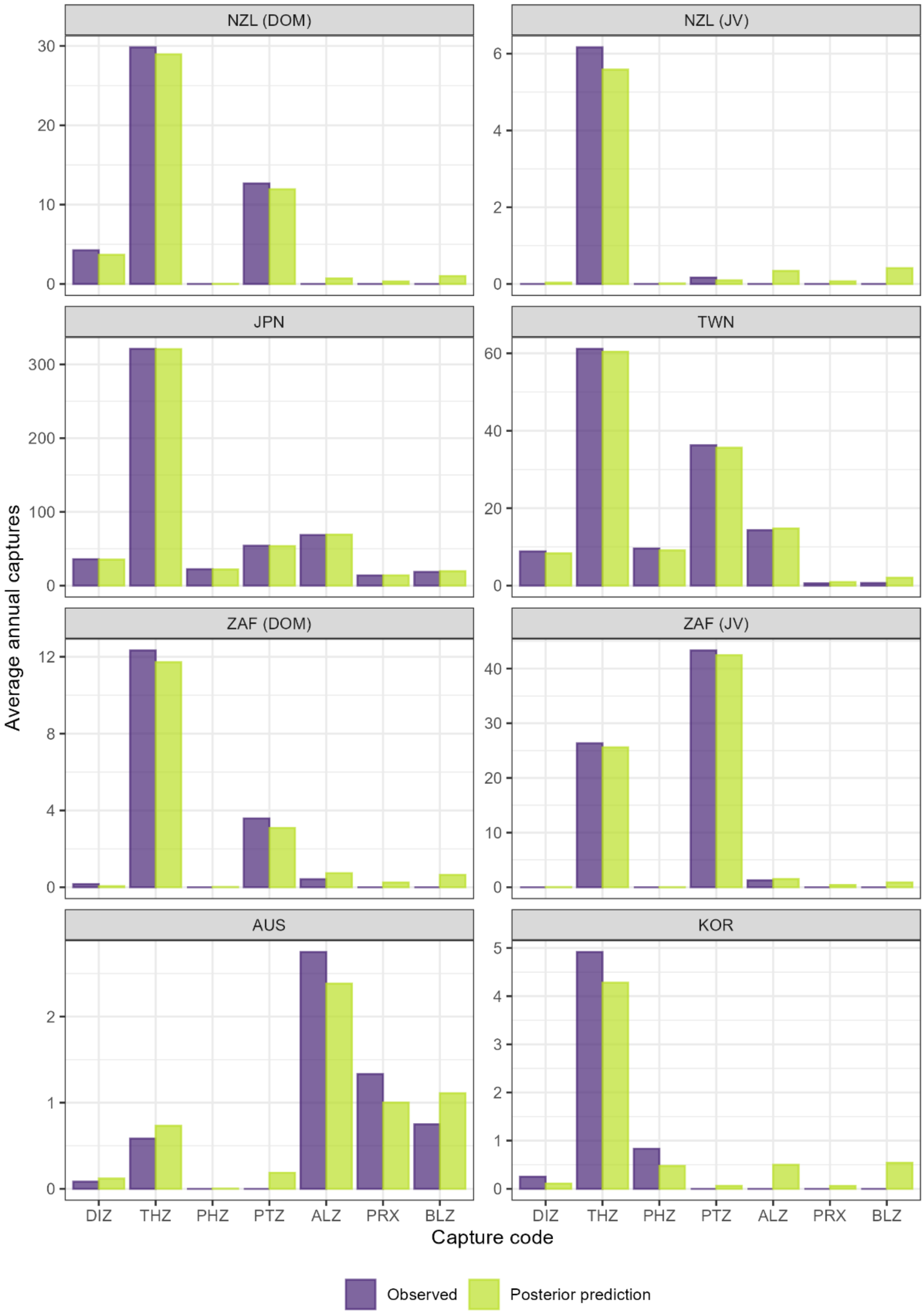


Figure 6: Fit to average annual empirical captures by capture code and fishery group from the selected 2025 risk assessment model. DOM denotes domestic fleet, and JV Joint Venture operations.

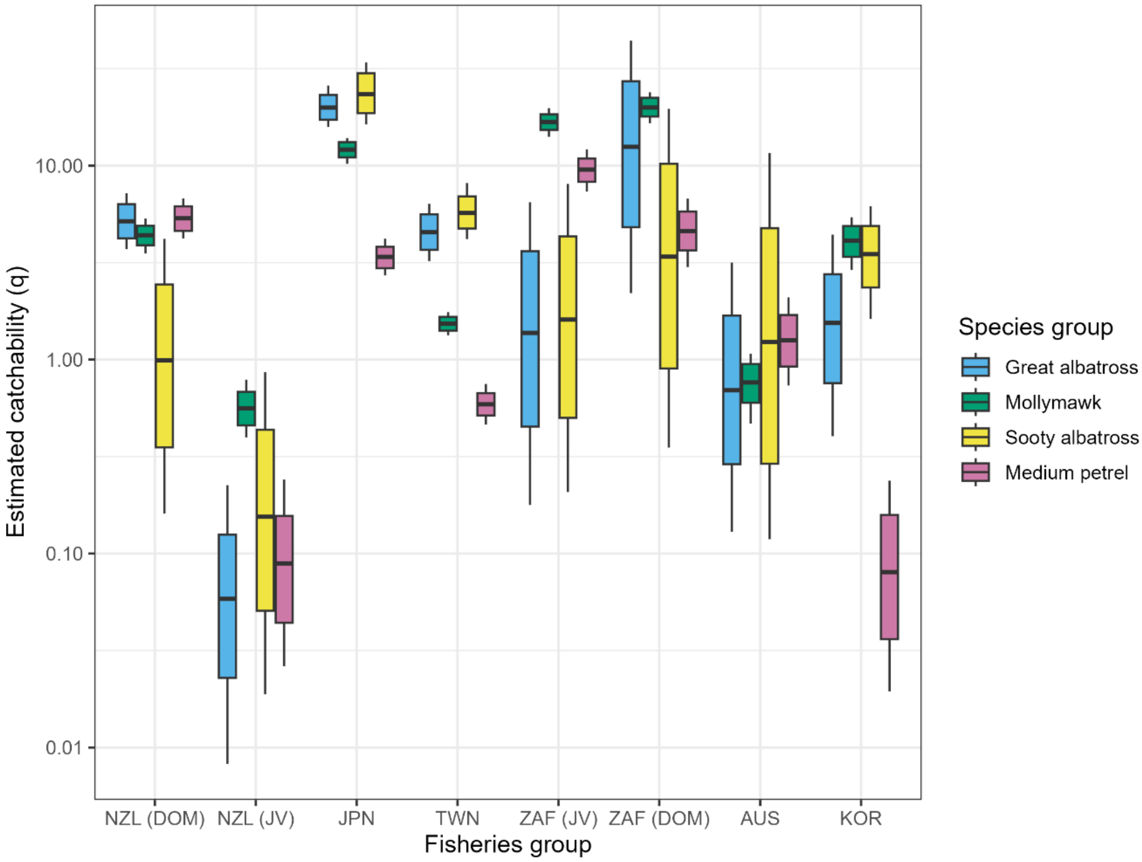
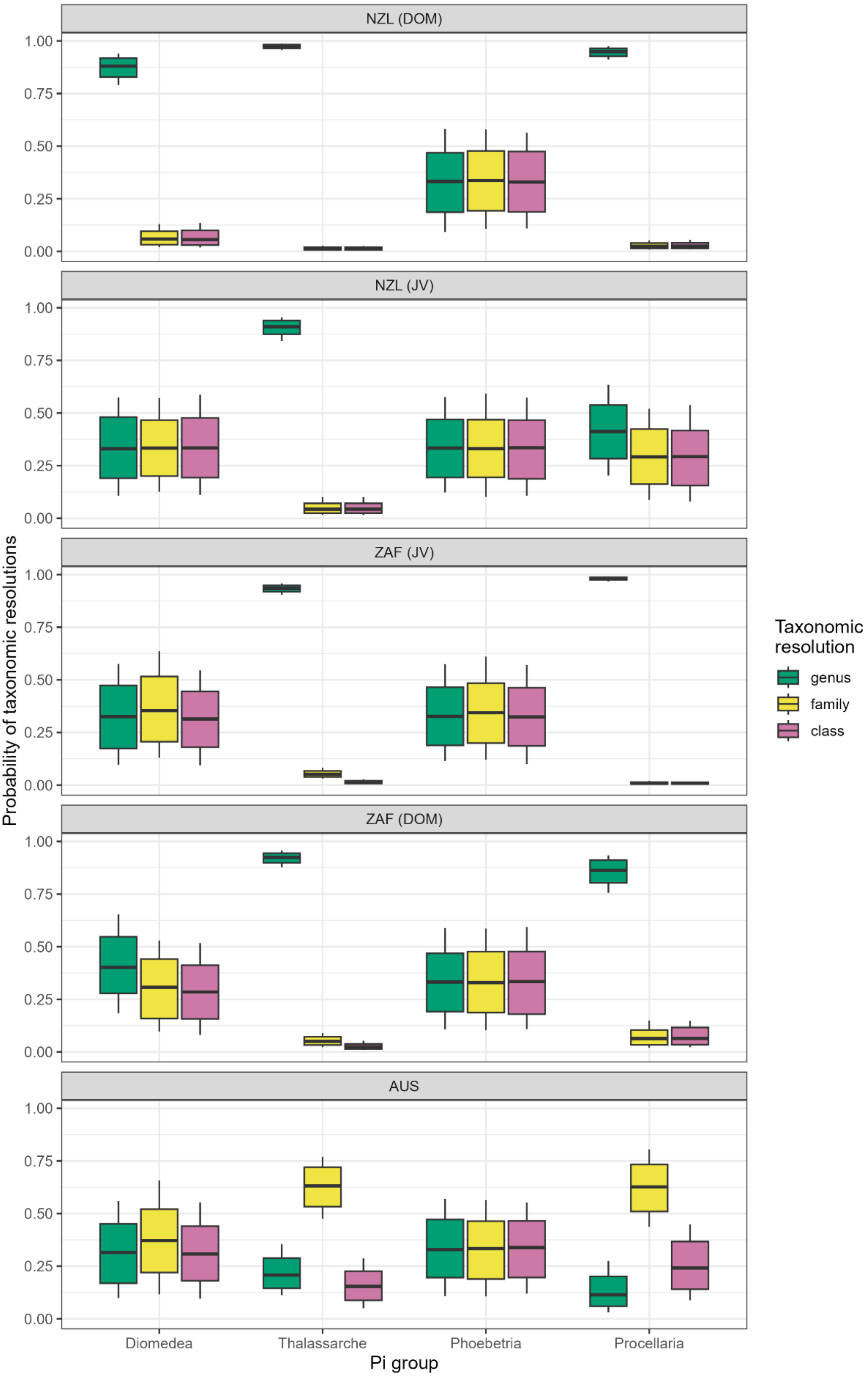


Figure 7: Estimated catchabilities per species group and fishery group (on the log-10 scale) from the selected 2025 risk assessment model. DOM denotes domestic fleet, and JV Joint Venture operations.

a) NZL (DOM), NZL (JV), ZAF (DOM), ZAF (JV) and AUS



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b) JPN, TWN and KOR

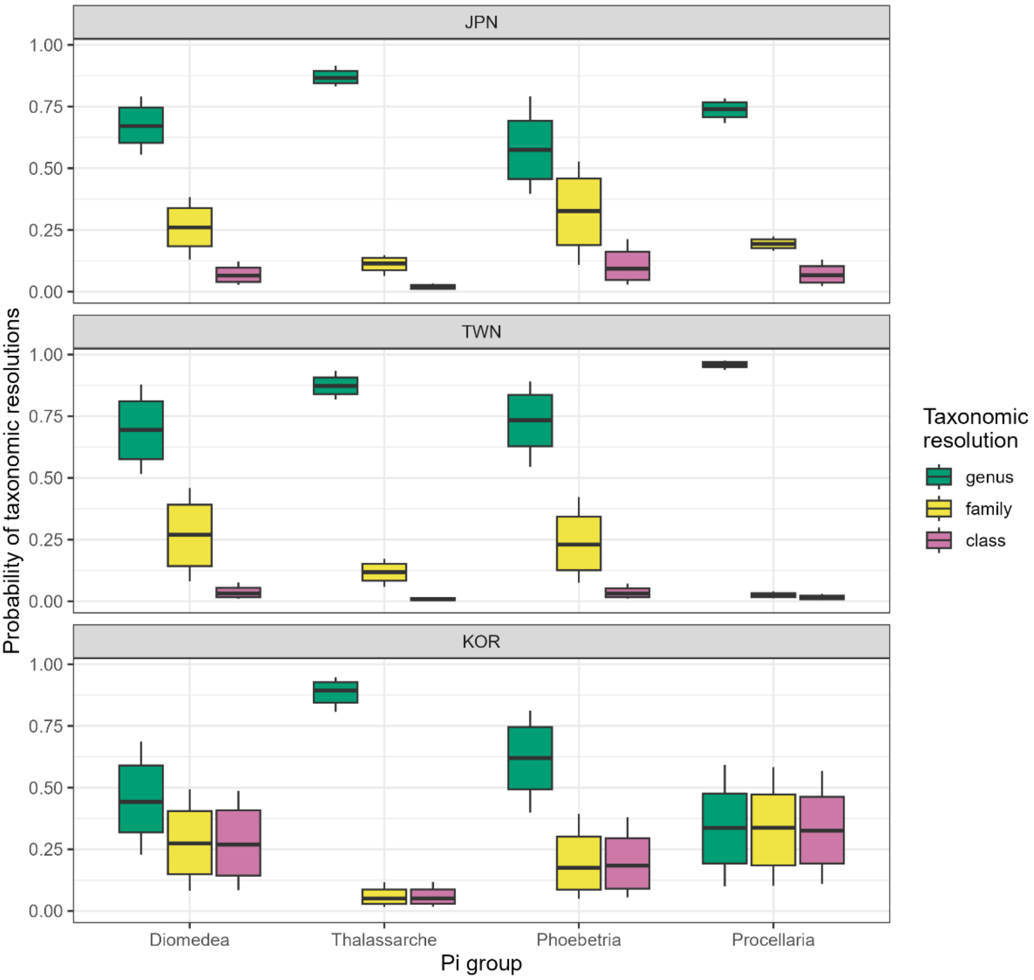
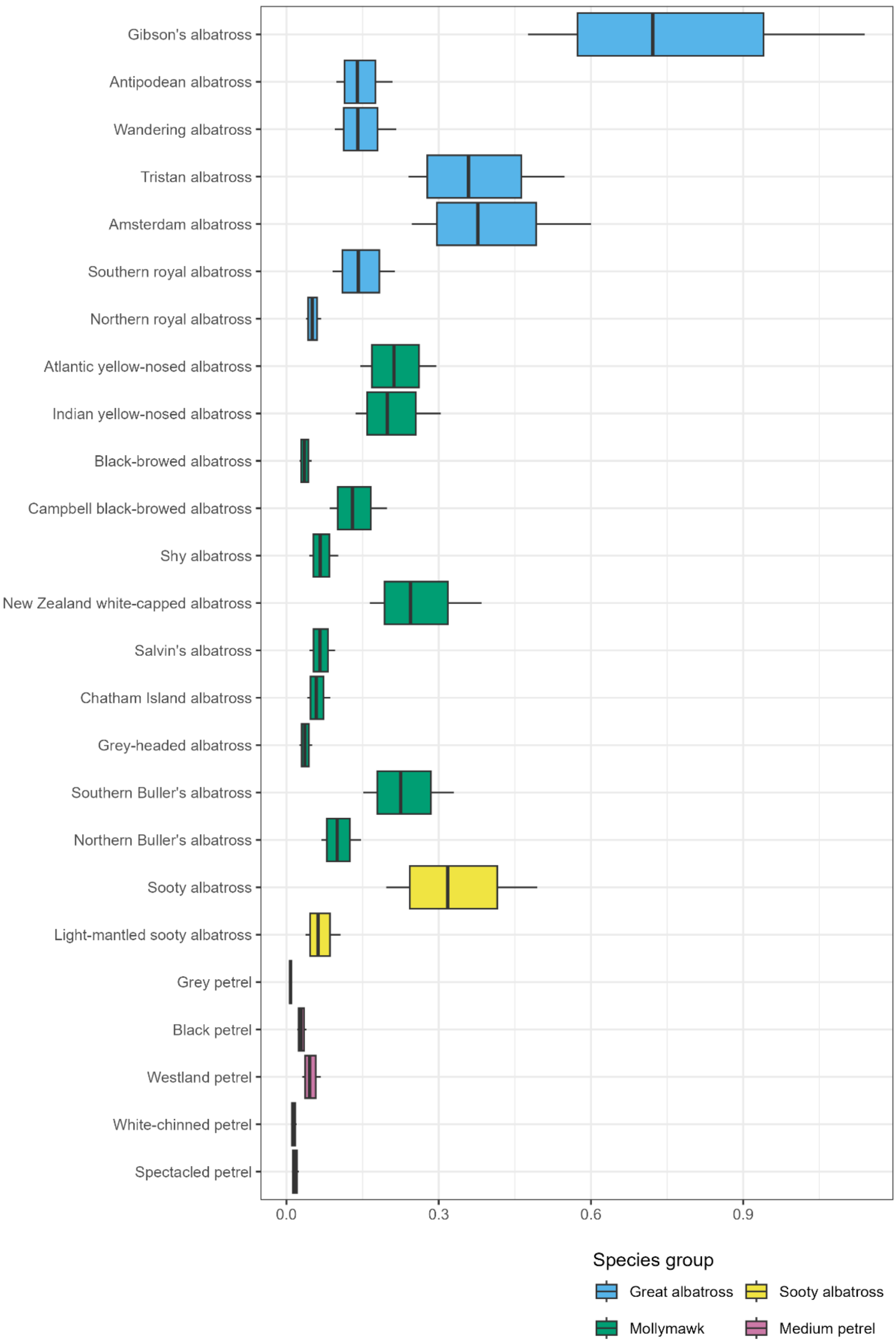


Figure 8 continued.



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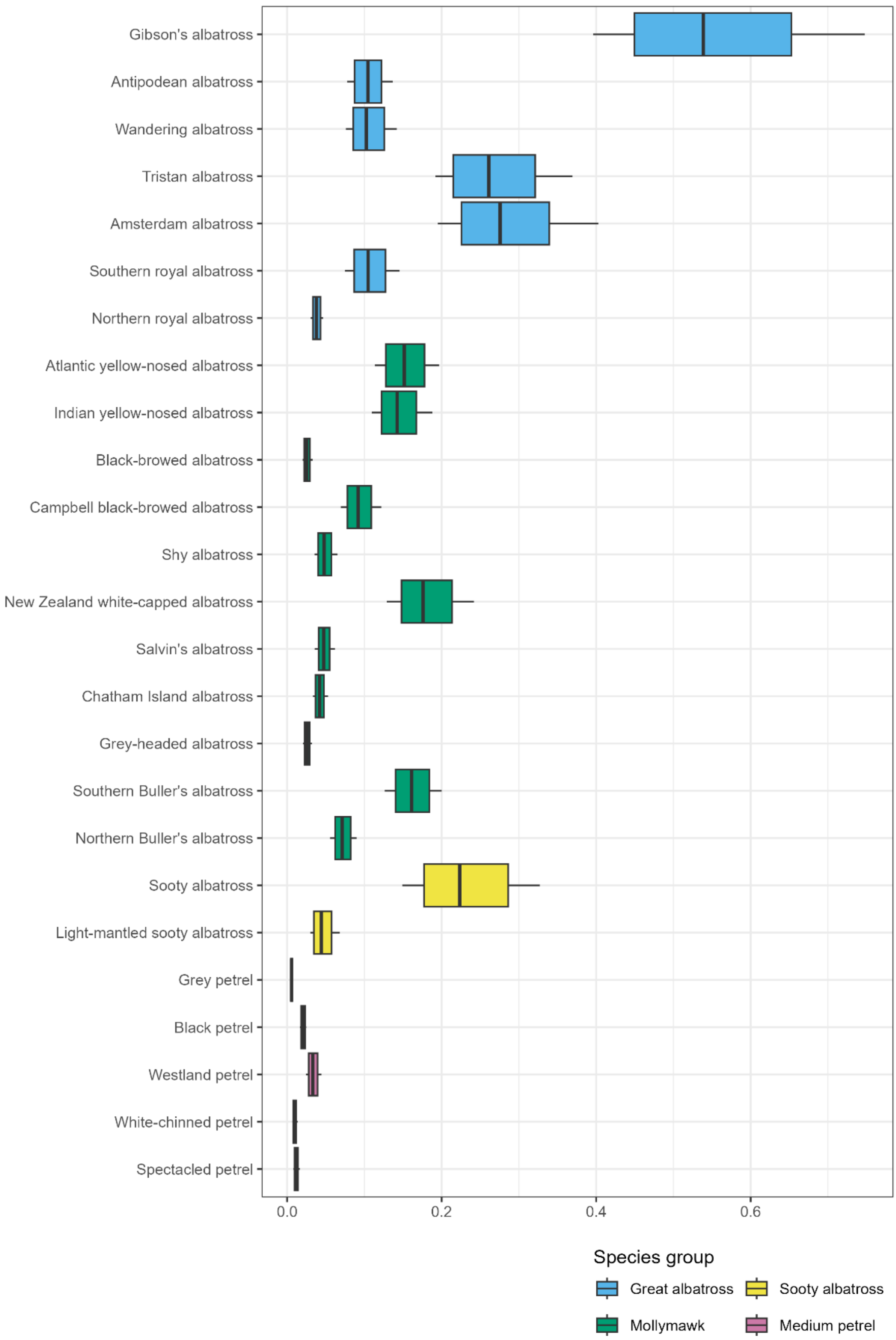
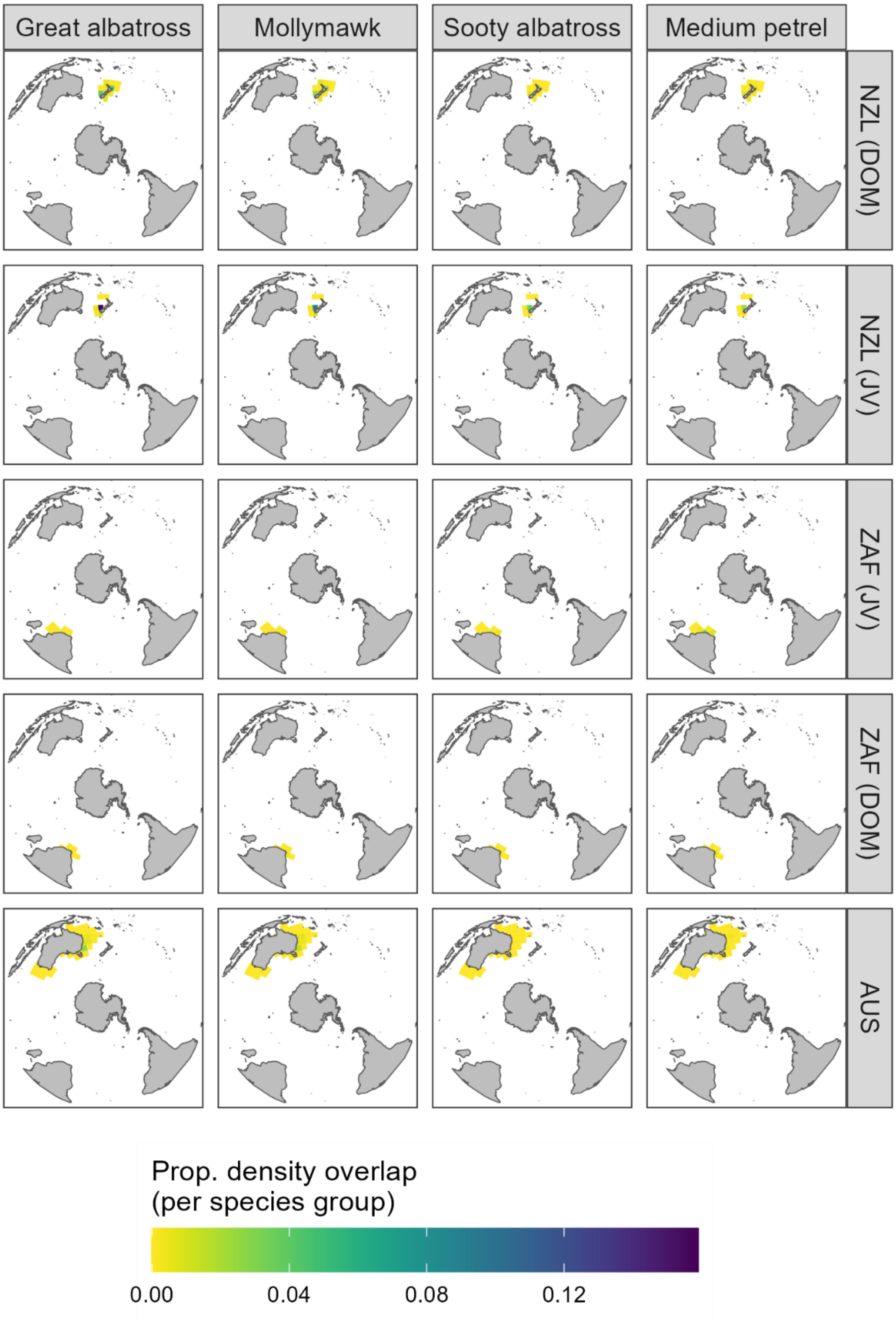


Figure 10: Estimated relative mortality rates per species from observable deaths (i.e., with no cryptic mortalities), relative to $r_s \cdot N_s$, from the selected 2025 risk assessment model.

a) NZL (DOM), NZL (JV), ZAF (DOM), ZAF (JV) and AUS



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b) JPN, TWN and KOR

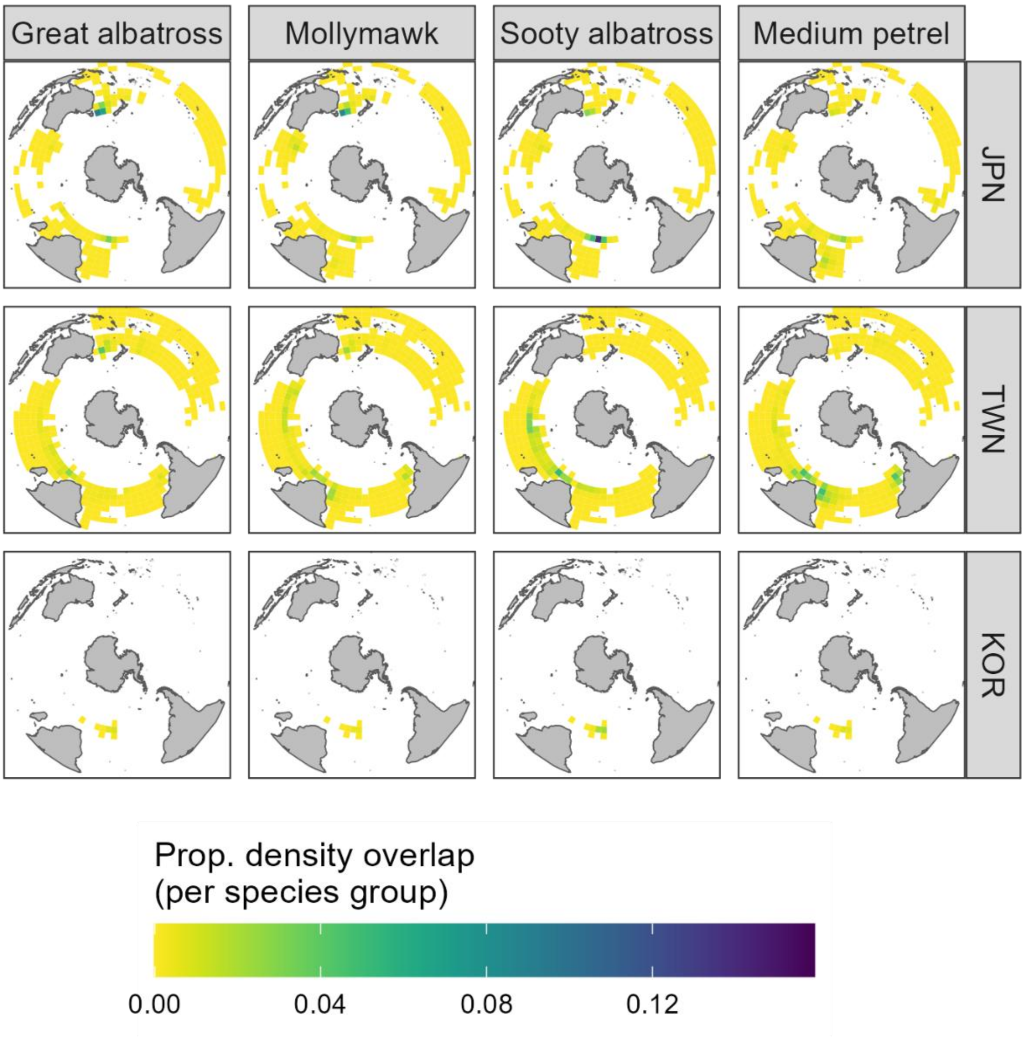
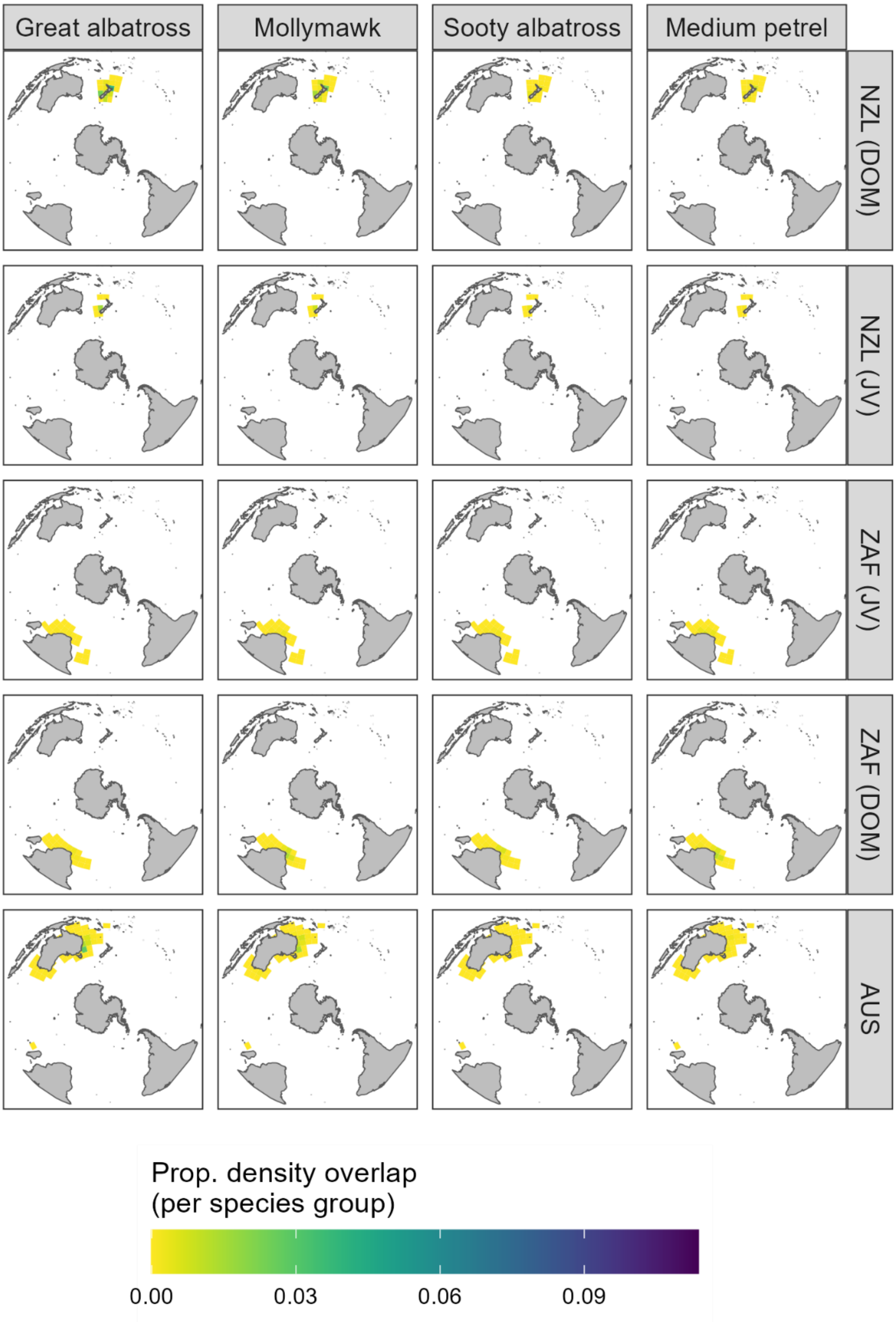


Figure 11 continued.

a) NZL (DOM), NZL (JV), ZAF (DOM), ZAF (JV) and AUS



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b) JPN, TWN and KOR

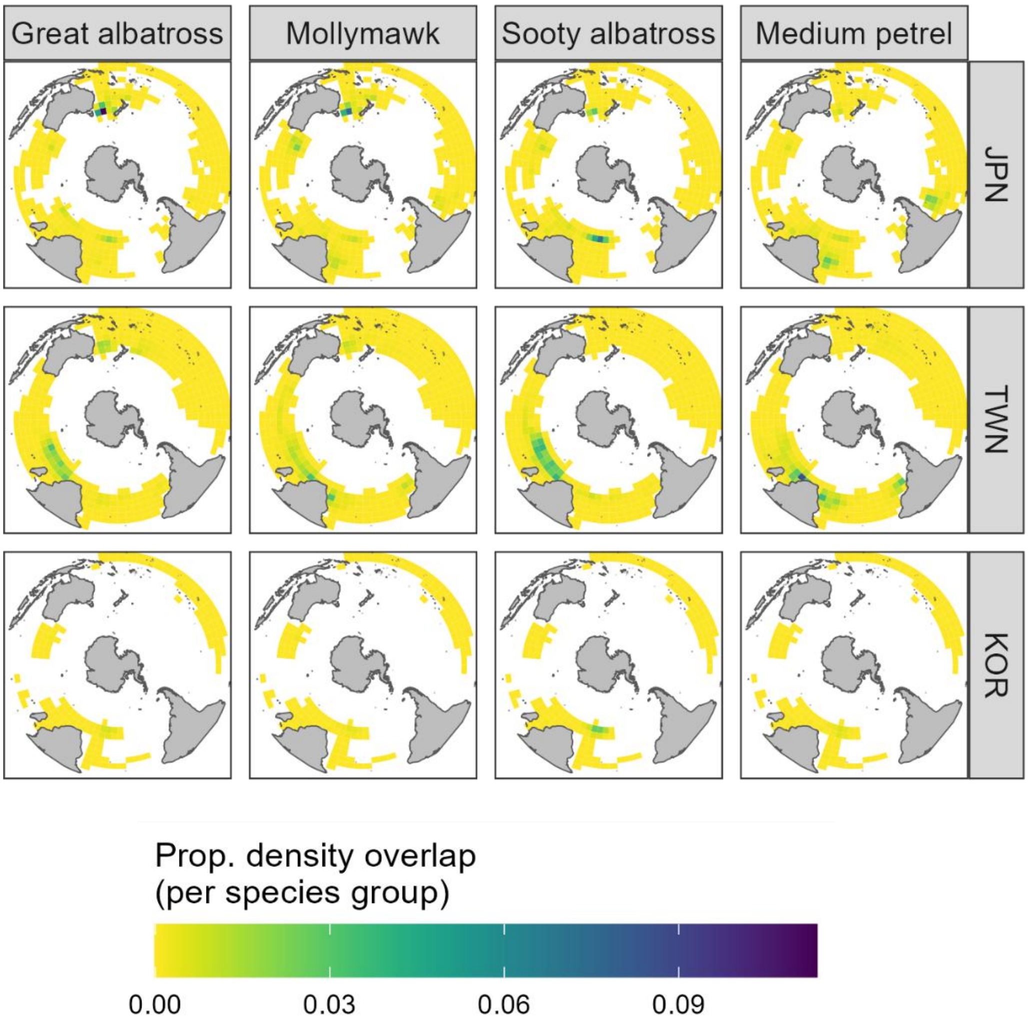


Figure 12 continued.

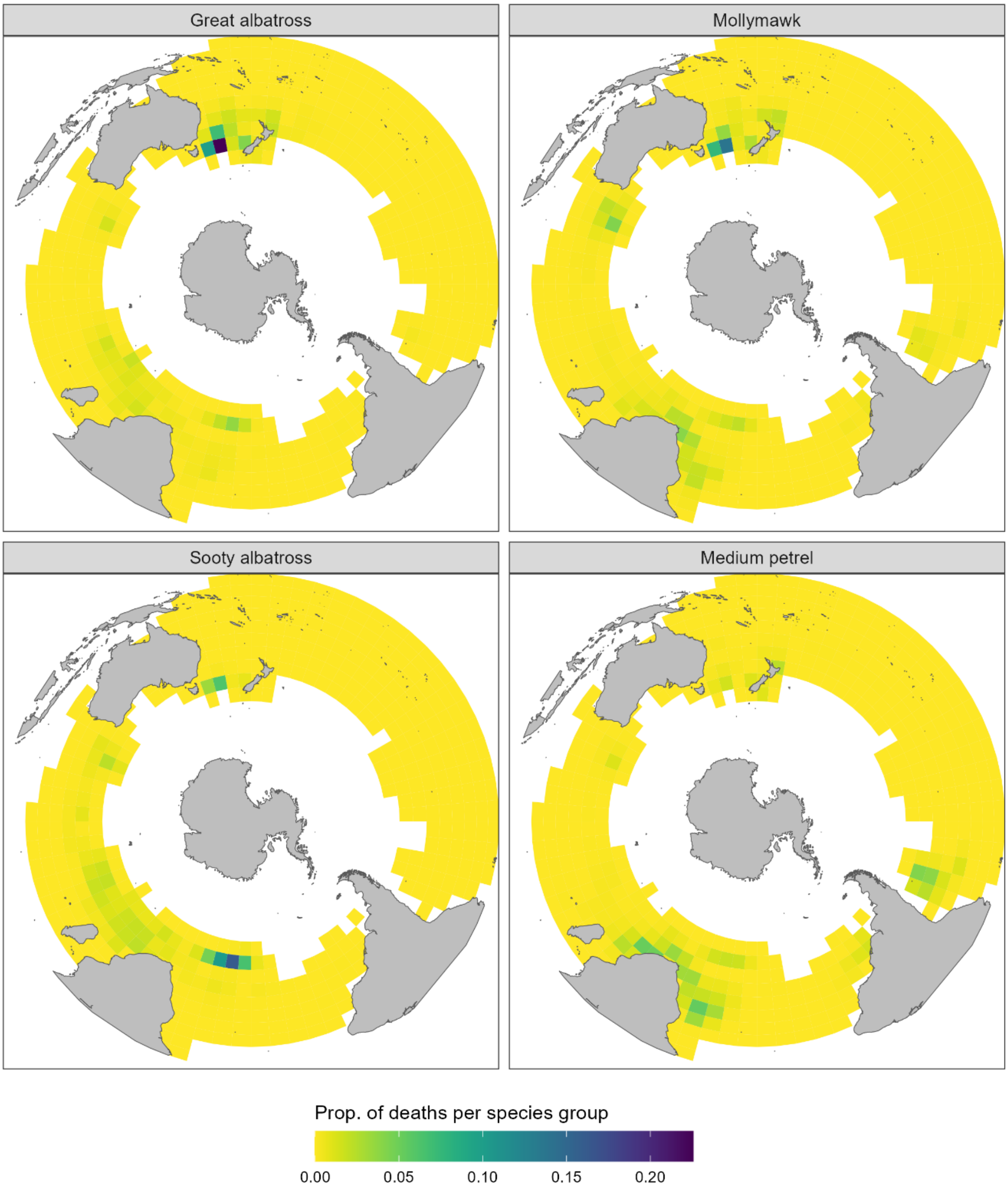
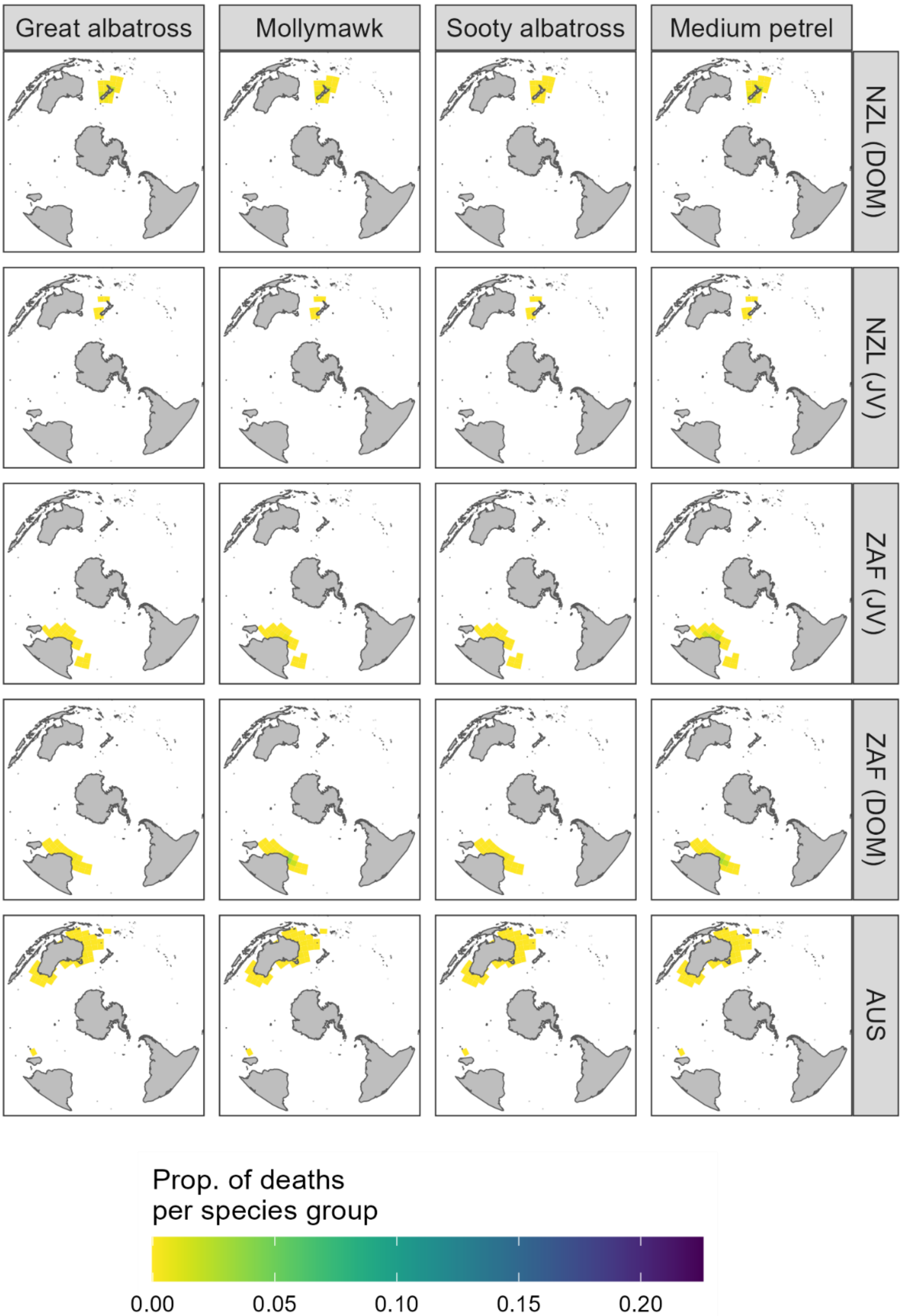


Figure 13: The spatial distribution of total estimated annual deaths per species group from the selected 2025 risk assessment model, provided as the proportion of total annual deaths of each species group by 5°cell.

a) NZL (DOM), NZL (JV), ZAF (DOM), ZAF (JV) and AUS



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b) JPN, TWN and KOR

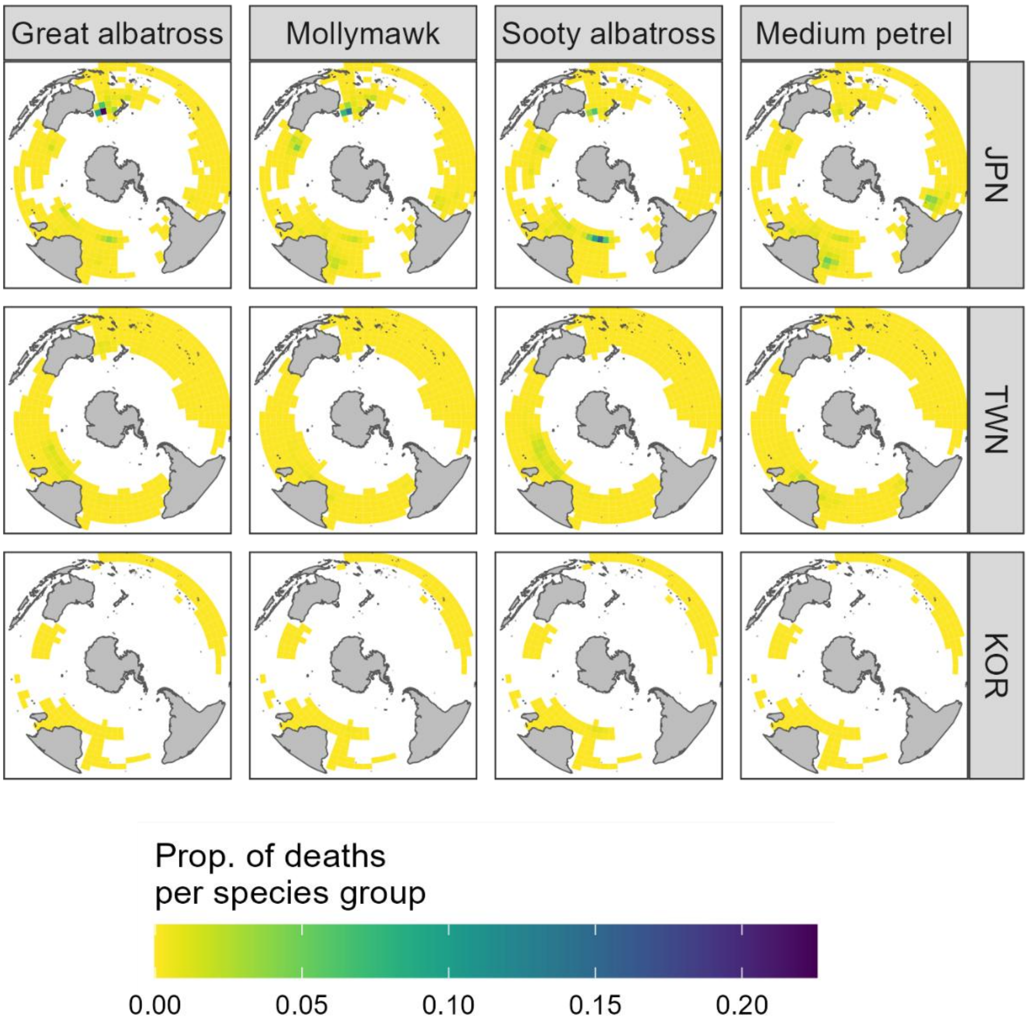
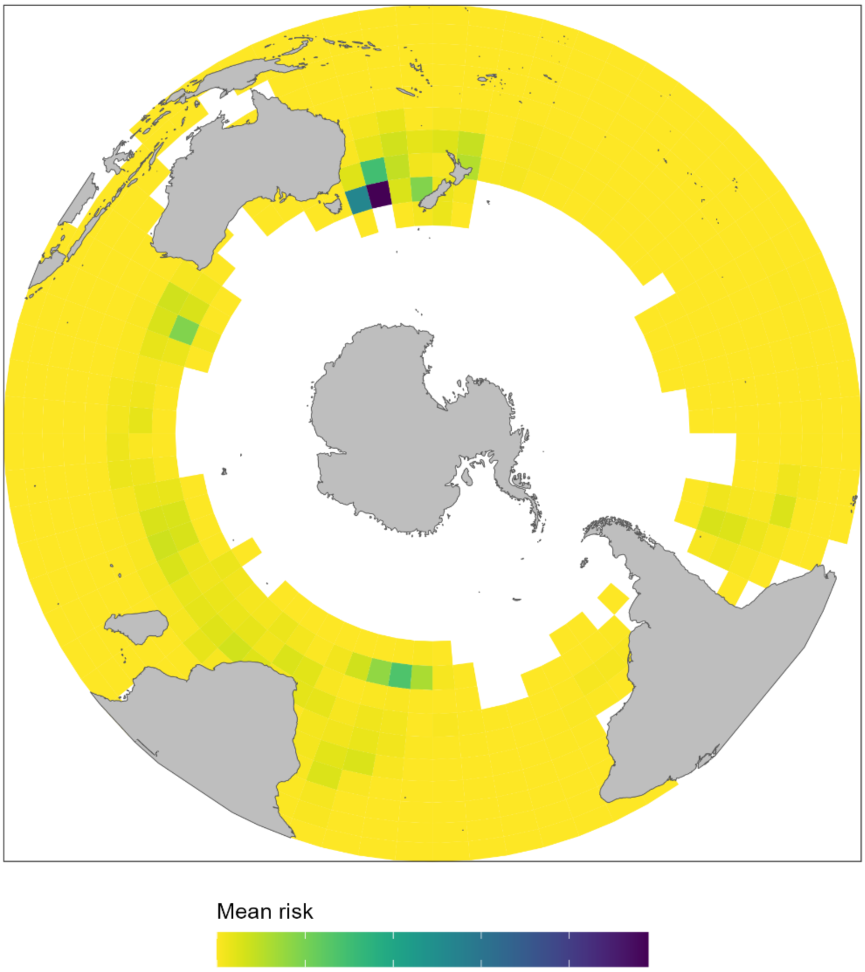


Figure 14 continued.



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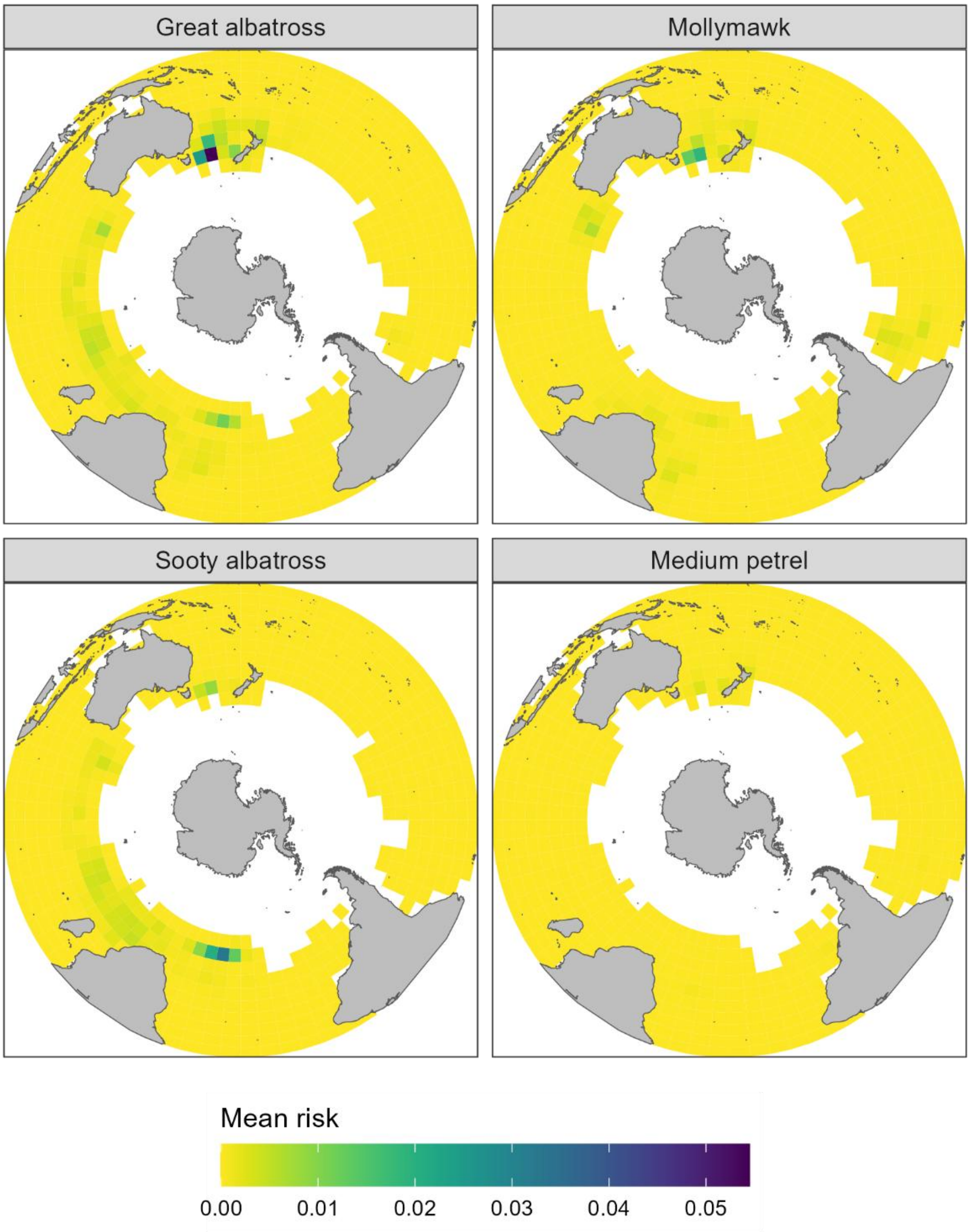
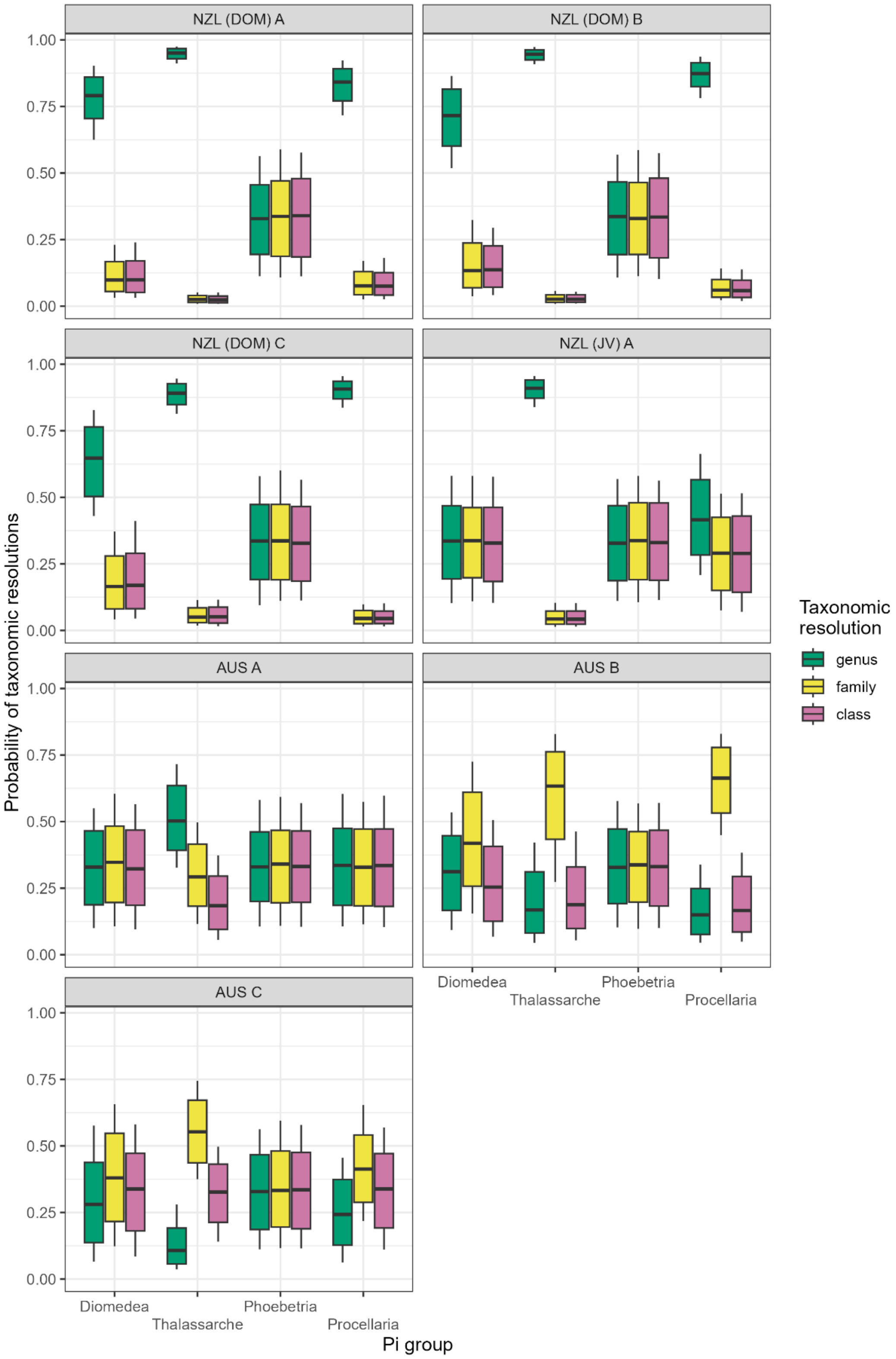


Figure 16: Maps of the mean of species-specific relative mortalities per species group from the selected 2025 risk assessment model.

a) NZL (DOM), NZL (JV) and AUS



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b) JPN, TWN and KOR

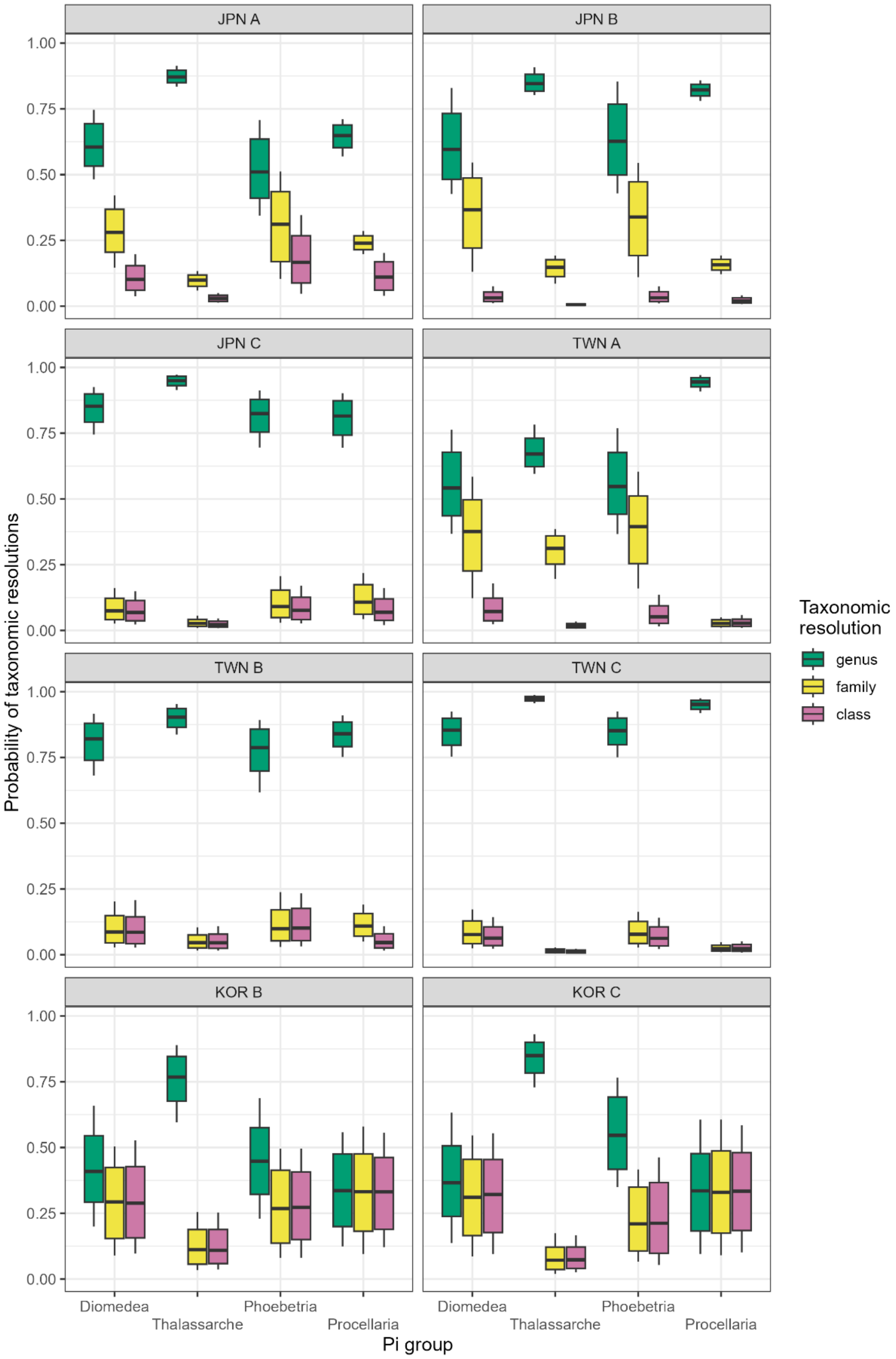


Figure 17 continued.

c) ZAF (DOM) and ZAF (JV)

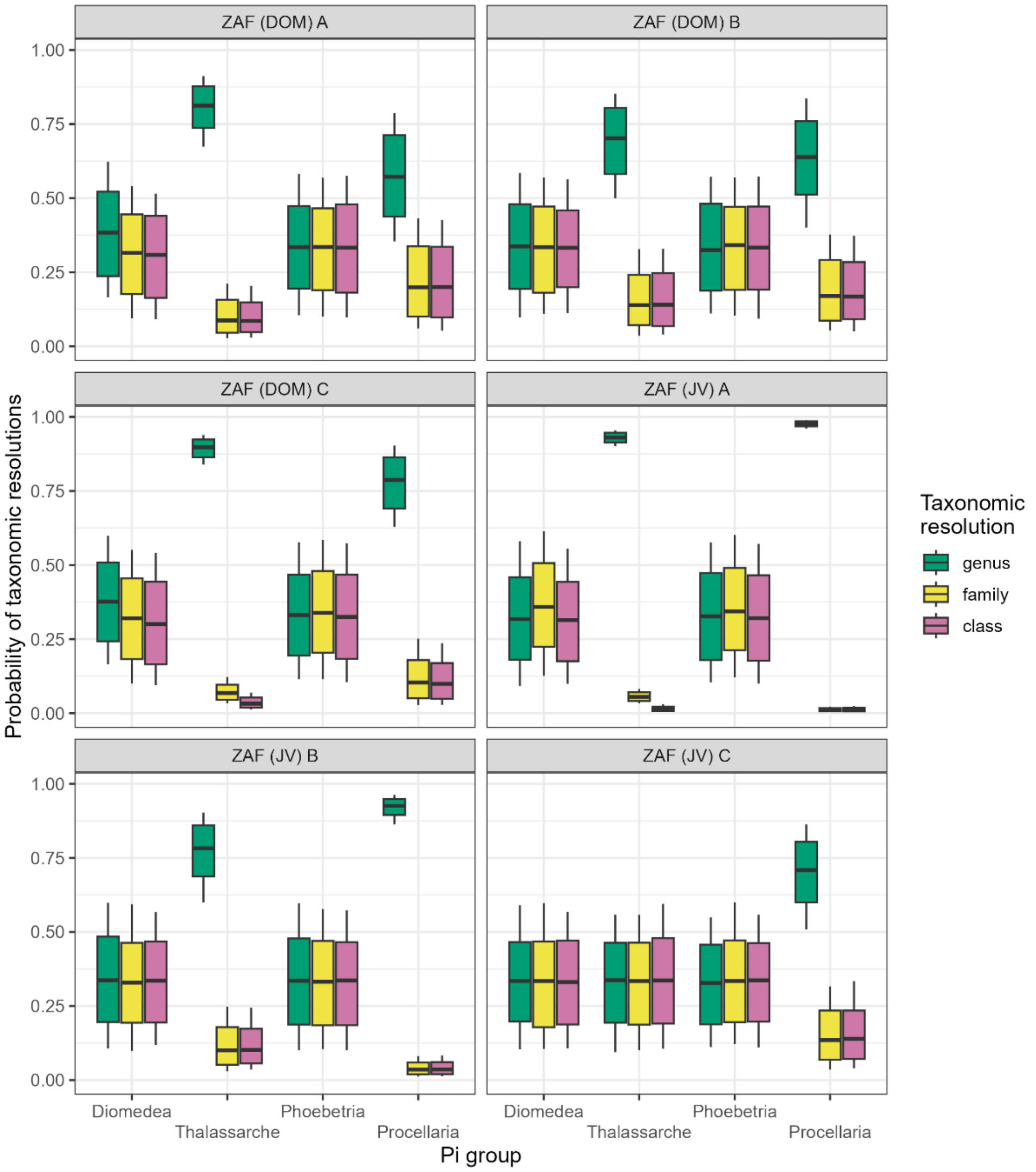
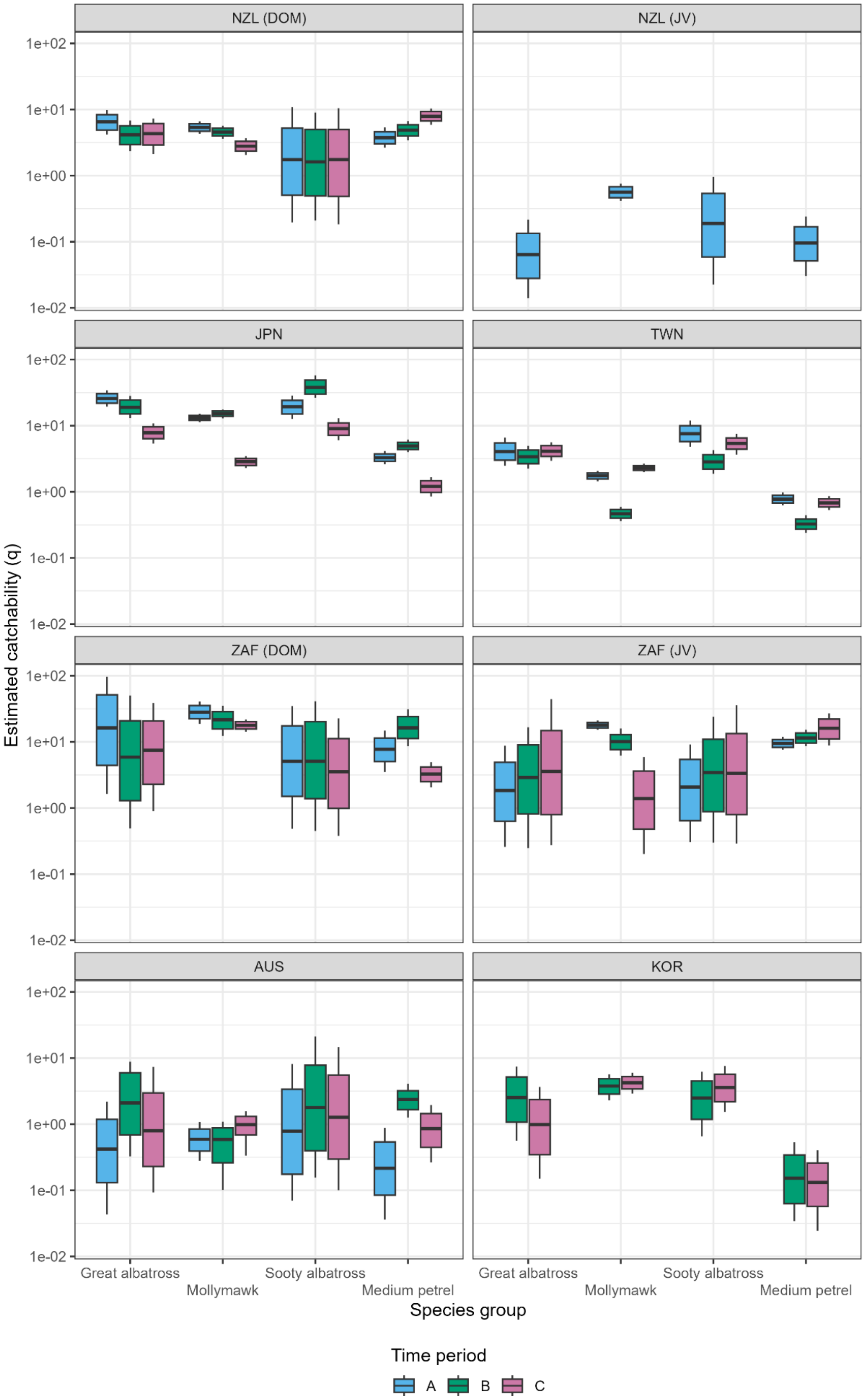


Figure 17 continued.



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Seabird distribution modelling for the 2025 southern hemisphere spatially explicit fisheries risk assessment

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Prepared by:
Jennifer Devine

For any information regarding this report please contact:

Jennifer Devine
Fisheries, senior scientist

+64 3 545 7880
jennifer.devine@niwa.co.nz

National Institute of Water & Atmospheric Research Ltd
PO Box 893
Nelson 7040

Phone +64 3 548 1715

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Executive summary

This report updates the distribution maps for sixteen albatross and petrel taxa (Table 1) for the 2025 spatially explicit fisheries risk assessment model (SEFRA) for the CCSBT pelagic longline fisheries on seabirds.

Tracking data for most species were requested from individual data owners via Bird Life International; some tracking data were also received directly from the New Zealand Department of Conservation (DOC). A review of the original distribution maps by world experts identified key tracking datasets to be added and emphasis was given to obtaining those, with mixed success. This update to the models weighted the relative densities by mean colony size, which improved the distributions for all species.

Seabird data distributions were determined using spatial generalised additive models (GAMs) that included a 3-dimensional spatiotemporal spline model, which smoothed simultaneously across position and date, fitted with a Tweedie distribution, where the estimated Tweedie parameter was between 1–2, indicating a compound Poisson-gamma distribution. All models explained between 67–91% of the deviance. Weighting the tracks directly by colony size produced better fits (in terms of deviance explained and residual patterns) than models that did not include weighting. This approach is also preferred on a theoretical basis, by reducing bias in observed distributions at a population level resulting from differing levels of tracking data at a colony level. The models fit by including colony size as an offset, weighting each observation's contribution to the likelihood, or by including colony name as an additional factor in the model produced much poorer fits than directly scaling the relative density by mean colony size, i.e., residual patterns were worse and extreme densities were predicted at the margins of the modelled spatial range (e.g. where no data existed).

Tracking data were not obtained for all the major breeding colonies for six of the assessed seabird taxa. For some of these colonies, quarterly predictions of spatial count were available from the study by Carneiro et al. (2020). The colonies that needed augmentation made up 20% of the population for Sooty albatross (Tristan da Cunha) and Atlantic yellow-nosed albatross (Gough), while size of the colonies for the other four species ranged between 1–11% of the total population.

1 Background

This report updates the distribution maps for sixteen albatross and petrel taxa (Table 1) for the 2025 spatially explicit fisheries risk assessment model (SEFRA) for the CCSBT pelagic longline fisheries on seabirds.

Table 1: Albatross and petrel taxa updated for the 2025 risk assessment.

Common name	Scientific name
Gibson's albatross	*Diomedea antipodensis gibsoni*
Wandering albatross	*Diomedea exulans*
Southern royal albatross	*Diomedea epomophora*
Atlantic yellow-nosed albatross	*Thalassarche chlororhynchos*
Black-browed albatross	*Thalassarche melanophris*
Campbell black-browed albatross	*Thalassarche impavida*
Shy albatross	*Thalassarche cauta*
Grey-headed albatross	*Thalassarche chrysostoma*
Southern Buller's albatross	*Thalassarche bulleri bulleri*
Northern Buller's albatross	*Thalassarche bulleri platei*
Sooty albatross	*Phoebetria fusca*
Light-mantled sooty albatross	*Phoebetria palpebrata*
Grey petrel	*Procellaria cinerea*
Black petrel	*Procellaria parkinsoni*
Westland petrel	*Procellaria westlandica*
White-chinned petrel	*Procellaria aequinoctialis*

2 Methods

2.1 Tracking data

Tracking data for most species in Table 1 were requested from individual data owners via Bird Life International; some tracking data were also received directly from the New Zealand Department of Conservation (DOC) (Table 2). A review of the original distribution maps (unpublished) by world experts identified key tracking datasets to be added and emphasis was given to obtaining those, with mixed success. Because the risk assessment model is currently only for adult birds, irrespective of breeding status, tracking data were included only for adults or where life stage was not known.

2.2 Data grooming

Tracking data were groomed following methods similar to those by Carneiro et al. (2020). Gaps exceeding 24 hours were discarded by splitting the deployment into separate tracks. Each track was interpolated regularly in time to obtain points that were equally spaced. Any points falling on land or where speed of bird was in excess of 100 km per hour were removed. Tracks that incorrectly crossed the 180° or 360° line were manually corrected. All points were then reassigned positions within a 0.25° lat-lon grid cell.

Each track was handled individually. Because different tag types report data differently and to ensure tag type did not have influence on the model, each point along the track was weighted by the time between reports (half the time from the previous observation + half the time to the next observation). Weighted observations were converted from time in seconds to days. This then produced a weighted count per day per track for a given 0.25° lat-lon grid cell and a given month. This weighting did not remove issues that may occur if a tag type lasts longer, i.e., tracks with longer time series will have more data. The observations in a cell were then summed and divided by the number of days spent in that cell in that month. Values were then standardised by dividing by the mean (values were between 0 and 1). The relative density of each track was than weighted by the mean colony size (average number of breeding pairs) (Table 3), noting that various methods of weighting the relative densities by colony size both within the spatial models (i.e., weighting each observation's contribution to the likelihood) or by directly weighting the data (as done here) were assessed for best fit before applying the chosen weighting method. If only one colony was present, data were not weighted by mean colony size (e.g., Campell black-browed albatross, Westland petrel).

After each track was standardised, all values for all tracks in each cell and month were summed to create a relative density of birds in each 0.25° lat-lon grid cell for a given month. By standardising each track prior to aggregating, the characteristics of a few, such as those birds that behaved differently, did not dominate in the model. Using standardised mean weighted counts eliminated the need to include a random effect in the model, which greatly sped up computation time, a necessity with the number of birds and lat-lon cells that were modelled.

Data were autocorrelated because each observation in a track was not independent (an observation at time t was correlated to the observation at t-1), but each complete track was treated independently (i.e., each bird behaved independently).

2.3 Spatial models

Seabird data distributions were determined using spatial generalised additive models (GAMs) that included a 3-dimensional tensor product smoother that smooths simultaneously across a location (latitude and longitude) and time (month). Smoother specifications treat space and time as being dissimilar, by using different smoothing parameters to push the 2-dimensional spatial smoother through time, where the smoother on the time component is fit with a cubic regression spline (see Marra et al. 2011). The temporal spline was specified to treat December and January as if they were next to each other in time; hence, the predicted smoother was constrained in December to be near the predicted smoother in January. The spatial smoother (the 2-dimensional smooth on latitude and longitude) was fit using a Gaussian process (gp) smoother because it can deal with spatial autocorrelation better than most other types of smoothers, while still varying smoothly within the space dimension (Marra et al. 2011); cyclic smoothers for the spatial component may sometimes cause problems and result in poor fits, with no structure (Wood 2017). When distributions needed to wrap around the world, a cyclic smooth on longitude was often found to be a better fit.

Models were fitted to tracking data aggregated to a 1-degree cell resolution using the '*bam*' function within the *mgcv* R package (Wood 2003, 2017) and a Tweedie distribution. Tweedie distributions are a subfamily of exponential dispersion models that have the ability to replicate a wide range of distributions via the power function and were preferred because they perform well when fitting to data that are positive, continuous, and contain many zero observations (Jørgensen 1987). Tweedie distributions, model fits, residual patterns, percentage deviance explained, plots of partial fits, and relative importance of parameters were inspected, and the best model was chosen. Longitude was typically in 0° to 360° space to keep positions crossing 180° near to each other, unless otherwise specified. For birds that had a circumpolar distribution, the spatial spline was specified to wrap around the globe, i.e., treat 0° and 360° near to each other in space.

Expected densities were predicted into a 1-degree cell resolution spatial grid for each month, but often extremely small values were predicted at the margins of the distribution, which caused e.g., densities to be predicted across continental boundaries where species were known not to occur, such as across the southern tip of South America. A soap film smoother was tested, which distorts the film towards the data of highest occurrence; these smooths were constructed to not cross boundary features, such as continents. However, this did not fully resolve the issue. A manual soap film boundary was thus constructed, where values that were less than the 40^{th} percentile were set to 0 (values were less than 10^{-5}). Data were then aggregated at a 5 ° lat-lon resolution. To remove data where only a few 1 ° lat-lon cells contributed to the 5 ° lat-lon cell, densities below the 40^{th} percentile were again set to 0. This resolved issues at the margins of the predicted distribution, such that predictions did not cross continents.

Tracking data were not obtained for all the major breeding colonies of all the assessed seabird taxa (Table 3). For some of these colonies, quarterly predictions of spatial count were available from the study by Carneiro et al. (2020). For many taxa, the predictions of Carneiro et al. (2020) were representative of juveniles as well as at-sea foraging adults, whereas the current analysis was based on adult data, although Carneiro et al. (2020) 'noted that the spatial foraging patterns of each age stage were often not very different'. The Carneiro et al. (2020) study reported that their predictions were representative of density, but from closer inspection they were representative of mean count per 5-degree grid cell (i.e., not accounting for the area of each cell) and, so, were in a comparable format to the spatial predictions from the current study.

As such, it was decided to use the Carneiro et al. (2020) spatial predictions to plug some of the gaps in tracking data by colony (Table 3). This was achieved by merging the predictions from the current study with those of Carneiro et al. (2020) after these had first been rescaled for colony size based on the most recent estimate of breeding pairs. For each species for which the Carneiro et al. (2020) layers were used, this was achieved as follows:

1. Reproject the Carneiro layers to match the projection used for making predictions in the current study (coordinate reference system = "+proj=laea +lat_0=-90 +lon_0=170").

2. Rescale the layers from Carneiro et al. (2020) and the current study to sum to the total estimated adult population size for the respective colony, calculated as the total number of breeding pairs for the colony.

3. For each month, sum all rasters across all colonies for which there was a prediction from Carneiro et al. (2020) or from the current study. As per the description given by Carneiro et al. (2020) for which the layers were for quarterly periods, the summer prediction was used for the months of December, January and February, autumn = March, April and May, winter = June, July and August, and spring = September, October and November.

4. Rescale the monthly rasters so that each sums to 1.

3 Results

3.1 Tracking data

Tracking data were obtained for many of the main breeding colonies for most of the 16 species (Tables 2–3). The amount of data received was an improvement over the previous distribution maps (Devine et al. in press), where some missing colonies made up to 58% of the breeding pairs. Spatial predictions from Carneiro et al. (2020) augmented the predicted distributions of six species. Augmentation was because data from breeding colonies were missing for Gibson's albatross (Auckland Islands), grey-headed albatross (PEI), light-mantled albatross (PEI), and sooty albatross (PEI), while information on the remaining colonies was missing for only some of the months. The information used from Carneiro et al. (2020) for Sooty albatross (Tristan da Cunha) and Atlantic yellow-nosed albatross (Gough) made up 20% of the breeding pairs, while the size of the colonies for the other four species ranged between 1–11% (Table 3).

Table 2: **Information on tracking data obtained, including number of datasets used (of those available in BirdLife International), the dataset identification number, and number of tracks per colony and life stage. Track duration is the mean (standard deviation) in hours; NA indicates not enough data to estimate. Note that while permission to data had been granted, not all data were included in the modelling but are included here for full transparency. Temporal coverage does not include information from juvenile or immature birds. PEI refers to Prince Edward Island. Juv indicates juvenile, Imm indicates immature.**

Common name	No. used	Dataset id by site	No. tracks by life stage	No. tracks per colony	Track duration (hrs)	Temporal coverage
Gibson's albatross	3†	Adams: DOC†	Adult: 41 Juvenile: 22	Adams: 63	Adult: 3262 (1576) Juvenile: 6427 (2248)	January–September
Wandering albatross	43 (of 45)	Kerguelen: 435, 1318, 1320 Crozet: 436, 437, 1133, 1134, 1135, 1136, 1137, 1138, 1319, 1321, 1322 South Georgia: 460, 461, 462, 463, 473, 1387, 1394, 1395, 1405, 1885, 1888, 1889, 1890, 1891, 1892, 1893, 1895, 1896, 2005, 2006, 2272 Macquarie: 412 Marion Island (PEI): 465, 1513, 1516, 1517, 1528, 2210 Non-breeding/site unknown: 464	Adult: 1766 Unknown: 4 Fledgling: 19 Juvenile: 78 Immature: 115 Juv/Imm: 13	Iles Kerguelen: 89 Iles Crozet: 636 Ile de la Possession: 13 Bird Island (SGSSI): 1089 Marion Island: 153 Macquarie Island: 8 Non-breeding/site unknown: 7	Adult: 1741 (4035) Unknown: 451 (208) Fledgling: 5801 (3462) Juvenile: 2502 (2425) Immature: 3908 (3361) Juv/Imm: 4040 (2050)	Iles Kerguelen: all months Iles Crozet: all months Ile de la Possession: NA Bird Island (SGSSI): all months Marion Island: Jan–Sept Macquarie Island: Dec–Mar Non-breeding/site unknown: Aug–Dec
Southern royal albatross	4 (of 4)	Campbell Islands: 431, 556, 2246, 2266	Adult: 56 Unknown: 10	Campbell: 66	Adult: 171501 (129635) Unknown: 296 (89)	All months
Atlantic yellow-nosed albatross	9 (of 10)	At sea: 1412, 1560 Gough Island: 700, 1103, 1104, 1455 Inaccessible Island: 1506 Nightingale: 1105, 1504	Adult: 128 Unknown: 7 Immature: 3	At sea: 11 Gough Island: 81 Inaccessible Island: 18 Nightingale: 28	Adult: 585 (438) Unknown: 350 (335) Immature: 787 (796)	At sea: Oct–May Gough Island: Oct–Jan Inaccessible Island: Oct–Nov Nightingale: Oct–Nov
Grey-headed albatross	21 (of 26)	Marion Island/PEI: 1508, 1509, 1514, 1515, 1527, 2208 Islas Ildefonso: 485 Campbell Islands: 430, 1082, 2173 Islas Diego Ramirez: 484, 486 South Georgia: 459, 494, 495, 1383, 1390, 1391, 1845 Macquarie Island: 409, 496	Adult: 782 Juvenile: 28 Fledgling: 1	Bird Island: 451 Campbell Island: 91 Islas Diego Ramirez: 67 Islas Ildefonso: 1 Macquarie Island: 10 Marion Island: 191	Adult: 1689 (4375) Juvenile: 1870 (1314) Fledgling: 1228 (NA)	Bird Island: all months Campbell Island: all months Islas Diego Ramirez: Nov –Feb Islas Ildefonso: November Macquarie Island: Nov –Jan Marion Island: all months

Common name	No. used	Dataset id by site	No. tracks by life stage	No. tracks per colony	Track duration (hrs)	Temporal coverage
Southern Buller's albatross	3	Solander: 1 (DOC)† Snares: 2 (DOC)†	Adult: 56	Solander: 20 Snares: 36	Adults: 5813 (3273)	Solander: Mar–Aug Snares: all months
Northern Buller's albatross	3	Motuhara: 2 (DOC)† Chatham Island/Pyramid: 644	Adult: 81	Motuhara: 79 The Pyramid: 2	Adult: 7484 (2351)	Motuhara: all months The Pyramid: November
Shy albatross	9 (of 9)	Albatross Island: 414, 440, 1378, 1381 Pedra Branca: 416, 442 The Mewstone: 415, 441, 1379	Adult: 171 Fledgling: 26 Juvenile: 6 Juv/Imm: 6	Albatross Island: 179 Pedra Branca: 11 The Mewstone: 20	Adult: 377 (1294) Fledgling: 697 (470) Juvenile: 2944 (1012) Juv/Imm: 2278 (315)	Albatross Island: all months Pedra Branca: Mar–Apr, Nov–Dec The Mewstone: Nov–Aug
Campbell black-browed albatross	2 (of 2)	Campbell Islands: 429, 2172	Adult: 78	Campell Island: 78	Adult: 7479 (3013)	All months
Black-browed albatross	34 (of 46)	Kerguelen: 426, 1295, 1296, 1297 South Georgia: 457, 492, 493, 1382, 1388, 1389, 1537, 2004, 2225 Islas Diego Ramirez: 483, 487 Falkland Island/Islas Malvinas: 488, 489, 490, 491, 594, 600, 602, 603, 604, 685, 899, 901, 1448, 1451, 1454 Islas Albatros: 2275, 2276 Macquarie Island: 408, 445	Adult: 2168 Fledgling: 2 Juvenile: 13 Immature: 276 Juv/Imm: 3	Beauchene Island: 60 Bird Island: 826 Iles Kerguelen: 236 Islas Diego Ramirez: 115 Islas Albatros: 21 Jeanne d'Arc Peninsula: 26 Macquarie Island: 9 New Island: 700 Saunders Island: 253 Steeple Jason: 216	Adult: 1549 (3133) Fledgling: 2157 (345) Juvenile: 1119 (945) Immature: 525 (1952) Juv/Imm: 2395 (473)	Beauchene Island: Feb–Apr, Oct–Dec Bird Island: all months Iles Kerguelen: all months Islas Diego Ramirez: all months except January and September Islas Albatros: all months Jeanne d'Arc Peninsula: Feb, Nov-Dec Macquarie Island: Nov–Jan New Island: all months Saunders Island: all months Steeple Jason: all months
Sooty albatross	13 (of 13)	Marion Island: 651, 1512, 1529, 2209 Crozet: 425, 1313 Ile Amsterdam: 606, 1312 Tristan da Cunha: 1292 Gough Island: 420, 424, 1290 Prince Edward Island: 835	Adult: 311 Unknown: 10 Juvenile: 18	Marion Island: 193 Crozet: 50 Ile Amsterdam: 16 Tristan da Cunha: 3 Gough Island: 75 Prince Edward Island: 2	Adult: 1057 (1766) Unknown: 3150 (1556) Juvenile: 3527 (3511)	Marion Island: all months Crozet: all months Ile Amsterdam: Dec–Aug Tristan da Cunha: Oct–Dec Gough Island: all months Prince Edward Island: Mar–Sept

Common name	No. used	Dataset id by site	No. tracks by life stage	No. tracks per colony	Track duration (hrs)	Temporal coverage
Light-mantled sooty albatross	15 (of 16) + 1†	Macquarie Island: 413, 443 South Georgia: 444, 1384 Marion/PEI: 649, 650, 833, 1511, 1530 Heard Island: 661 Crozet: 1306, 1604 Kerguelen: 1309, 1605 Campbell Island: 2245, 1 (DOC)†	Adult: 165 Unknown: 1 Juvenile: 7	Macquarie Island: 14 Bird Island: 62 Heard Island: 6 Crozet: 8 Kerguelen: 3 Campbell Island: 20 Canyon des Sourcils Noirs: 5 Ile de la Possession: 7 Marion Island: 48	Adult: 17802 (63904) Unknown: 2600 (NA) Juvenile: 2207 (1429)	Macquarie Island: Nov–Jan Bird Island: Dec–Apr Heard Island: Dec–Mar Crozet: Jan–Apr Kerguelen: NA Campbell Island: all months Canyon des Sourcils Noirs: all months Ile de la Possession: all months Marion Island: all months
Grey petrel	4 (of 4) + 1‡	Antipodes: 634 Gough: 1288, 1‡ Kerguelen: 1298, 1608 Marion: 1‡	Adult: 59 Unknown: 75	Antipodes Islands: 49 Gough Island: 31 Ile Mayes: 37 Iles Kerguelen: 7 Marion Island: 10	Adult: 5640 (4367) Unknown: 5345 (4481)	Antipodes Islands: all months Gough Island: all months Ile Mayes: Apr–Feb Iles Kerguelen: Apr–Jun Marion Island: all months
Black petrel	5 (of 5) + 1†	Little Barrier: 659 Great barrier: 658, 949, 951, 2268, 1†	Adult: 83 Unknown: 80 Juvenile: 13	Little Barrier Island: 13 Great Barrier Island: 163	Adult: 3819 (3508) Unknown: 2276 (2562) Juvenile: 1178 (989)	Little Barrier Island: all months Great Barrier Island: all months
Westland petrel	6 (of 7)	Punakaiki: 448, 683, 1449, 1819, 2236, 2237	Adult: 333	Punakaiki: 333	Adult: 2837 (4004)	All months
White-chinned petrel	20 (of 20)	Crozet: 434, 1314, 1606 Kerguelen: 1317, 1607 South Georgia: 438, 439, 1386, 1396, 1500, 1558, 2032 Antipodes: 627, 635, 2260 Marion Island: 1582, 1592 New Island: 2029 Falkland Island/Kidney Island: 2030 Adams Island: 2024	Adult: 315 Unknown: 77 Juvenile: 26	Adams Island: 102 Antipodes Islands: 68 Bird Island: 102 Iles Crozet: 47 Kidney Island: 9 Marion Island: 31 New Island: 5	Adult: 4377 (5373) Unknown: 2337 (1852) Juvenile: 874 (835)	Adams Island: Apr–Feb Antipodes Islands: all months Bird Island: all months Iles Crozet: all months Kidney Island: all months except Mar Marion Island: all months New Island: all months except Mar (1 track in Sept)

† Data were provided by the New Zealand Department of Conservation (DOC).

‡ Data were provided by Jaimie Cleeland.

Table 3: Source of spatial information for the major breeding colonies of the assessed seabird taxa, the mean colony size (number of breeding pairs), whether tracking data were available (in BirdLife International) from the colony for the previous (2023) or current (2025) distribution mapping (adult or unknown age tracks only), and whether maps were available from Carneiro et al. (2020). '*' indicates which of these sources was used to make the final spatial distribution layer of each respective taxon, noting that permission had not been obtained to use some data. No spatial information was available for some colonies and these colonies were thus not represented by the spatial layers produced by this assessment. The number of tracks may not match Table 2 because some tracks were removed during grooming or colony site was unknown.

Common name	Colony	Mean colony size	Tracking 2023	Tracking 2025	Carneiro
Gibson's albatross	Disappointment	244			
	Adams	4 181	PTT 12*; GPS 0; GLS 0	PTT 41*; GPS 0; GLS 0	Y*‡
Wandering albatross	South Georgia (Islas Georgias del Sur)	1 278	PTT 12*; GPS 66*; GLS 170*	PTT 229*; GPS 521*; GLS 170*	Y
	Prince Edward	1 600			
	Marion	2 668	PTT 3*; GPS 34*; GLS 0	PTT 3*; GPS 150*; GLS 0	
	Crozet	2 324	PTT 479*; GPS 29*; GLS 98*	PTT 479*; GPS 29*; GLS 98*	Y
	Kerguelen	2 252	PTT 44*; GPS 0; GLS 23*	PTT 44*; GPS 0; GLS 23*	Y
	Macquarie	8	PTT 12; GPS 0; GLS 4	PTT 4*; GPS 0; GLS 4	
Southern royal albatross	Enderby	47			
	Motu Ihupuku/Campbell	5 767	PTT 17*; GPS 0; GLS 0	PTT 52*; GPS 0; GLS 14*	
Atlantic yellow-nosed albatross	Tristan da Cunha	15 250			
	Inaccessible	2 000	PTT 0; GPS 18*; GLS 0	PTT 0; GPS 18*; GLS 0	
	Nightingale	4 000	PTT 0; GPS 28*; GLS 0	PTT 0; GPS 28*; GLS 0	
	Gough	5 300	PTT 7*; GPS 74*; GLS 113	PTT 7*; GPS 74*; GLS 113	Y*
	Middle & Stoltenhoff	250			
Grey-headed albatross	South Georgia (Islas Georgias del Sur)	18 475	PTT 30*; GPS 64*; GLS 53*	PTT 302*; GPS 64*; GLS 53*	Y
	Islas Diego Ramirez	18 358	PTT 50*; GPS 0; GLS 0	PTT 67*; GPS 0; GLS 0	
	Prince Edward	1 506			Y*
	Marion	8 180	PTT 6; GPS 86*; GLS 25	PTT 6; GPS 191*; GLS 25	
	Crozet	6 319			
	Kerguelen	6 445			

Common name	Colony	Mean colony size	Tracking 2023	Tracking 2025	Carneiro
	Macquarie	100	PTT 9; GPS 5; GLS 2	PTT 9*; GPS 5; GLS 2	
	Campbell	3 672	PTT 5*; GPS 24*; GLS 0	PTT 5*; GPS 24*; GLS 64*	
	Islas Ildefonso	NA	PTT 1; GPS 0; GLS 0	PTT 1*; GPS 0; GLS 0	
Southern Buller's albatross§	Hautere/Solander	4 793	PTT 452*; GPS 97*; GLS 102*	PTT 20*; GPS 0; GLS 0	
	Tini Heke/Snares	8 700	PTT 452*; GPS 97*; GLS 102*	PTT 3*; GPS 5*; GLS 28*	Y
Northern Buller's albatross§	Motuhara/Forty-fours	16 081	PTT 452*; GPS 97*; GLS 102*	PTT 10*; GPS 2*; GLS 69*	
	Rangitatahi/Sisters	3 273			
Shy albatross	Albatross Island	5 585	PTT 55*; GPS 0; GLS 0	PTT 55*; GPS 103*; GLS 0	
	Pedra Branca	90	PTT 6; GPS 0; GLS 0	PTT 6*; GPS 0; GLS 0	
	Mewstone	9 660	PTT 5*; GPS 0; GLS 0	PTT 5*; GPS 0; GLS 0	
Campbell black-browed albatross	Motu Ihupuku/Campbell	14 129	PTT 10*; GPS 0; GLS 0	PTT 10*; GPS 0; GLS 68*	
Black-browed albatross	Falklands (Islas Malvinas)	474 219	PTT 200*; GPS 2*; GLS 201*	PTT 200*; GPS 485*; GLS 252*	Y
	South Georgia (Islas Georgias del Sur)	55 119	PTT 358*; GPS 180*; GLS 182*	PTT 363*; GPS 209*; GLS 226*	Y
	Islas Diego de Almagro	15 594	PTT 13; GPS 0; GLS 0	PTT 13; GPS 0; GLS 0	
	Islotes Evangelistas	4 818			
	Islas Diego Ramirez	61 749	PTT 13*; GPS 0; GLS 15*	PTT 100*; GPS 0; GLS 15*	Y*
	Islas Ildefonso	54 284	PTT 26; GPS 0; GLS 0	PTT 26; GPS 0; GLS 0	
	Islote Albatros	104	PTT 0; GPS 38; GLS 0	PTT 0; GPS 19*; GLS 0	
	Islote Leonard	545			
	Crozet	710			
	Kerguelen	2 880	PTT 58*; GPS 0; GLS 202*	PTT 58*; GPS 0; GLS 202*	Y
	Heard	600	PTT 10; GPS 0; GLS 0	PTT 10; GPS 0; GLS 0	
	Macquarie, Bishop & Clerk	192	PTT 9; GPS 5; GLS 2	PTT 7*; GPS 5; GLS 2	
	New Zealand Subantarctic	146			
Sooty albatross	Gough	3 750	PTT 6*; GPS 13*; GLS 56*	PTT 6*; GPS 13*; GLS 56*	

Common name	Colony	Mean colony size	Tracking 2023	Tracking 2025	Carneiro
	Inaccessible	500			
	Nightingale	150			
	Stoltenhoff	37			
	Tristan da Cunha	2 675	PTT 0; GPS 3*; GLS 0	PTT 0; GPS 3*; GLS 0	Y*
	Prince Edward	1 500	PTT 2*; GPS 0; GLS 0	PTT 2*; GPS 0; GLS 0	Y*
	Marion	2 000	PTT 10*; GPS 59*; GLS 0	PTT 10*; GPS 183*; GLS 0	
	Crozet	2 144	PTT 41*; GPS 0; GLS 0	PTT 41*; GPS 0; GLS 0	
	Amsterdam	394	PTT 7*; GPS 0; GLS 0	PTT 7*; GPS 0; GLS 0	
Light-mantled sooty albatross	South Georgia (Islas Georgias del Sur)	5 000	PTT 42*; GPS 20; GLS 0	PTT 42*; GPS 20*; GLS 0	
	Prince Edward	150			Y*
	Marion	268	PTT 10*; GPS 10*; GLS 0	PTT 10*; GPS 38*; GLS 0	
	Crozet	2 159	PTT 4*; GPS 0; GLS 7*	PTT 4*; GPS 0; GLS 7*	
	Kerguelen	4 000	PTT 0; GPS 0; GLS 5*	PTT 0; GPS 0; GLS 5*	
	Heard	350	PTT 6; GPS 0; GLS 0	PTT 6*; GPS 0; GLS 0	
	Macquarie	2 150	PTT 4*; GPS 0; GLS 3	PTT 14*; GPS 0; GLS 3	
	Maukahuka/Auckland	5 000			
	Motu Ihupuku/Campbell	1 600	PTT 20; GPS 0; GLS 0	PTT 20*; GPS 0; GLS 0	
	Moutere Mahue/Antipodes	250			
Grey petrel	Gough	17 500	PTT 0; GPS 15*; GLS 16*	PTT 0; GPS 15*; GLS 16*	Y
	Prince Edward & Marion	5 000	PTT 0; GPS 0; GLS 10*	PTT 0; GPS 0; GLS 10*	Y
	Crozet	5 500			
	Kerguelen	3 400	PTT 7*; GPS 0; GLS 37*	PTT 7*; GPS 0; GLS 37*	
	Amsterdam	7			
	Macquarie	252			
	Motu Ihupuku/Campbell	98			
	Moutere Mahue/Antipodes	73 860	PTT 0; GPS 0; GLS 49*	PTT 0; GPS 0; GLS 49*	

Common name	Colony	Mean colony size	Tracking 2023	Tracking 2025	Carneiro
Black petrel	Hauturu-o-Toi/Little Barrier	620	PTT 0; GPS 0; GLS 13*	PTT 0; GPS 0; GLS 13*	Y[†]
	Aotea/Great Barrier	4 836	PTT 0; GPS 30*; GLS 0	PTT 0; GPS 30*; GLS 112*	Y[†]
Westland petrel	Punakaiki	6 223	PTT 20*; GPS 142*; GLS 8*	PTT 20*; GPS 158*; GLS 151*	Y
White-chinned petrel	South Georgia (Islas Georgias del Sur)	773 150	PTT 23; GPS 15; GLS 42	PTT 23*; GPS 15*; GLS 51*	Y
	Prince Edward	12 000			Y
	Marion	24 000	PTT 0; GPS 21*; GLS 10*	PTT 0; GPS 21*; GLS 10*	
	Crozet	44 428	PTT 33*; GPS 0; GLS 10*	PTT 33*; GPS 0; GLS 10*	
	Kerguelen	234 000	PTT 21*; GPS 0; GLS 24*	PTT 21*; GPS 0; GLS 24*	
	Disappointment	153 000			
	Adams	28 300	PTT 0; GPS 0; GLS 102	PTT 0; GPS 0; GLS 102*	
	Motu Ihupuku/Campbell	22 000			
	Moutere Mahue/Antipodes	26 400	PTT 0; GPS 0; GLS 61*	PTT 0; GPS 0; GLS 66*	Y
	New Island/Kidney Island[§]	55	PTT 0; GPS 0; GLS 14	PTT 0; GPS 0; GLS 14*	

[‡] Distribution map was named Auckland Islands.

[†] Data from both colonies were merged into one distribution map.

[§] Breeding pairs from (Reid et al. 2007).

[§] Previous distribution maps did not differentiate between the two species.

3.2 Spatiotemporal models

The best models for all species included a 3-dimensional spatiotemporal spline model, which smoothed simultaneously across position and date, fitted with a Tweedie distribution, where the estimated Tweedie parameter was between 1–2, indicating a compound Poisson-gamma distribution (Table 4). Weighting the tracks directly by colony size produced better fits (in terms of deviance explained and residual patterns) than models that did not include weighting. This approach is also preferred on a theoretical basis, in reducing bias in observed distributions at a population level resulting from differing levels of tracking data at a colony level. The models fit by including colony size as an offset, weighting each observation's contribution to the likelihood, or by including colony name as an additional factor in the model produced much poorer fits than directly scaling the relative density by mean colony size, i.e., residual patterns were worse and extreme densities were predicted at the margins of the modelled spatial range (e.g. where no data existed). All models explained between 67–91% of the deviance.

Modelled predicted relative mean density by month and 5-degree grid cell are shown by species below, while the Appendices A–P include:

- A spatial plot of all ungroomed tracking data locations for all life stages obtained by this study, using separate colours for each colony;
- A spatial plot of all groomed and interpolated tracking data locations for only adults (or where life stage was not specified), using separate colours for each track;
- A spatial plot of the density of processed tracking data locations by month, aggregated by 1-degree grid cell; and
- Model diagnostic plots, including a quantile-quantile plot and model residuals plotted spatially.

Table 4: Model formulation including information on the type of splines and smooth terms, estimated Tweedie parameter, and percent deviation explained. 'te' indicates a tensor product smooth, 'gp' is a Gaussian process smooth, 'cc' is a cyclic cubic regression spline, and 'cs' is the shrinkage version of a cubic regression spline, where both 'cc' and 'cs' splines are a type of penalized cubic regression spline whose endpoints match (i.e., first and last values are considered near to each other in space or time).

Species	Tweedie *ρ*	Model formulation	% Dev.
Gibson's albatross	1.440	~ te(lat, lon, month, d = c(2, 1), bs = c("gp","cc"), k=c(3,8,4))	87.9
Wandering albatross	1.544	~ te(lat, lon, month, d = c(1,1, 1), bs = c("gp","cc",”cc”), k=c(7, 28, 6))	81.0
Southern royal albatross	1.530	~ te(lat, lon, month, d = c(2, 1), bs = c("gp"), k=c(4, 12, 5))	77.6
Atlantic yellow-nosed albatross	1.532	~ te(lat, lon, month, d = c(2, 1), bs = c("gp","cc"), k=c(5, 3, 4))	85.9
Black-browed albatross	1.695	~ te(lat, lon, month, d = c(1, 1, 1), bs = c("cs","cc","cc"), k=c(7, 20, 7))	91.0
Campbell black-browed albatross	1.321	~ te(lat, lon, month, d = c(2, 1), bs = c("cs","cc"), k=c(4, 12, 4))	69.1
Shy albatross	1.628	~ te(lat, lon, month, d = c(2, 1), bs = c("gp","cc"), k=c(3, 3, 3))	87.8
Grey-headed albatross	1.587	~ te(lat, lon, month, d = c(1, 1, 1), bs = c("gp","cc", “cc”), k=c(7, 18, 8))	86.9
Southern Buller's albatross	1.364	~ te(lat, lon, month, d = c(2, 1), bs = c("gp","cc"), k=c(4, 8, 5))	67.1
Northern Buller's albatross	1.308	~ te(lat, lon, month, d = c(2, 1), bs = c("gp","cc"), k=c(4, 8, 3))	73.8
Sooty albatross	1.520	~ te(lat, lon, month, d = c(2, 1), bs = c("gp", "cc"), k=c(5, 12, 4))	77.0
Light-mantled sooty albatross	1.645	~ te(lat, lon, month, d = c(1, 1, 1), bs = c("gp", "cc", "cc"), k = c(7, 13, 7))	78.5
Grey petrel	1.583	~ te(lat, lon, month, d = c(1, 1, 1), bs = c("gp","cc", “cc”), k=c(6, 15, 6))	72.2
Black petrel	1.457	~ te(lat, lon, month, d = c(2, 1), bs = c("gp","cc"), k=c(5, 7, 4))	73.7
Westland petrel	1.522	~ te(lat, lon, month, d = c(1, 1, 1), bs = c("gp","cc", “cc”), k = c(4, 12, 6))	85.0
White-chinned petrel	1.631	~ te(lat, lon, month, d = c(1, 1, 1), bs = c("gp","cc", “cc”), k = c(4, 11, 5))	68.3

3.3 Species-specific results

3.3.1 Gibson's albatross

Datasets received were from the New Zealand Department of Conservation (DOC). Four additional datasets held by BirdLife International that were identified as Gibson's albatross were requested, but no response was received. These data included tracks that extended along the southern coast of Australia and slightly to the west of Australia, which would have expanded the predicted distribution for several months, but noting that it was difficult to determine whether two of these datasets may have already been among those received from the New Zealand DOC. Of the received data, no data were from the October–December period and tracks were very limited in January and September.

Distribution maps fitted from the data indicated a slight westward movement, along the southern coast of Australia in June–November (Figure 1). The Carneiro et al. (2020) distribution maps for the Auckland Island colony (all four quarters) were used to augment the spatial distribution, which extended the distribution along the southern coast of Australia in most months (Figure 2).

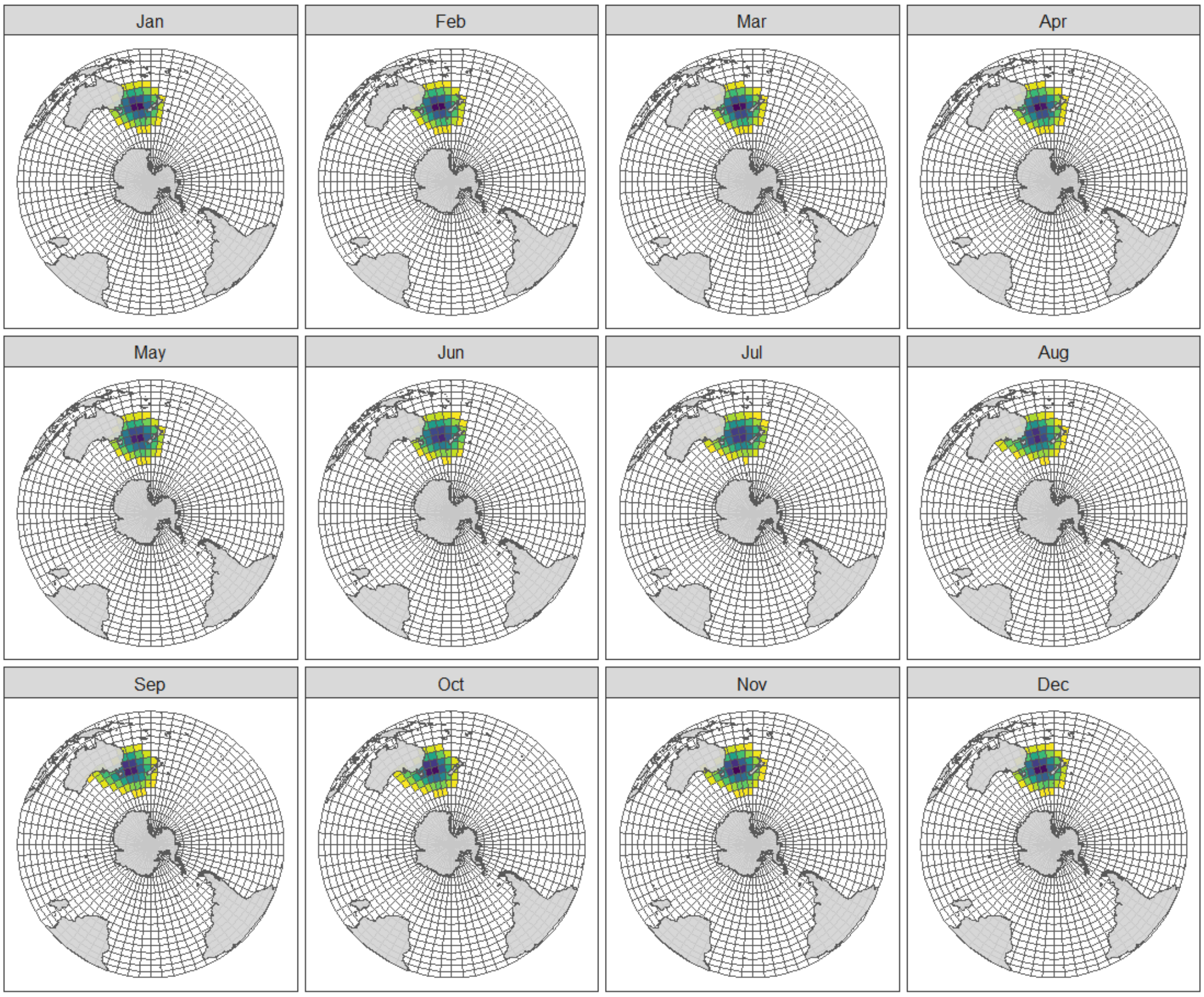

Figure 1: Gibson's albatross (*Diomedea antipodensis gibsoni*) predicted distribution by month. Yellow indicates low densities, and dark blue indicates high densities.

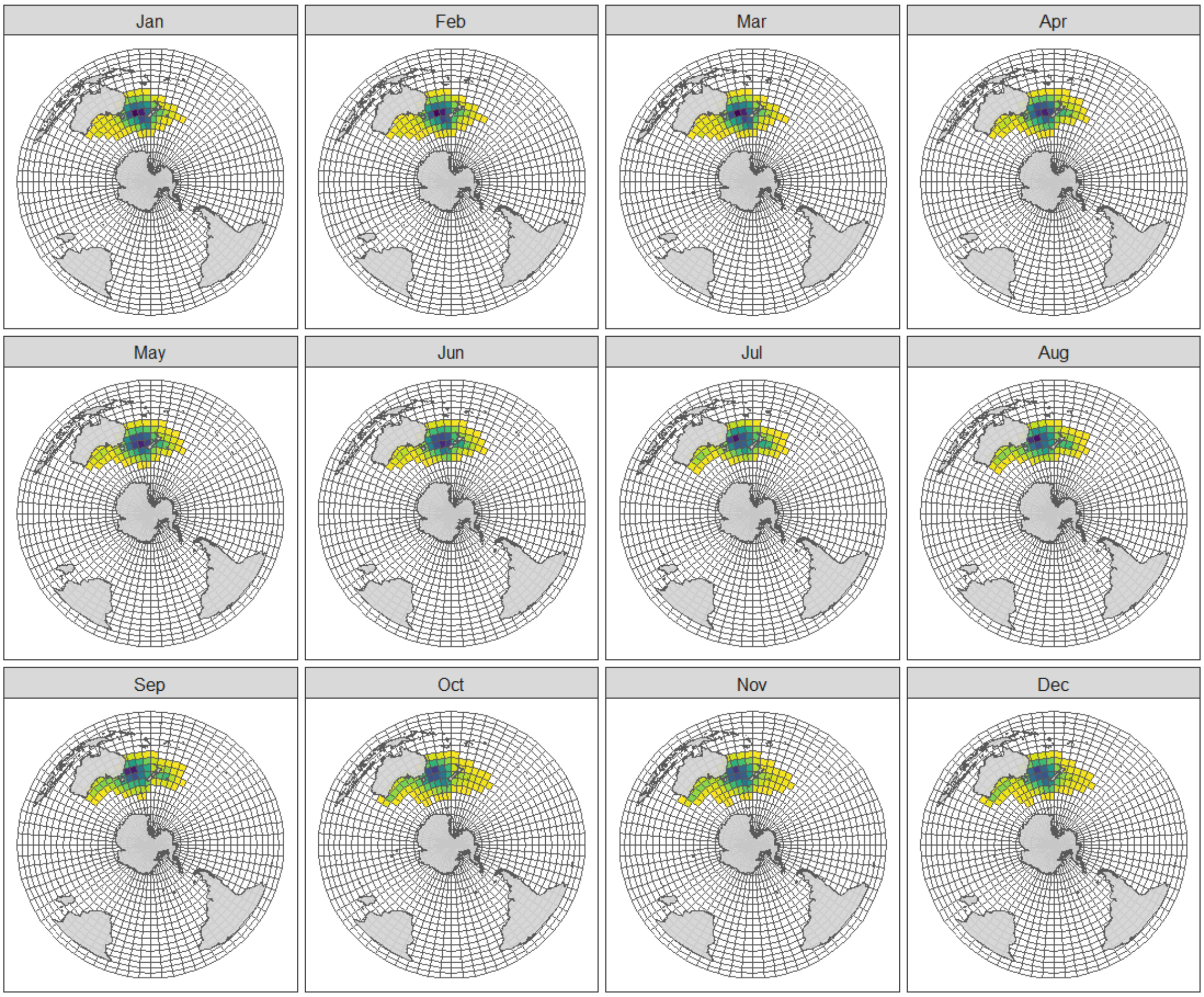

Figure 2: Gibson's albatross (*Diomedea antipodensis gibsoni*) predicted distribution by month, after augmentation with the Auckland Island colony distribution maps of Carneiro et al. (2020). Yellow indicates low densities, and dark blue indicates high densities.

3.3.2 Wandering albatross

A response to data requests was not received for only two datasets (of 45) that were requested through BirdLife International. All datasets identified by the external review, including data from the South Atlantic Ocean (e.g., South Georgia) were received. Of the received data, data were available from the Macquarie colony only from December–March, and from the Marion Island colony for January–September; all other colonies had coverage over all months.

Distribution maps fitted from the data indicated a circumpolar distribution for all months except February–March, with densest concentrations in the south Atlantic (Falklands/South Georgia area) and south Indian Oceans (Figure 3). The distribution was weighted (as a result of including weighting by the mean colony size) towards the Marion, Crozet, and Kerguelen colonies in the south Indian Ocean; these colonies make up approximately 70% of the population. The Carneiro et al. (2020) distribution maps were not used to augment the predicted distribution.

Figure 3: Wandering albatross (*Diomedea exulans*) predicted distribution by month. Yellow indicates low densities, and dark blue indicates high densities.

3.3.3 Southern royal albatross

The external review (Edwards et al. 2025, Table A.6) identified that additional datasets were required because the previous analysis (Devine et al. in press) did not capture the circumpolar distribution of this species. Requests to use all datasets available in BirdLife International were granted for the update, which provided information on the distribution across the south Pacific Ocean for most months (Figure 4). Coverage of all months was good, but very few of the adult tracks circumnavigated the globe, which meant that the distribution of the species was limited except in the south Pacific Ocean region.

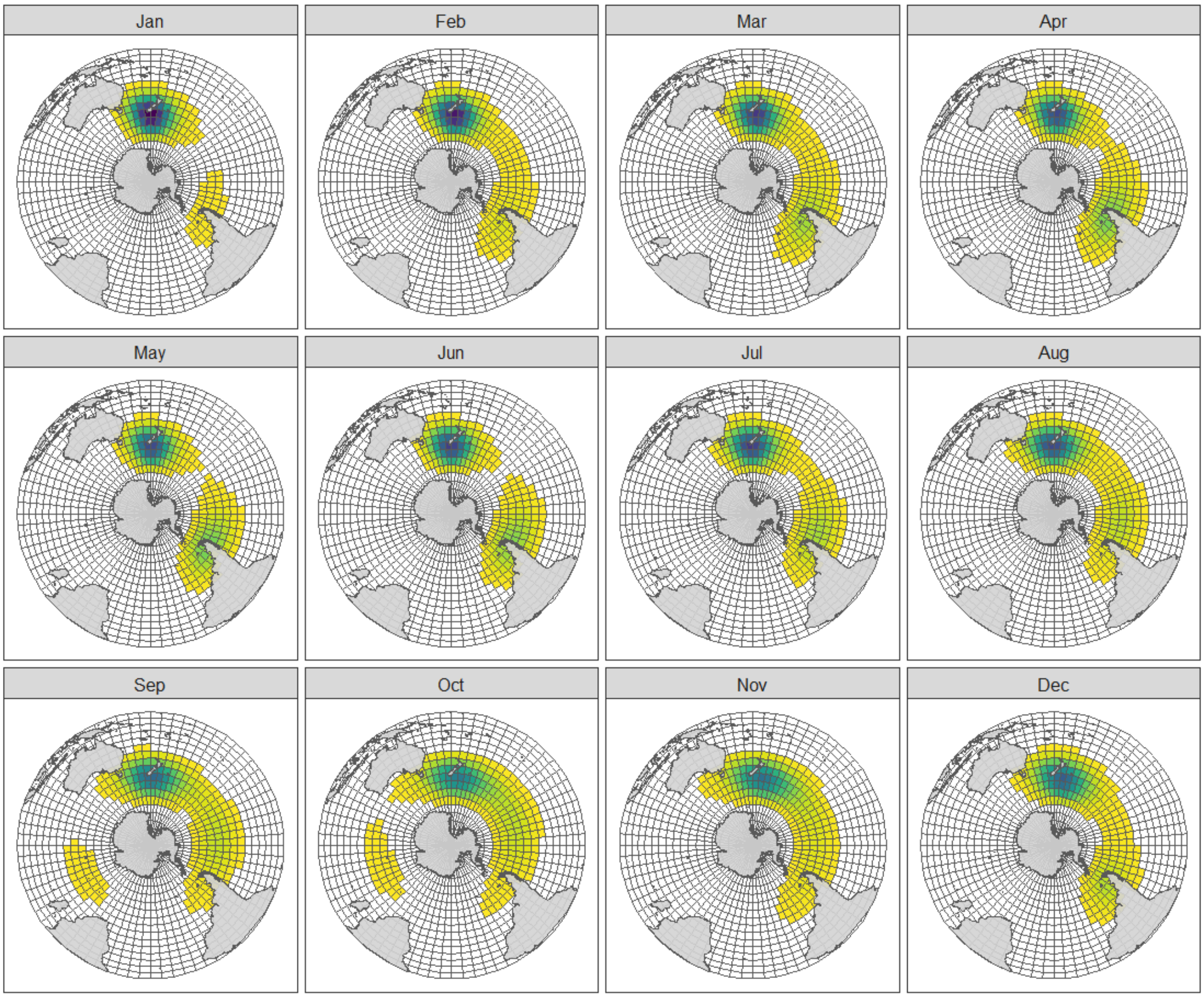

Figure 4: **Southern royal albatross (*Diomedea epomophora*) predicted distribution by month. Yellow indicates low densities, and dark blue indicates high densities.**

3.3.4 Atlantic yellow-nosed albatross

Additional datasets were required because the previous analysis did not capture the spatiotemporal movement across the south Atlantic Ocean or take into account known foraging areas, e.g., Benguela upwelling zone (see Table A.6 in Edwards et al. 2025). Requests to use all datasets available in BirdLife International were granted for all but one dataset (Table 2). No tracking data were available in June to September (all colonies) or for the main breeding colony (Tristan da Cunha). Convergence was an issue with this model, which was solved by adjusting the weighting (mean colony size) to be the mean of the colonies in the data instead of the mean of all known breeding colonies (i.e., removing Tristan da Cunha and Middle & Stoltenhoff) (Table 3).

The monthly distribution maps indicated an eastward movement across the south Atlantic Ocean, beginning in August, with a return to South America by April (Figure 5). Carneiro et al. (2020) distributions were used to augment the predicted distributions for the Gough breeding colony for all months except October–December, i.e., omitting months when the available tracking data had good coverage (Table 3, Figure 6). This augmentation meant that a proportion of the population remained at the coast of Africa in April–July (i.e., in the Benguela upwelling zone) and around Gough Island in the first three quarters of the calendar year (Figure 6).

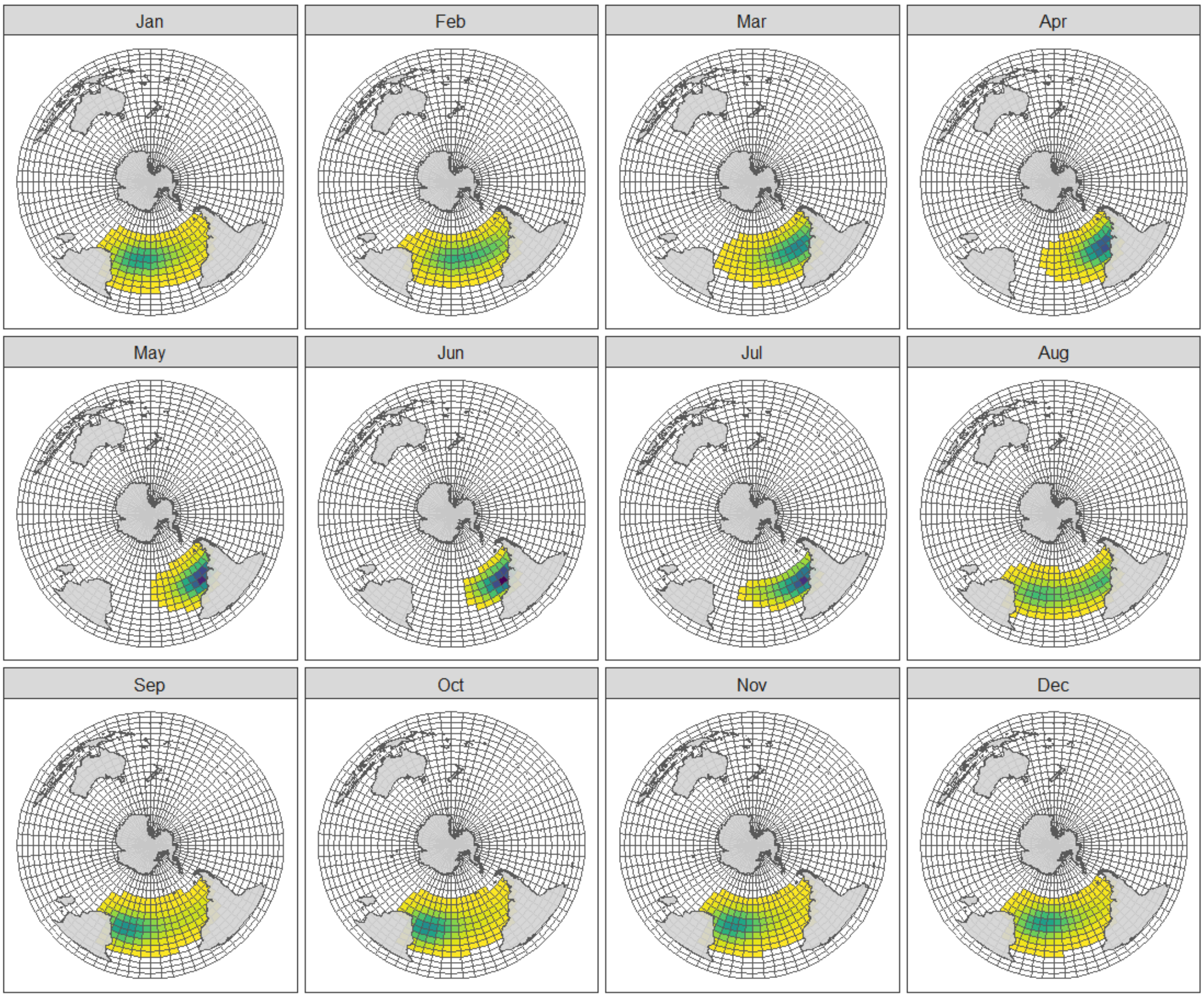

Figure 5: Atlantic yellow-nosed albatross (*Thalassarche chlororhynchos*) predicted distribution by month. Yellow indicates low densities, and dark blue indicates high densities.

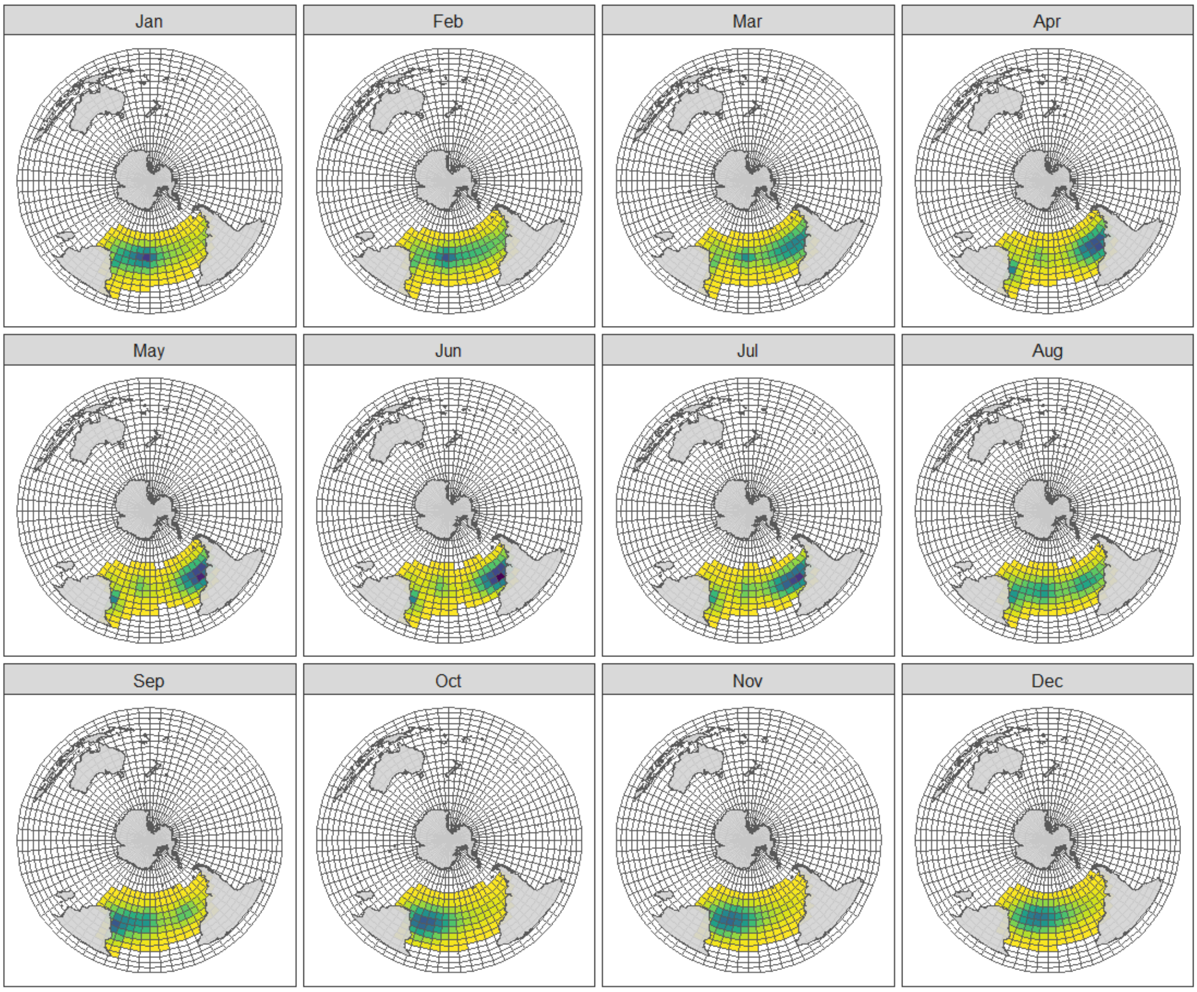

Figure 6: Atlantic yellow-nosed albatross (*Thalassarche chlororhynchos*) predicted distribution by month, after augmentation with the Gough Island colony distribution maps of Carneiro et al. (2020). Yellow indicates low densities, and dark blue indicates high densities.

3.3.5 Black-browed albatross

The external review of the previous distribution modelling (Devine et al. in press) noted the lack of tracking data from key colonies, including the Falkland Islands and southern Chile, and noted an additional 12 tracking datasets held by BirdLife International that would improve the distributions. Of those identified datasets, 9 were made available by data owners for the update, resulting in 34 (of 46) datasets being included (Table 2). In the available tracking data, a northward truncation in the south Indian Ocean was apparent (see Appendix E). Tracking data were available for most major colonies for all months but was sparse for the Islas Diego Ramirez colony (Table 3).

The additional tracking data improved the updated distribution maps, particularly in the south Indian and Atlantic Ocean sectors, and down-weighted the distribution towards the Australian Bight (Figure 7). The modelled distributions were circumpolar for May only but augmenting with the Islas Diego Ramirez colony maps from Carneiro et al. (2020) improved the distributions for the south Pacific region for all months (Figure 8).

Figure 7: Black-browed albatross (*Thalassarche melanophris*) predicted distribution by month. Yellow indicates low densities, and dark blue indicates high densities.

Figure 8: Black-browed albatross (*Thalassarche melanophris*) predicted distribution by month, after augmentation with the Islas Diego Ramirez colony distribution maps of Carneiro et al. (2020). Yellow indicates low densities, and dark blue indicates high densities.

3.3.6 Campbell black-browed albatross

The previous version included data from only February. An additional dataset was identified as necessary by the expert review and was included in the update (Table 2). This expanded coverage to all months and included a few tracks in the south Atlantic and Indian Ocean regions. This appeared to be one bird that flew south of South America, crossed the Atlantic, flew to Antarctica, and then returned to the southern Tasman Sea. Because of the low relative densities in these cells, they were not adequately modelled (see Appendix F). The final distribution map indicated a distribution localised to the south of New Zealand October–February, with distribution both westward into the south Indian Ocean and eastward, towards South America, the rest of the year (Figure 9).

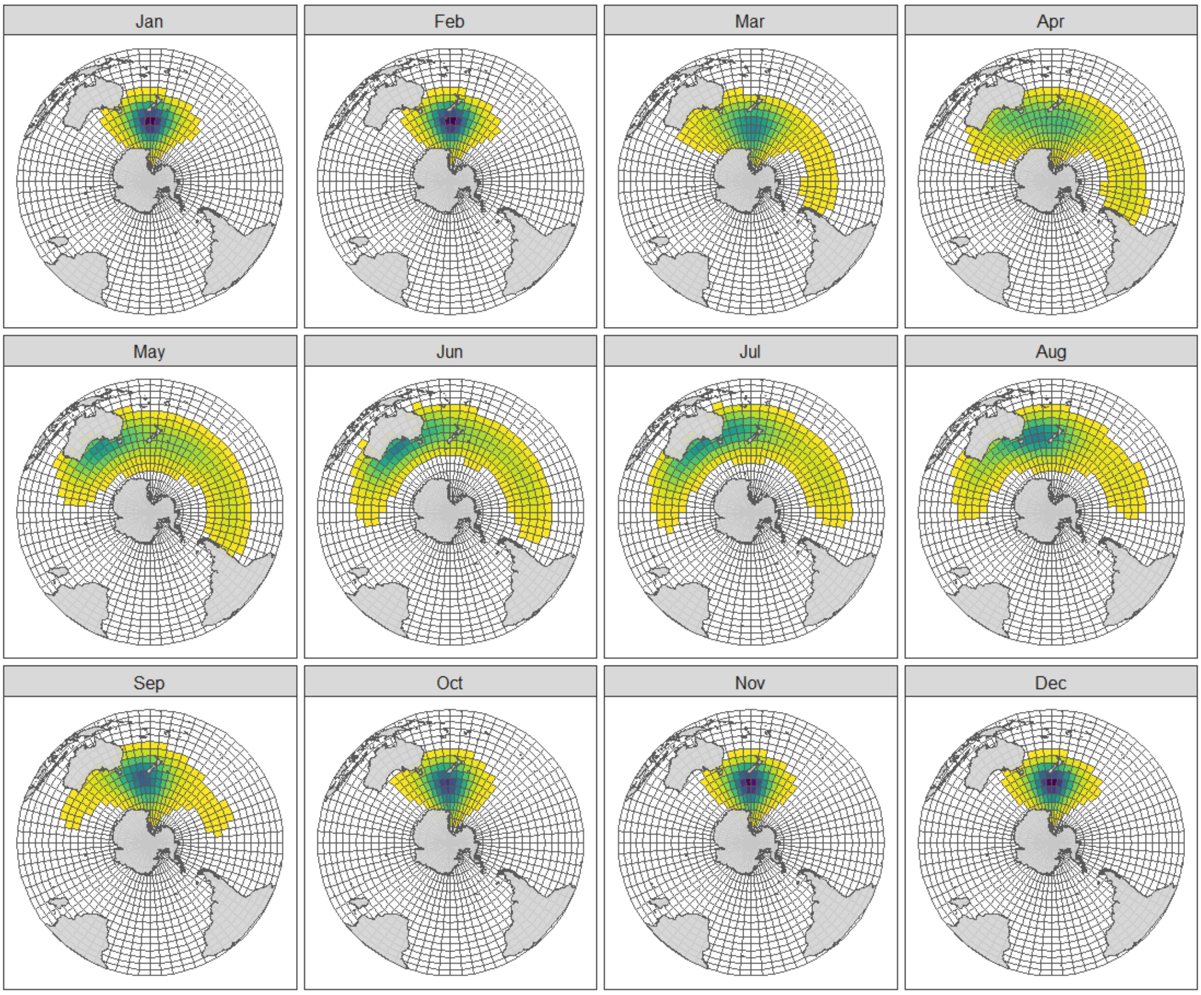

Figure 9: Cambell black-browed albatross (*Thalassarche impavida*) predicted distribution by month. Yellow indicates low densities, and dark blue indicates high densities.

3.3.7 Shy albatross

The review by international experts identified six additional datasets that would improve the distribution maps and included some wide-ranging tracks. Permission to use those data were given (Table 2). The review also noted that known foraging areas in the Indian Ocean, and off the east coast of South Africa were absent, but these tracking data were from juveniles and thus not included in the analysis (see Appendix G). Data for adults were only from the area around Tasmania and southern coastal Australia. This meant that the updated predicted monthly distribution did not differ greatly from the previous version except that tracks from Mewstone Island (the largest colony) were included (Figure 10, see Appendix G).

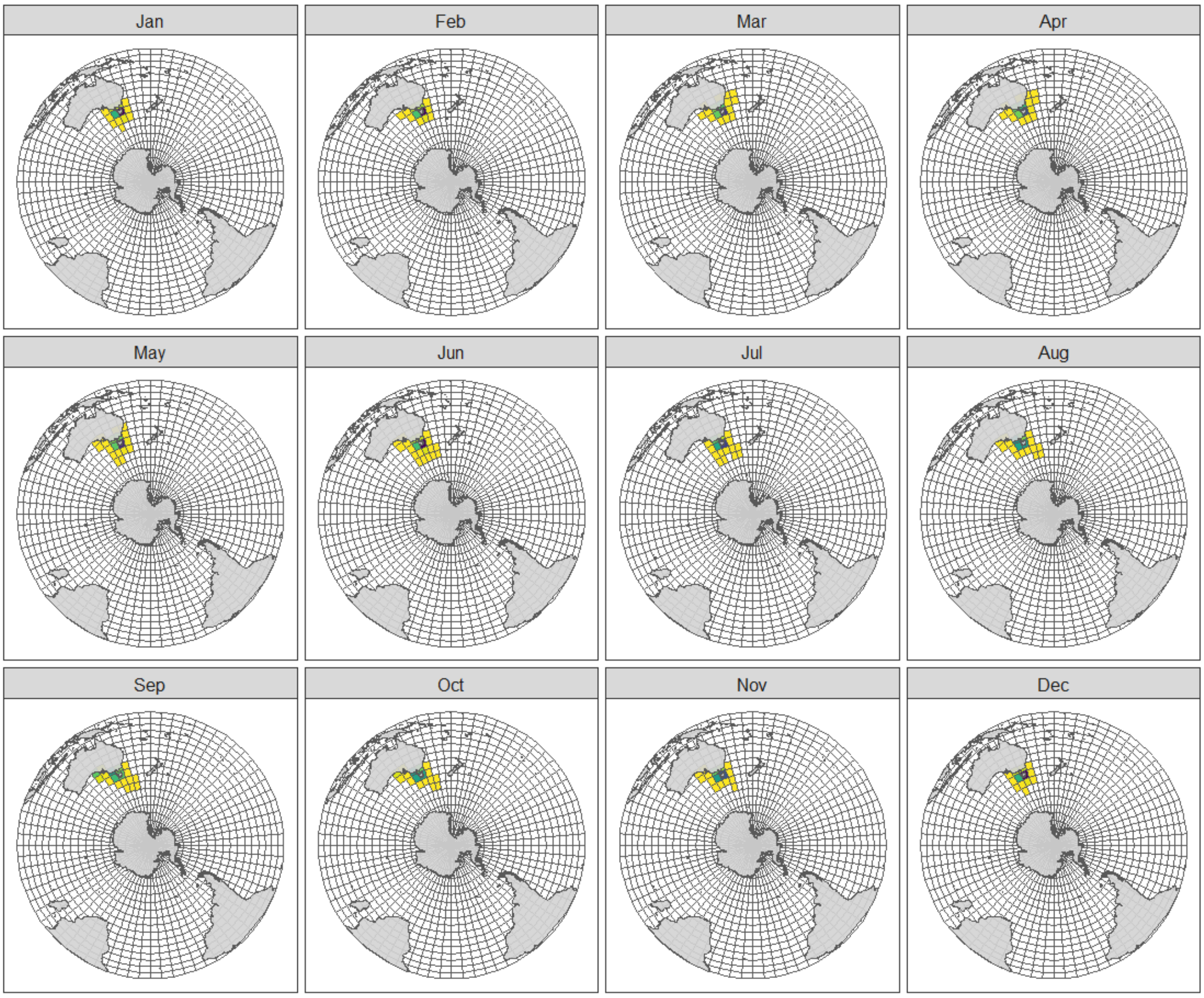

Figure 10:Shy albatross (*Thalassarche cauta*) predicted distribution by month. Yellow indicates low densities, and dark blue indicates high densities.

3.3.8 Grey-headed albatross

The review by international experts noted additional datasets that would improve the updated distribution maps and included some poorly represented colonies. Permission to use four of these datasets were given, which included the Islas Diego Ramirez, South Georgia, and Marion Island colonies (Table 2), but permission was not received to use other data identified as being key from Macquarie and Marion Islands.

Predicted distributions were largely circumpolar, but with some notable gaps in the distribution in the south Indian Ocean region between March–May (Figure 11). Augmentation with the Prince Edward Island colony maps from Carneiro et al. (2020) indicated a low-density circumpolar distribution in all months (Figure 12).

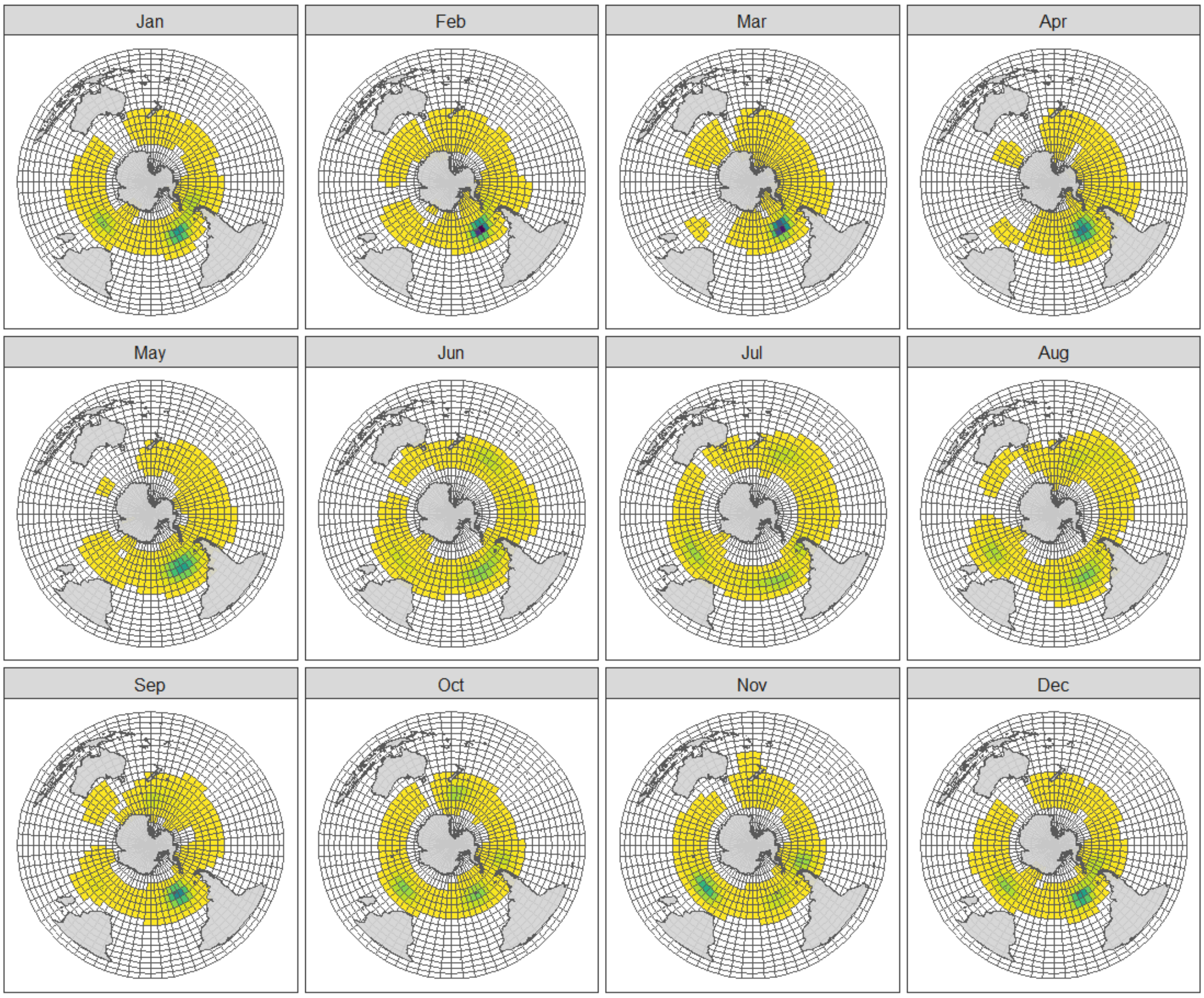

Figure 11: Grey-headed albatross (*Thalassarche chrysostoma*) predicted distribution by month. Yellow indicates low densities, and dark blue indicates high densities.

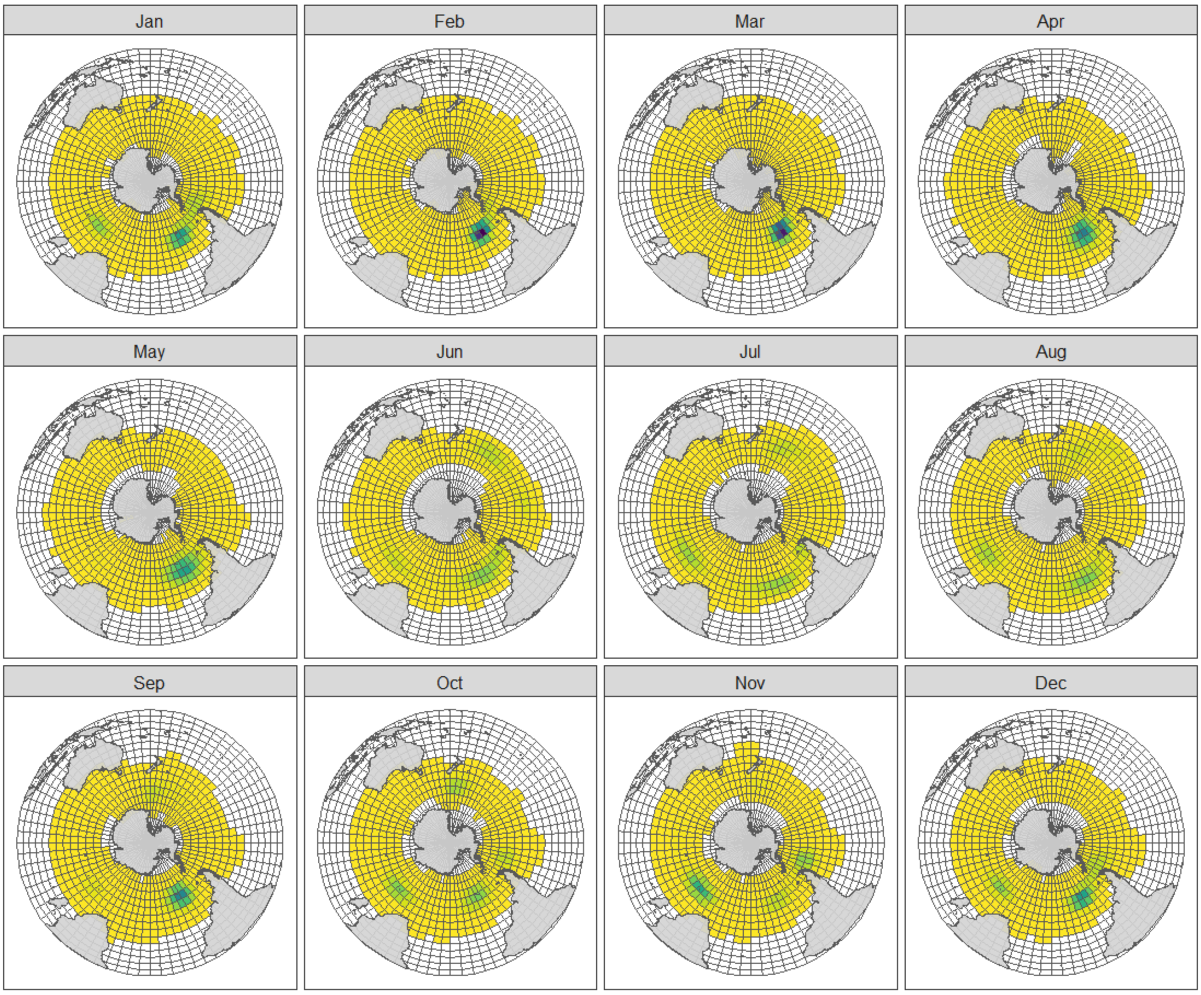

Figure 12: Grey-headed albatross (*Thalassarche chrysostoma*) predicted distribution by month, after augmentation with the Prince Edward Island colony distribution maps of Carneiro et al. (2020). Yellow indicates low densities, and dark blue indicates high densities.

3.3.9 Southern Buller's albatross

The previous analysis (Devine et al. in press) could not differentiate between Northern and Southern Buller's albatross because many of the tracking datasets held by BirdLife International did not differentiate between the two subspecies. The New Zealand DOC provided subspecies-specific tracking data to enable each to be modelled (Table 2). Tracking data from the Snares colony was missing information for December through March, and from Solander for September–February. Despite missing information for these months, the predicted distribution showed birds leaving South America and migrating to New Zealand for the breeding season, a pattern that was similar to that reported by Fischer et al. (2023) (Figure 13). Augmentation with the Carneiro et al. (2020) maps for the four missing months indicated a lower density of birds were at the breeding grounds in December–March (not shown) than the non-augmented maps. The decision was made to not use the augmented maps.

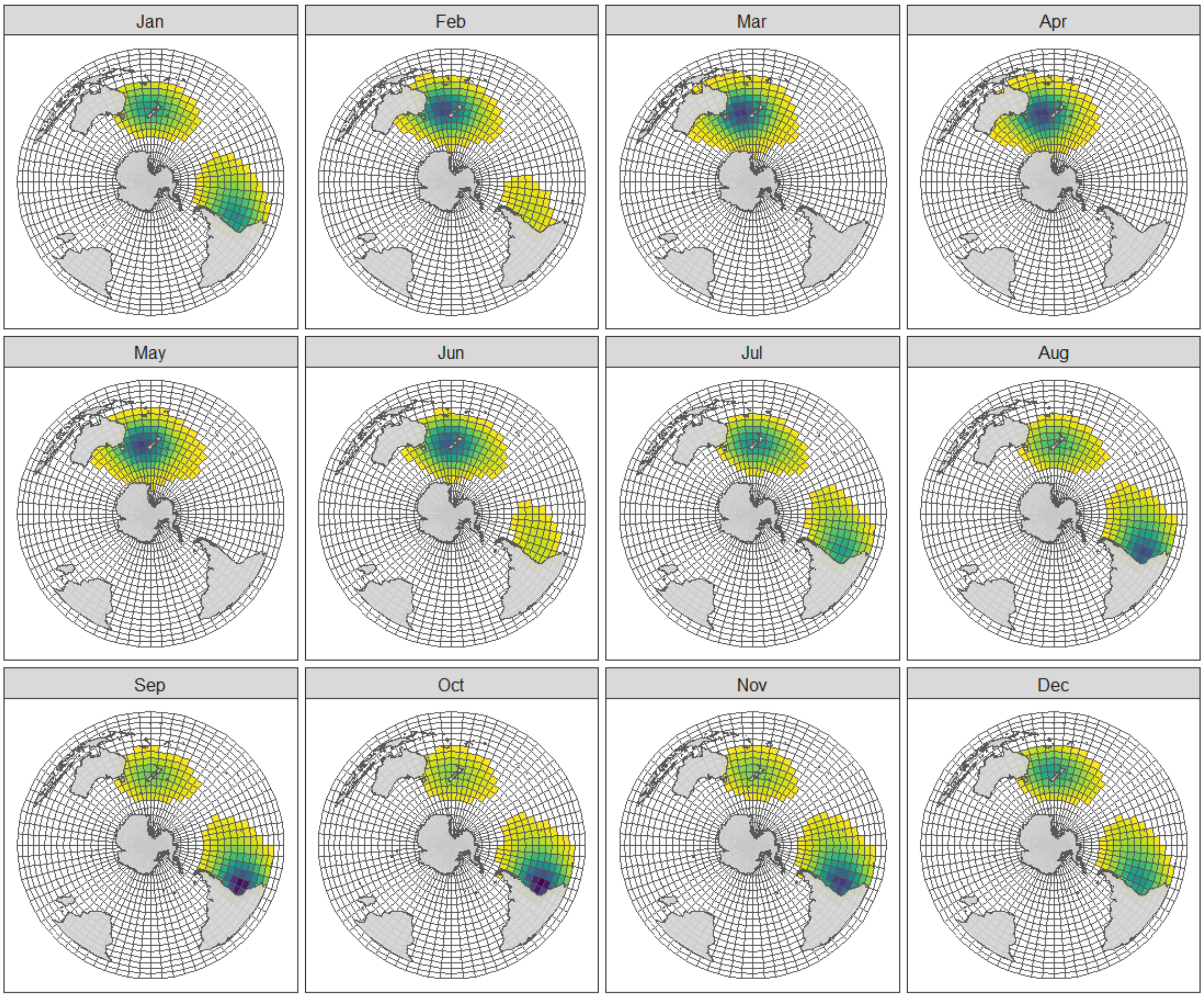

Figure 13: Southern Buller's albatross (*Thalassarche bulleri bulleri*) predicted distribution by month. Yellow indicates low densities, and dark blue indicates high densities.

3.3.10 Northern Buller's albatross

All provided tracking data were from the larger of the two colonies (i.e., Motuhara) (Tables 2–3). Increasing the number of knots in the spatiotemporal smoother made no improvement to the predicted distribution; the model was not able to completely shift all birds from around New Zealand to the South American coast in August (Figure 14).

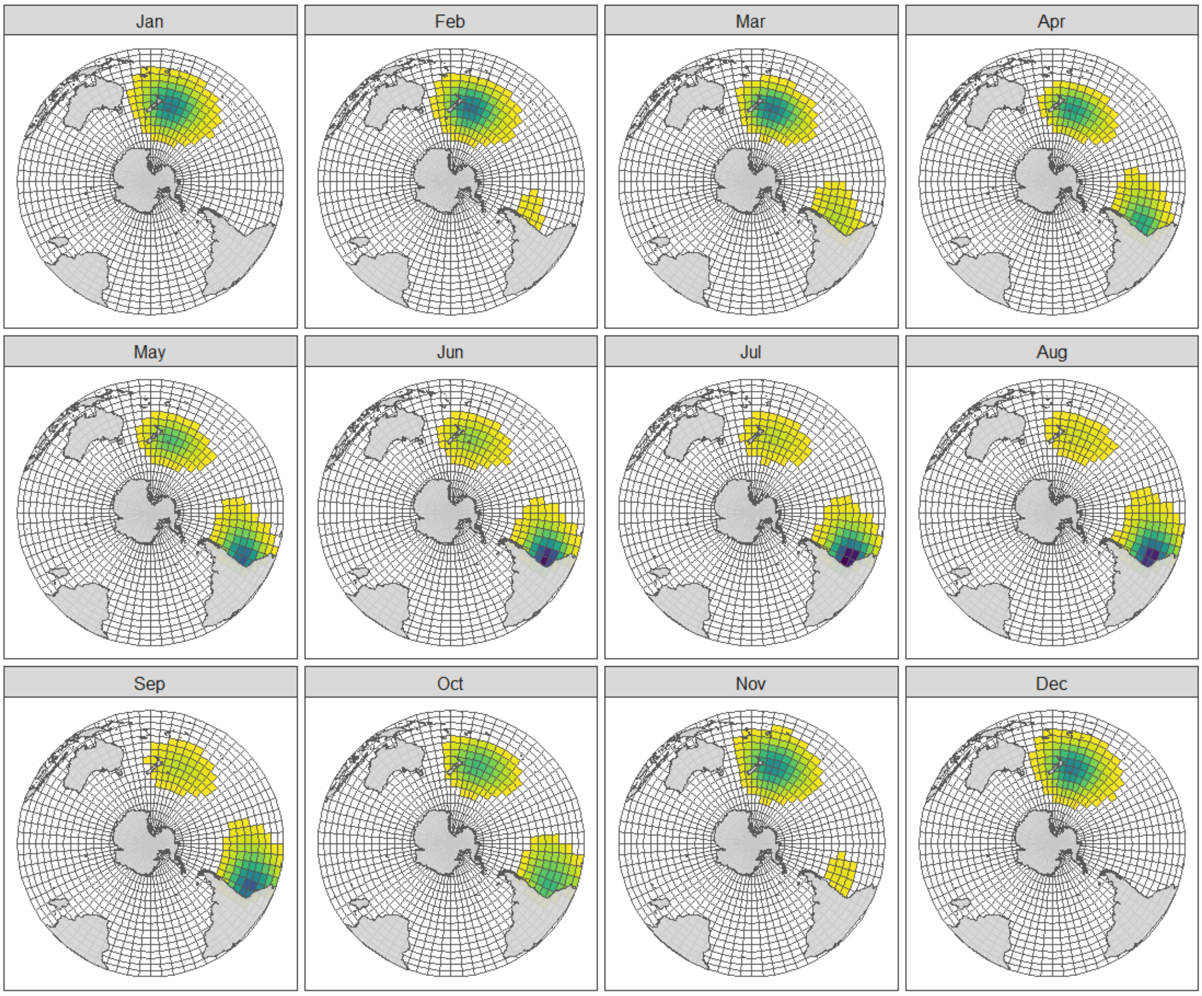

Figure 14: Northern Buller's albatross (*Thalassarche bulleri platei*) predicted distribution by month. Yellow indicates low densities, and dark blue indicates high densities.

3.3.11 Sooty albatross

Two additional tracking datasets were approved for use for this update, which meant that all available datasets were used (Table 2). Care was taken to use only data identified as sooty albatross, taking into consideration a comment from the external review (see Table A.6 in Edwards et al. 2025). Tracking data included only a few tracks in July and September for the Prince Edward Island colony (2 tracks in total), and no information January–October for the Tristan da Cunha colony (3 tracks in total). Because of this and the low number of tracks for two of the larger colonies, the Carneiro et al. (2020) maps were used to augment the predicted distributions (all months) for these two colonies. This resulted in more eastward distributions in the south Indian Ocean between September and March, and a more westward distribution September–March in the South Atlantic (Figures 15–16).

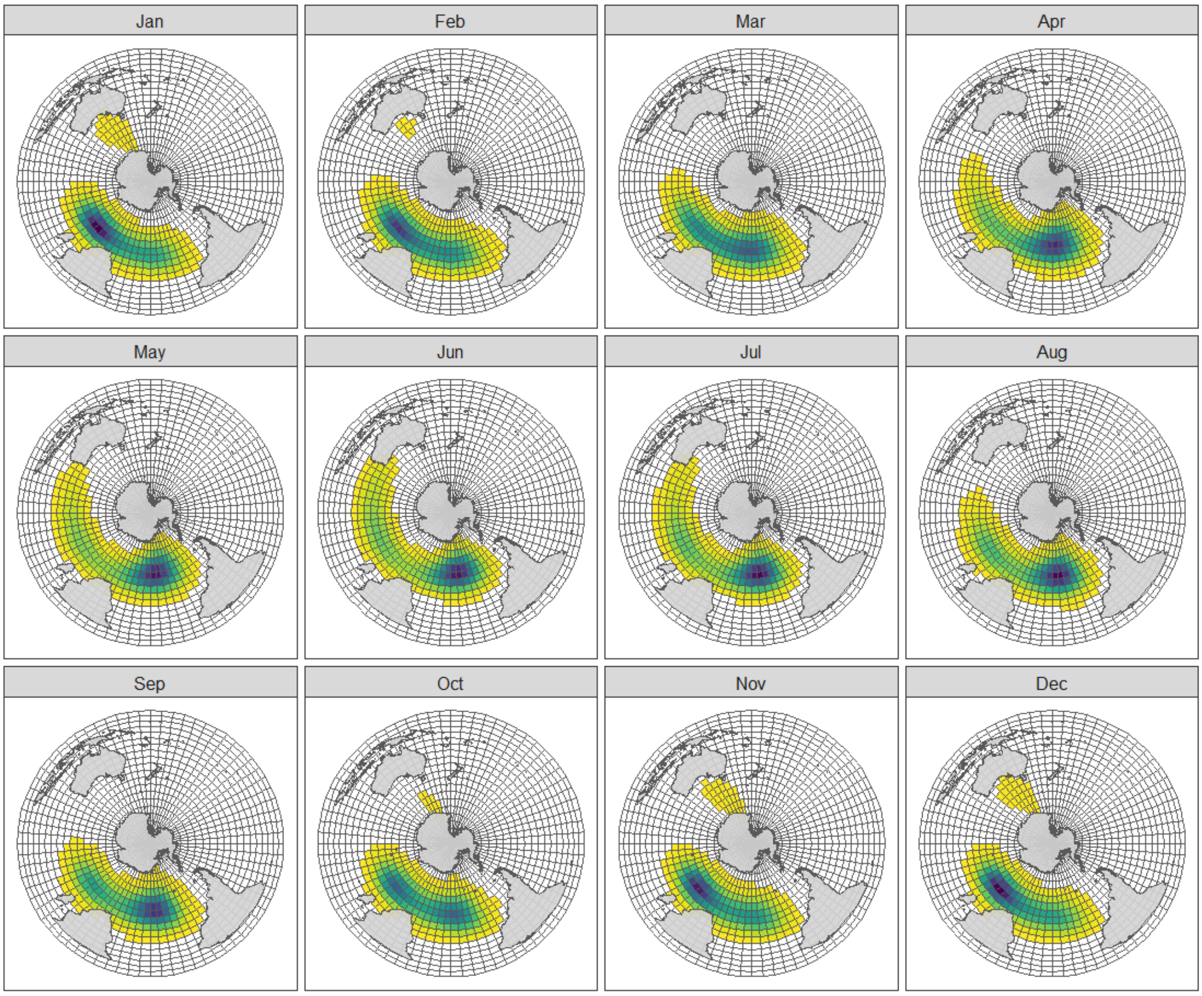

Figure 15: Sooty albatross (*Phoebetria fusca*) predicted distribution by month. Yellow indicates low densities, and dark blue indicates high densities.

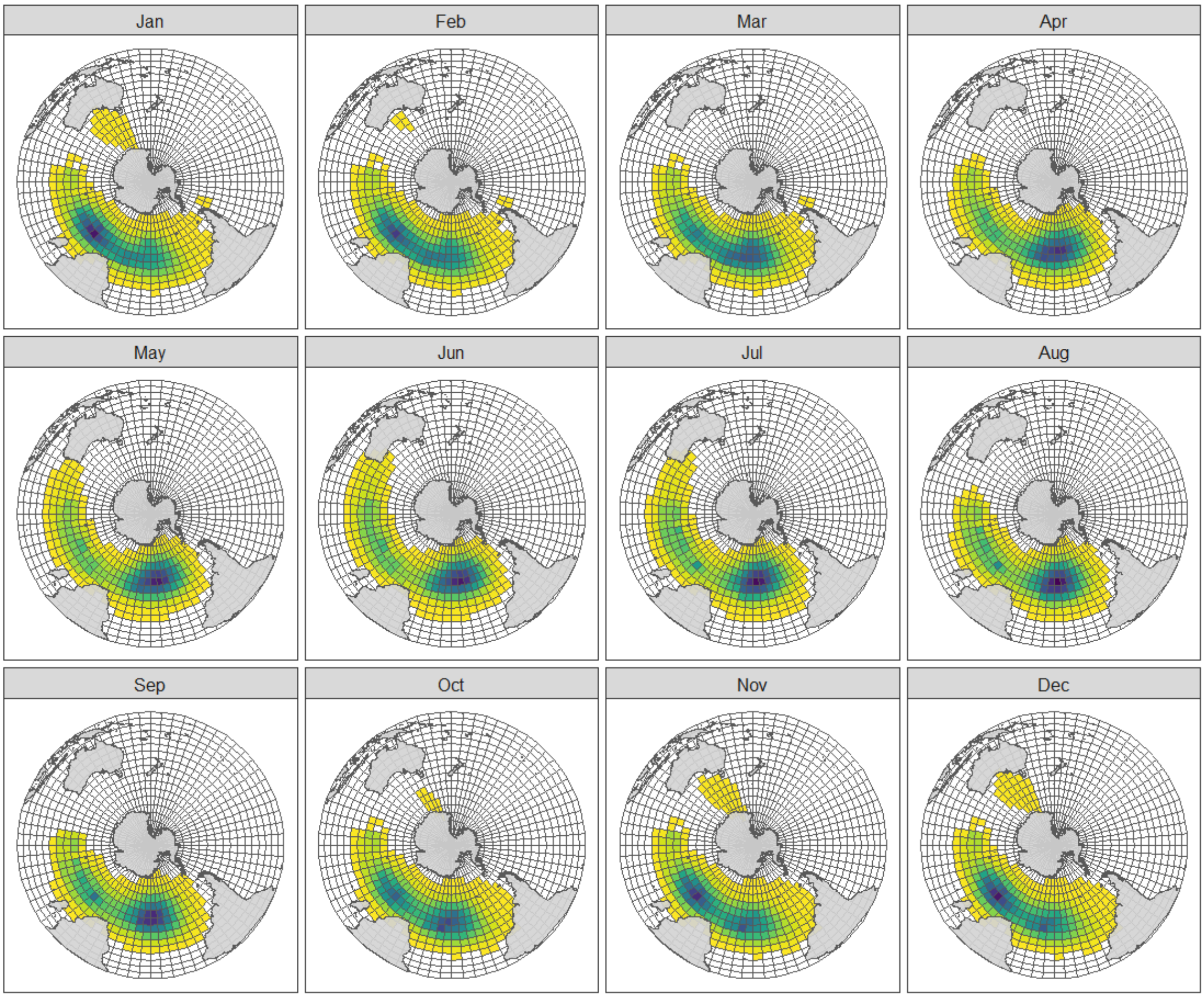

Figure 16: Sooty albatross (*Phoebetria fusca*) predicted distribution by month, after augmentation with the distribution maps of the Prince Edward Island and Tristan da Cunha colonies (Carneiro et al. 2020). Yellow indicates low densities, and dark blue indicates high densities.

3.3.12 Light-mantled sooty albatross

The review of the previous distribution mapping lacked data from the South Georgia, Crozet, and Kerguelen colonies. These data and an additional dataset from the New Zealand DOC from the Campbell colony were made available for the update (Table 2). The only dataset that was not available was from Macquarie Island, which contained only three tracks. Tracks were spare for the Marion colony in September–October. Distribution maps were augmented with the Prince Edward Island colony maps in Carneiro et al. (2020), but because it was a small colony, it made little discernible difference to the distribution maps (Figures 17–18). Light-mantled sooty albatross distributions were circumpolar in most months, but few tracks crossed the south Pacific Ocean in February and March.

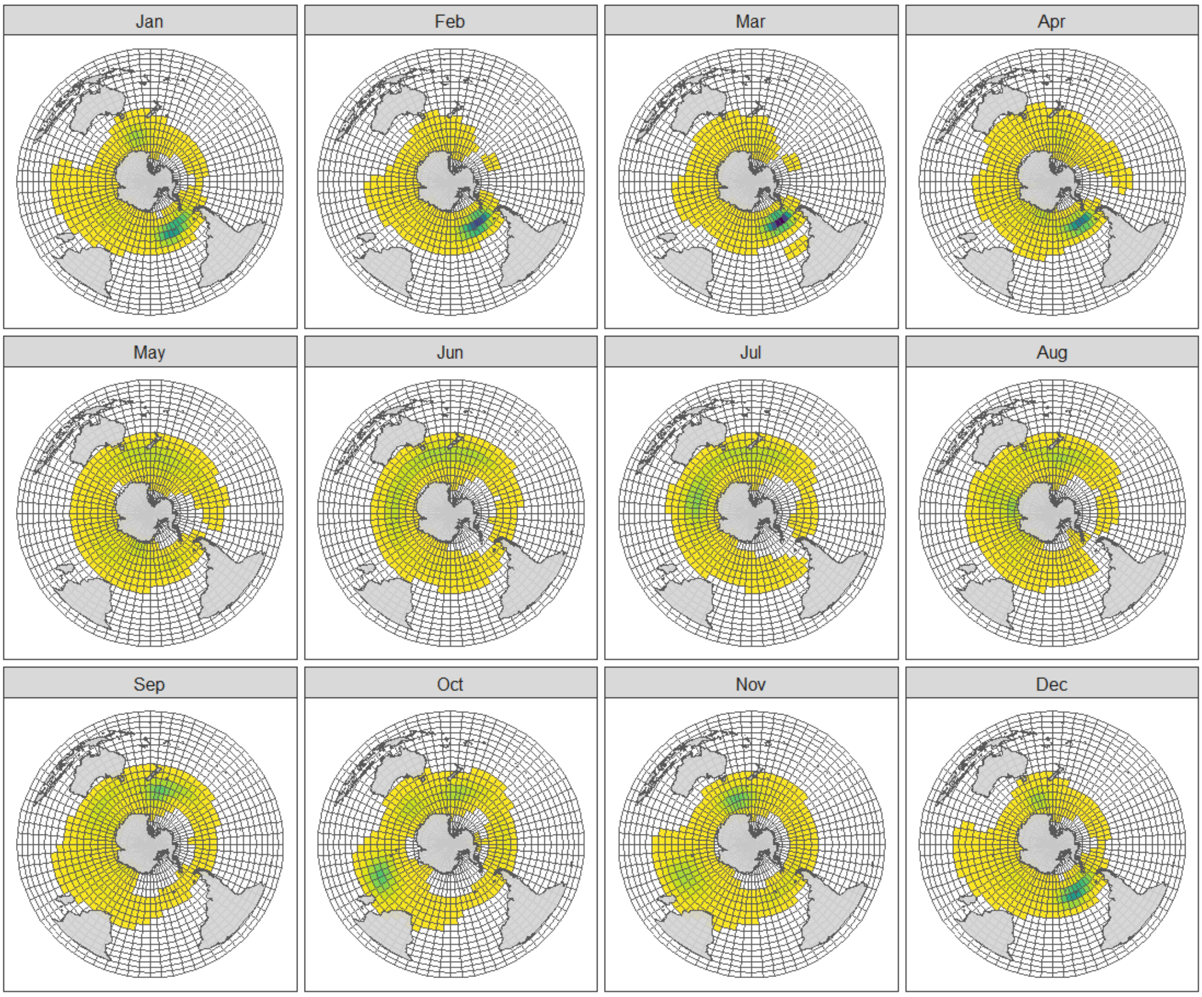

Figure 17: Light-mantled sooty albatross (*Phoebetria palpebrata*) predicted distribution by month. Yellow indicates low densities, and dark blue indicates high densities.

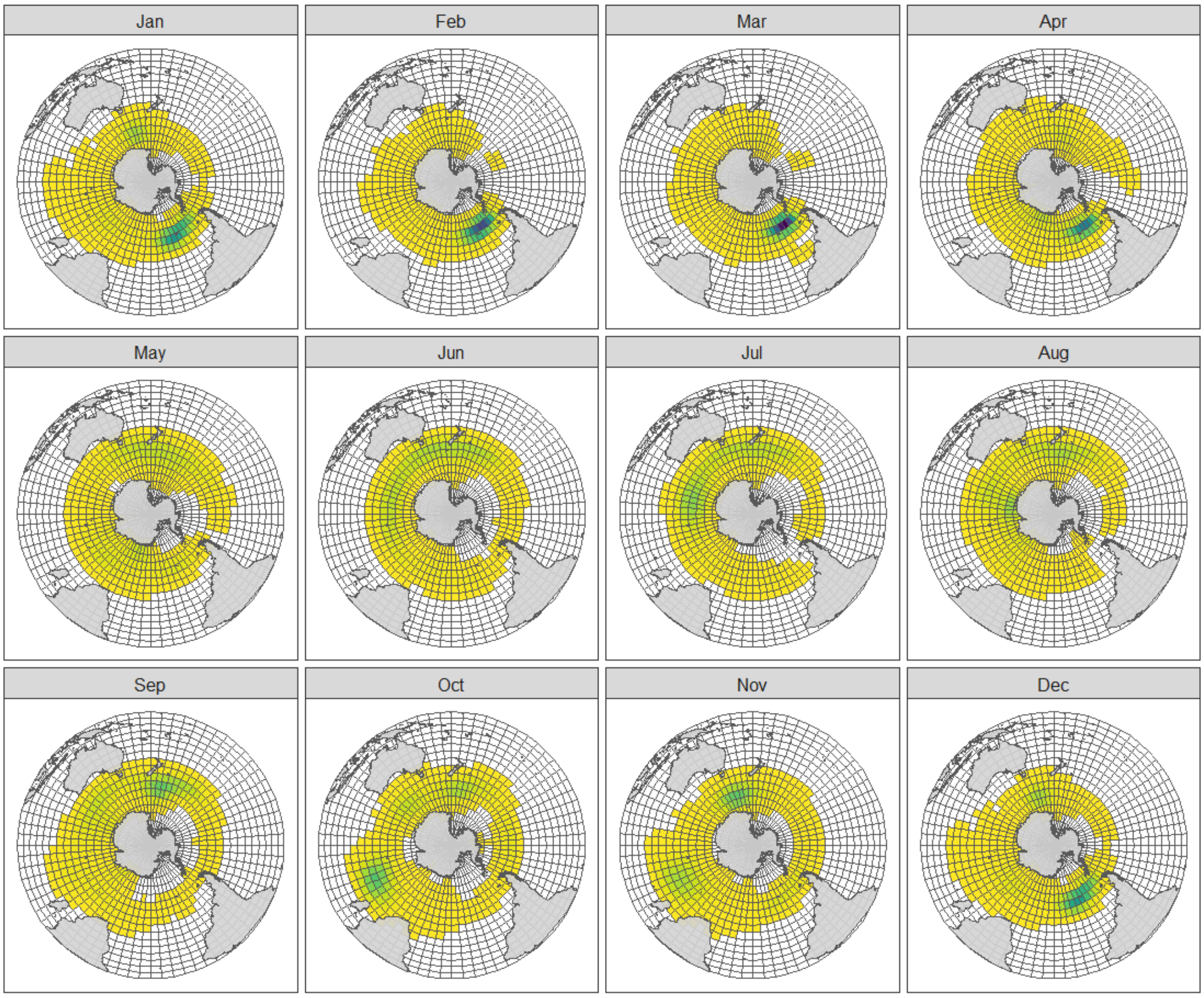

Figure 18: Light-mantled sooty albatross (*Phoebetria palpebrata*) predicted distribution by month, after augmentation with the Prince Edward Island colony distribution maps of Carneiro et al. (2020). Yellow indicates low densities, and dark blue indicates high densities.

3.3.13 Grey petrel

While no additional datasets were available for the updated analysis, the update included weighting by the mean colony size, which was not previously done. The Antipodes colony contained 70% of the population, followed by Gough Island (17%); all other colonies made up a minor proportion of the total grey petrel population (Table 3). Because of weighting the data, the distribution in the south Indian and Atlantic Oceans was de-emphasized (Figure 19). The Carneiro et al. (2020) distribution maps were not used to augment the predicted distribution.

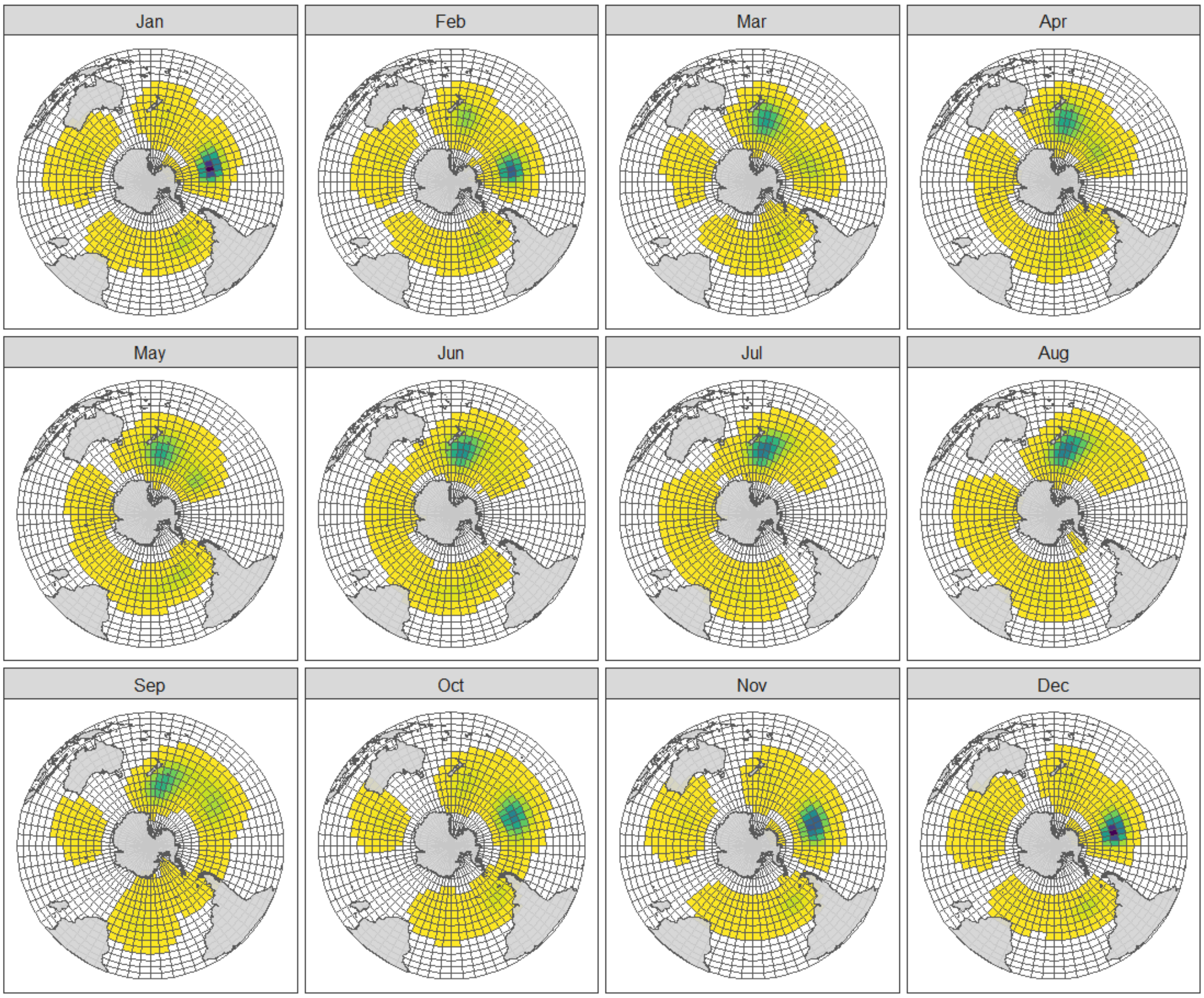

Figure 19: Grey petrel (*Procellaria cinerea*) predicted distribution by month. Yellow indicates low densities, and dark blue indicates high densities.

3.3.14 Black petrel

The external review noted that some tracks included in the previous distribution modelling may not have been black petrel tracks and that this species should be absent from New Zealand in July through September. Permission was given to use all available datasets in BirdLife International and an additional set for Aotea Great Barrier Island was provided by the New Zealand DOC (Table 2). The data identified as black petrel included tracks south of 43 °S (see Appendix N). Because these are predicting probable distribution for a species, very low relative densities were predicted around New Zealand in July, but the updated maps show that black petrels are now absent in August and September, having migrated across the south Pacific Ocean to the coast of South America and northward (Figure 20). The spatial distribution was allowed to cross the equator to simulate movement of this species into the northern hemisphere and along the coast of central America. The external review expressed concern that data had not been adequately groomed because predictions had been allowed to extend into the Caribbean Sea. Raw data were closely scrutinized. The movements were from four datasets (56 tracks) and were not associated with the equinox (as this can introduce errors); there was nothing to suggest that these data were not real, and the data were retained in the analysis. This may, however, be an issue with older GLS data and will require closer scrutiny (including working with experts) should distribution maps be updated in the future. Note that the greatest predicted density was to the Pacific

Ocean coast of South America (June–September) (Figure 20). The number of knots and model formulation had not been updated, so improvement to the distribution was due to the addition of three tracking datasets for the Great Barrier Island colony and weighting by colony size (Table 4). The Carneiro et al. (2020) distribution maps were not used to augment the predicted distribution.

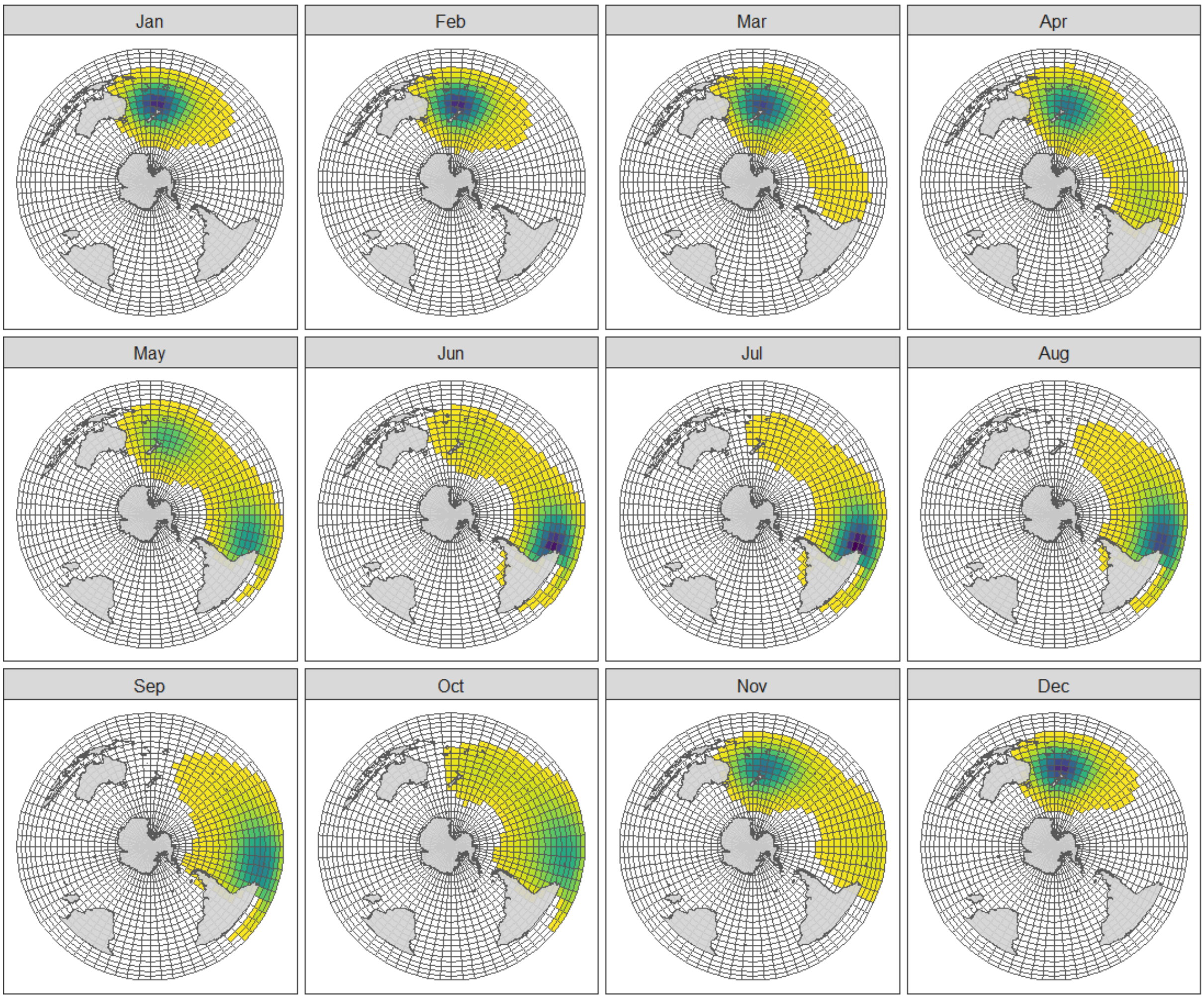

Figure 20: Black petrel (*Procellaria parkinsoni*) predicted distribution by month. Yellow indicates low densities, and dark blue indicates high densities.

3.3.15 Westland petrel

Two additional tracking datasets were provided for the updated analysis, which vastly improved the modelled distributions. Westland petrels were distributed only around New Zealand in June and July and were in high density along the South American coast (Chile and Argentina) in November–March (Figure 21). Tracking data supported the movement of birds around the tip of South America and to the Argentinian coast (see Appendix O). The external review noted that this species should not be present in New Zealand water in January–March (see Table A.6 in Edwards et al. 2025); however, the raw tracking data indicated a large number of tracks around New Zealand at that time (see Appendix O). The Carneiro et al. (2020) distribution maps were not used to augment the predicted distribution.

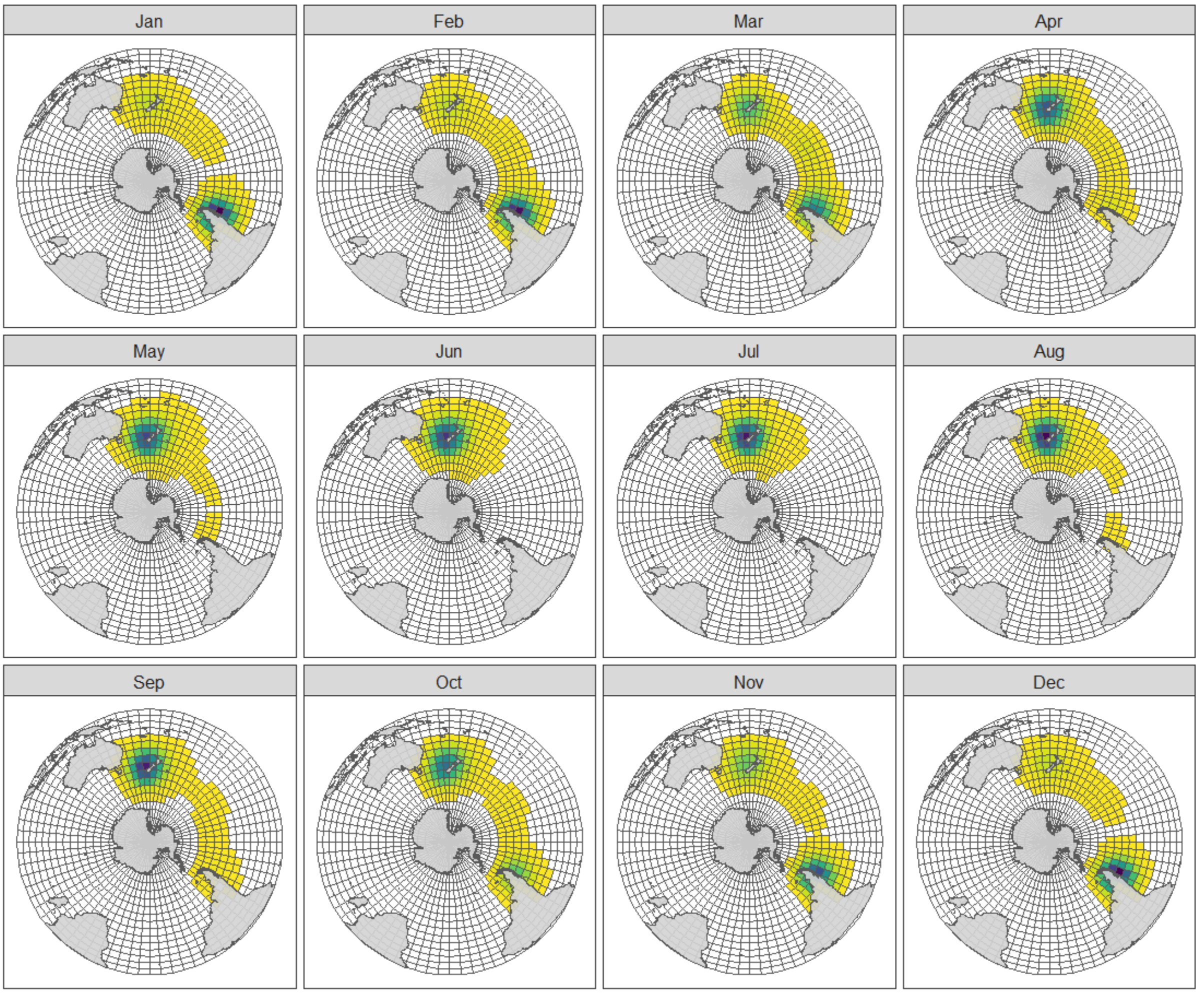

Figure 21: Westland petrel (*Procellaria westlandica*) predicted distribution by month. Yellow indicates low densities, and dark blue indicates high densities.

3.3.16 White-chinned petrel

Permission was granted to use all available tracking datasets in BirdLife International (Table 2). The external review noted that known foraging areas such as the Benguela upwelling zone were not present in the previous distributions. The current maps included an additional five datasets. Tracking data indicated movement of white-chinned petrels into this area between February and September (see Appendix P), and the predicted distributions also indicated relatively high densities here between April and August (Figure 22). However, distributions of the largest colony (South Georgia, Table 3) dominated the predicted distributions (Figure 22). The Carneiro et al. (2020) distribution maps were not used to augment the predicted distribution.

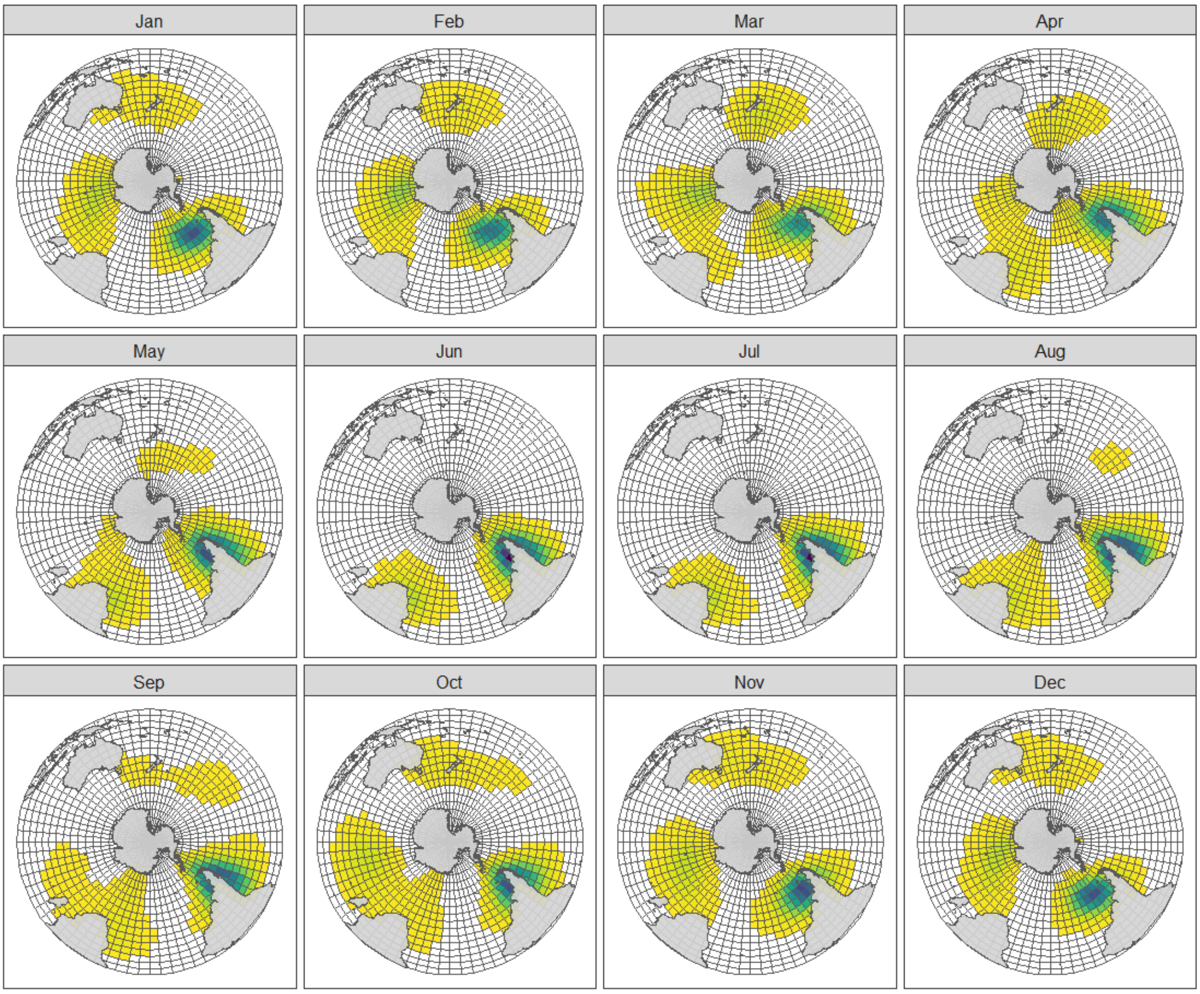

Figure 22: White-chinned petrel (*Procellaria aequinoctialis*) predicted distribution by month. Yellow indicates low densities, and dark blue indicates high densities.

4 Future wortk

Future iterations of the work presented could be improved through:

- Further inspection of older GLS tracks and potentially, where needed, reprocessing these using improved techniques (e.g., Merkel et al. 2016 A probabilistic algorithm to process geolocation data | Movement Ecology | Full Text) to reduce error. This could, for example, improve the distribution of Black Petrels and White-chinned Petrels.

- Further increase of sample sizes if and when new tracking data becomes available. This could, for example, improve the distributions of Northern and Southern Buller's Albatross. Table 3 further highlights which colonies would benefit most from future concerted tracking efforts. Wandering Albatrosses from Prince Edward Island, Atlantic Yellow-nosed Albatross from Tristan da Cunha, Grey-headed Albatross from Crozet and Kerguelen, Light-mantled Sooty Albatrosses from the Auckland Islands, Grey Petrels from Crozet, and White-chinned Petrels from Disappointment and Campbell Island appear global tracking priorities.

- Some further reprocessing of the augmentation steps using the maps from Carneiro et al. 2020 to align resolutions.

- Exploration of how tracking intensity within species, but among colonies, could be further accounted for.

5 Acknowledgements

The following list of individuals/organisations provided tracking data: Amanda Freeman, Ana Bertoldi Carneiro, Andrew Westgate, Andy Schofield, Antje Steinfurth, April Hedd, Aurore Ponchon, Azwianewi Makhado, Ben Dilley, Bindi Thomas, Chris Powell, Christina Hagen, Christopher Robertson, David Gremillet, David Nicholls, David Thompson, Dominic Rollinson, Elizabeth Bell, Ewan Wakefield, Falklands Conservation, Flavio Quintana, Graham Robertson, Henri Weimerskirch, Harry Marshall, Jacob Gonzalez-Solis, Jaime Cleeland, Javier Arata, Jean-Claude Stahl, John Arnould, Jose Pedro Granadeiro, Kalinka Rexer-Huber, Kris Carlyon, Leandro Bugoni, Leigh Torres, Lesley Thorne, Letizia Campioni, Lorna Deppe, New Zealand Department of Conservation (in particular, Kath Walker, Graeme Elliott, Graham Parker, Peter Moore, Brodie Philp, Theo Thompson, Chrissy Wickes, Jamie Darby, Mike Bell, Carlos Zavalaga, Kate Simister, Matt Charteris, Samhita Bose, Igor Debski, Graeme Taylor, Olivia Rowley, and Johannes Fischer), Paul Sagar, Paul Scofield, Paulo Catry, Peter Ryan, Pierre Pistorius, Richard Phillips, Robert Ronconi, Rosemary Gales, Ross Wanless, Scott Shaffer, Stefan Schoombie, Steffen Oppel, Susan Micol, Timothée Poupart, Todd Landers, Trevor Glass, Wildlife Management International Ltd., and William Montevecchi. The draft report was reviewed by Darren Stevens. This work was funded by Shearwater Analytics Ltd.

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Appendix A Gibson's Albatross

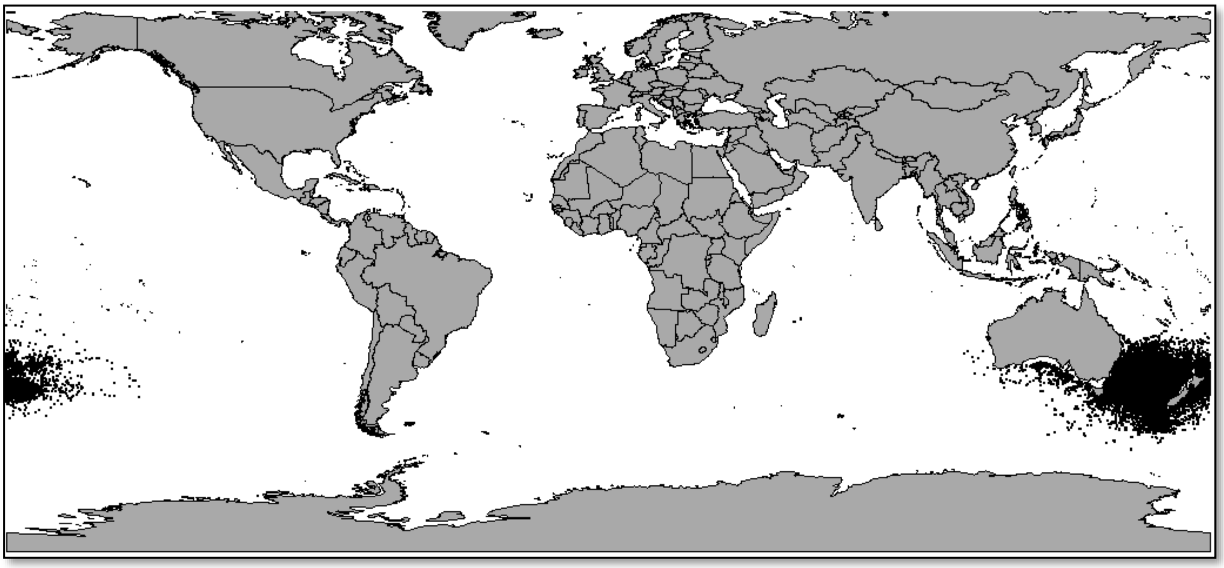


Figure A.1: Locations of ungroomed tracking data for all life stages, where different colours indicate different colonies.

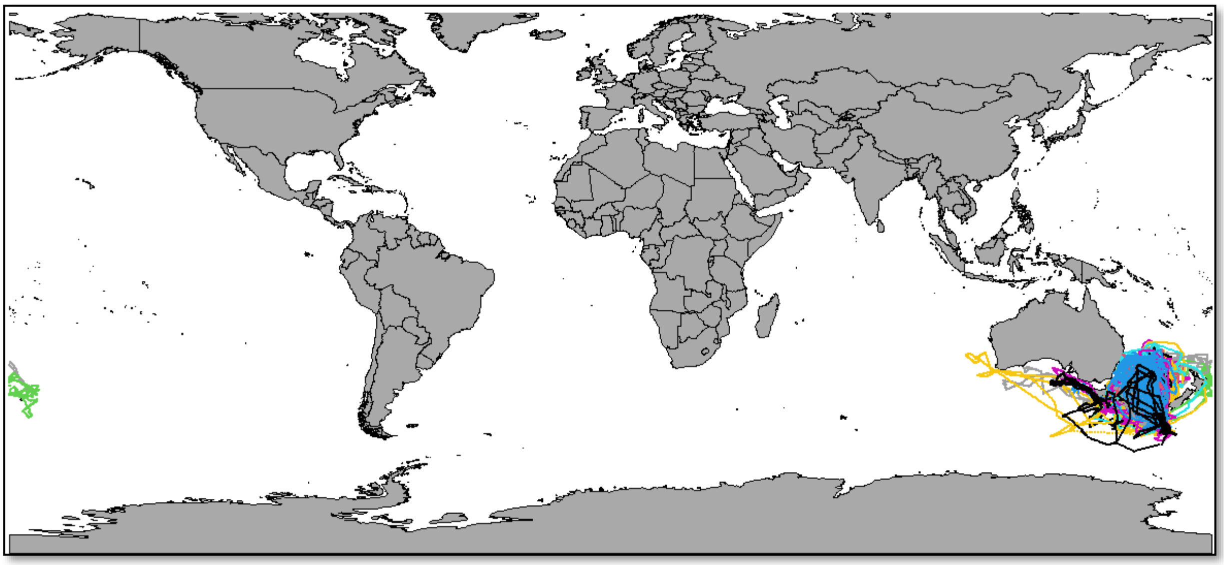


Figure A.2: Groomed and interpolated individual tracks for adult or unknown life stages, where different colours indicate different bird identifiers (noting that colours will repeat).

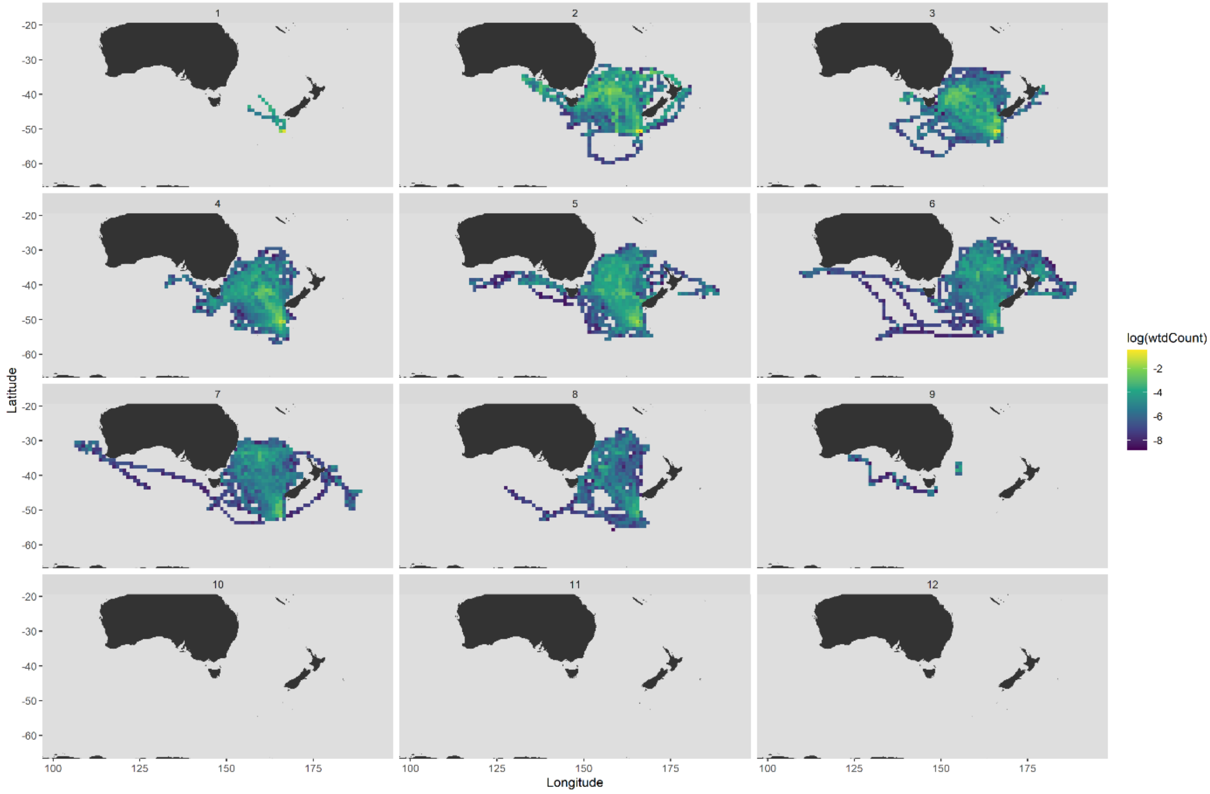
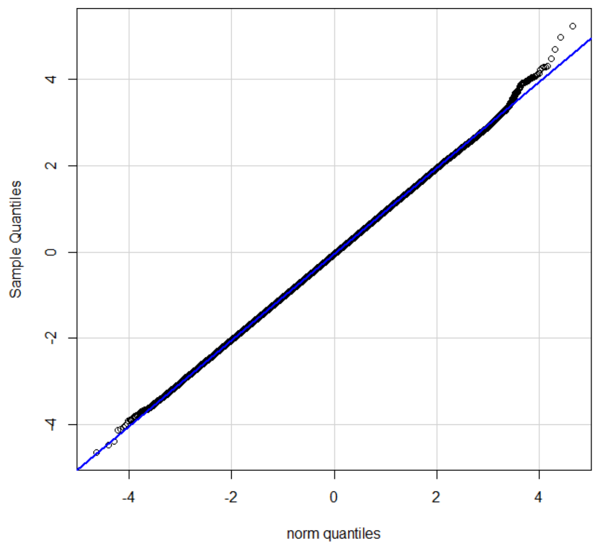


Figure A.3: Log relative density by month, aggregated by 1 ° lat-lon grid cell. Data were not weighted by mean colony size because only one colony was present.



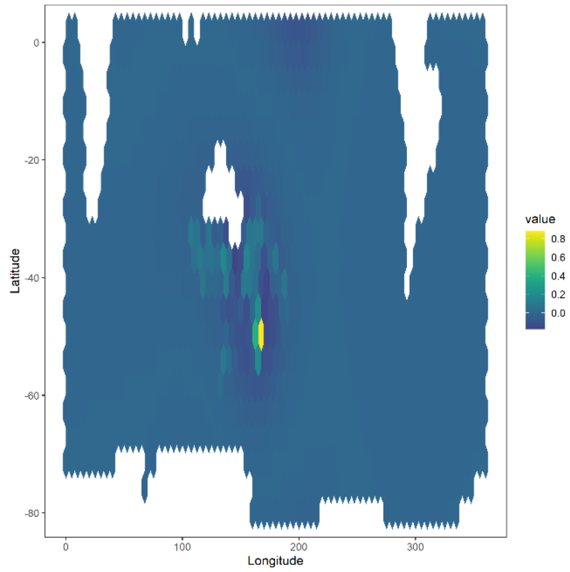


Figure A.4: Model diagnostic plots: residual QQ plot (left) and mean residual pattern by hexagonal grid cell (right).

Appendix B Wandering albatross

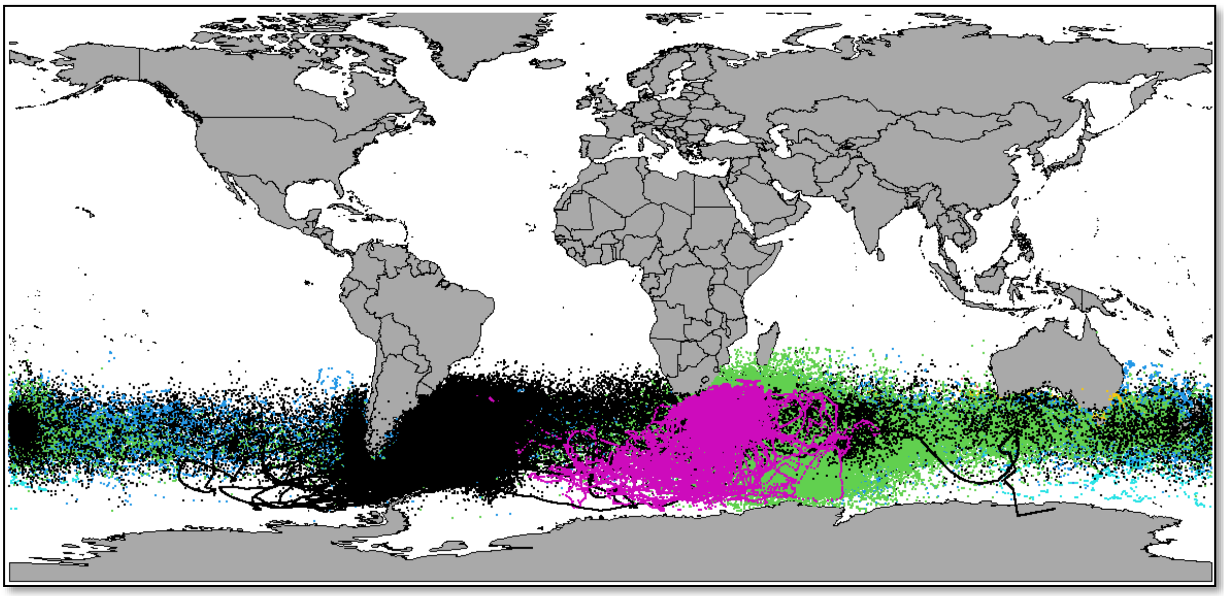


Figure B.5: Locations of ungroomed tracking data for all life stages, where different colours indicate different colonies.

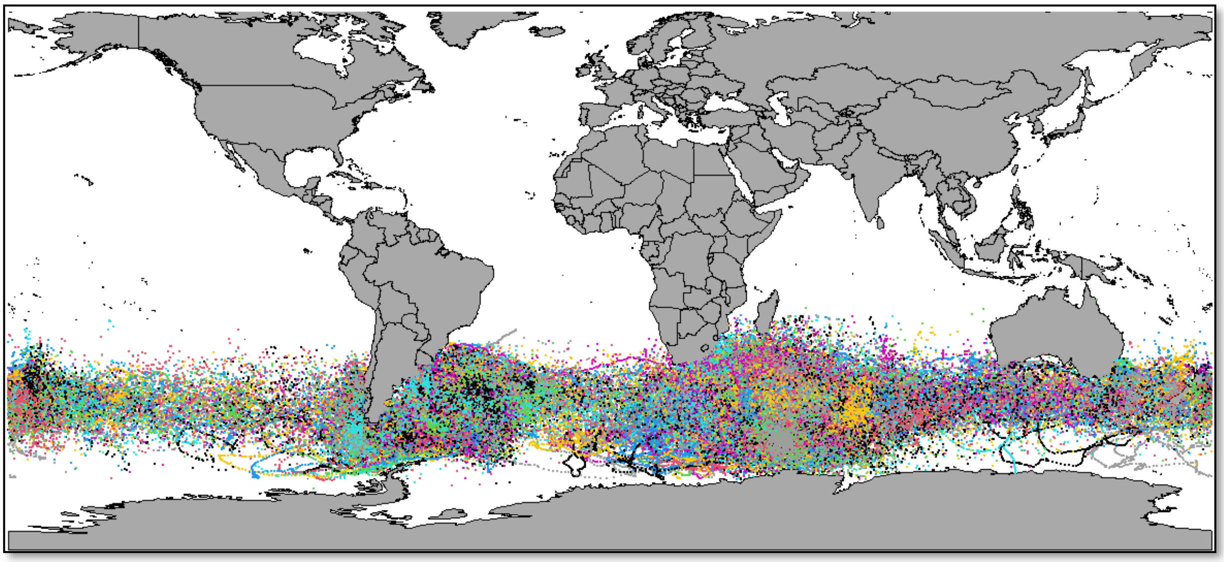


Figure B.6: Groomed and interpolated individual tracks for adult or unknown life stages, where different colours indicate different bird identifiers (noting that colours will repeat).

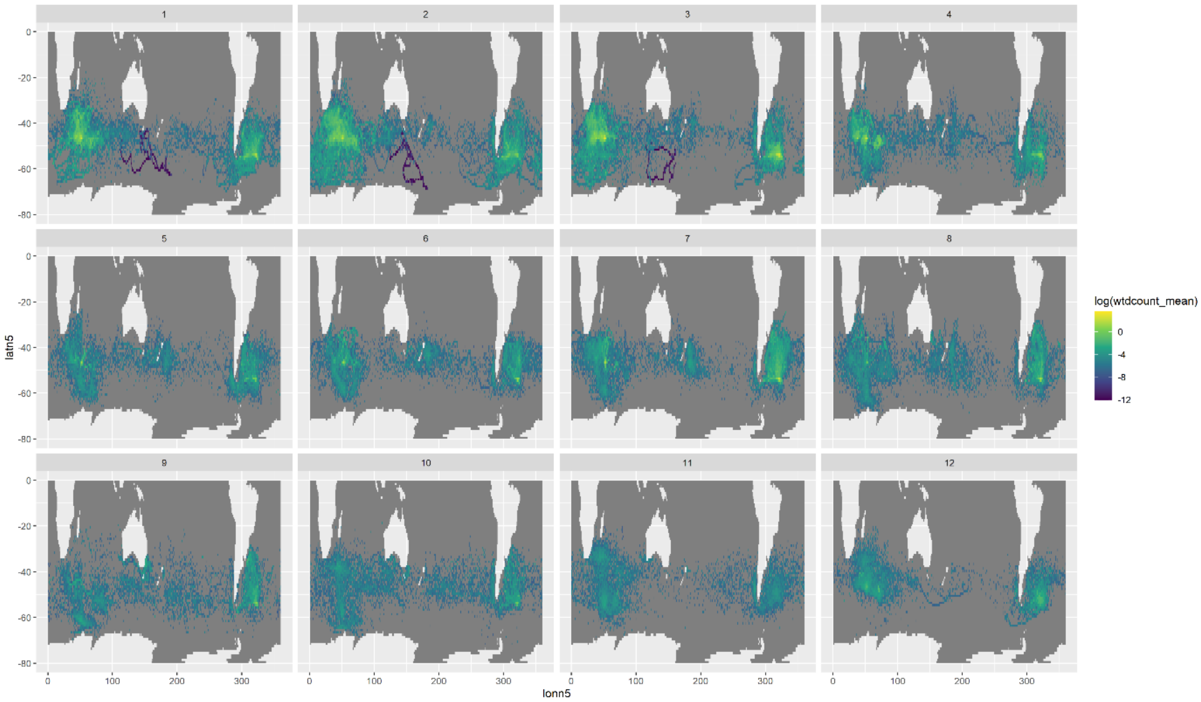


Figure B.7: Log mean weighted relative density by month, aggregated by 1 ° lat-lon grid cell.

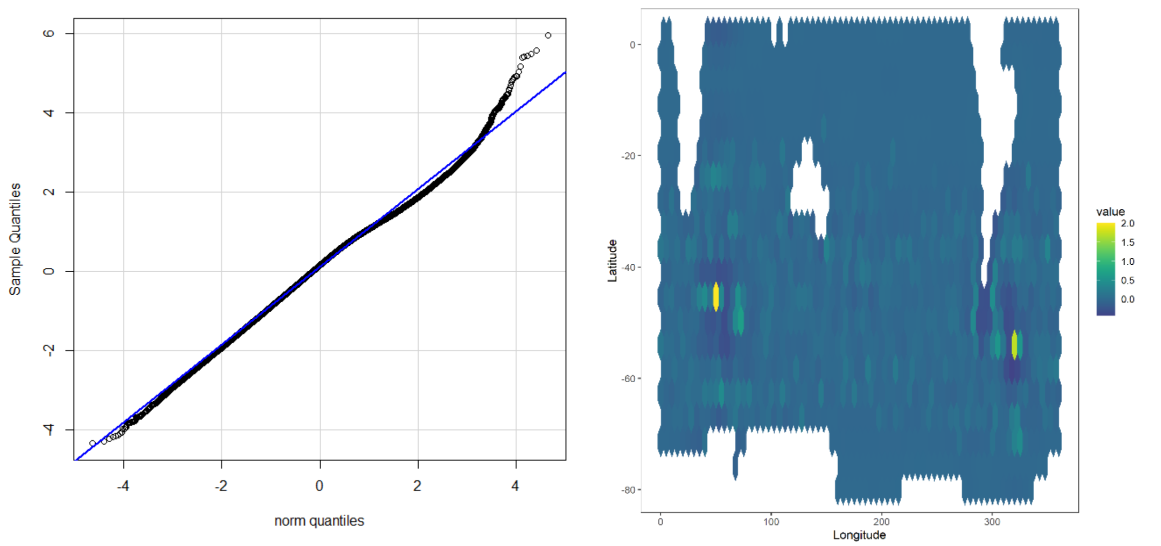


Figure B.8: Model diagnostic plots: residual QQ plot (left) and mean residual pattern by hexagonal grid cell (right).

Appendix C Southern royal albatross

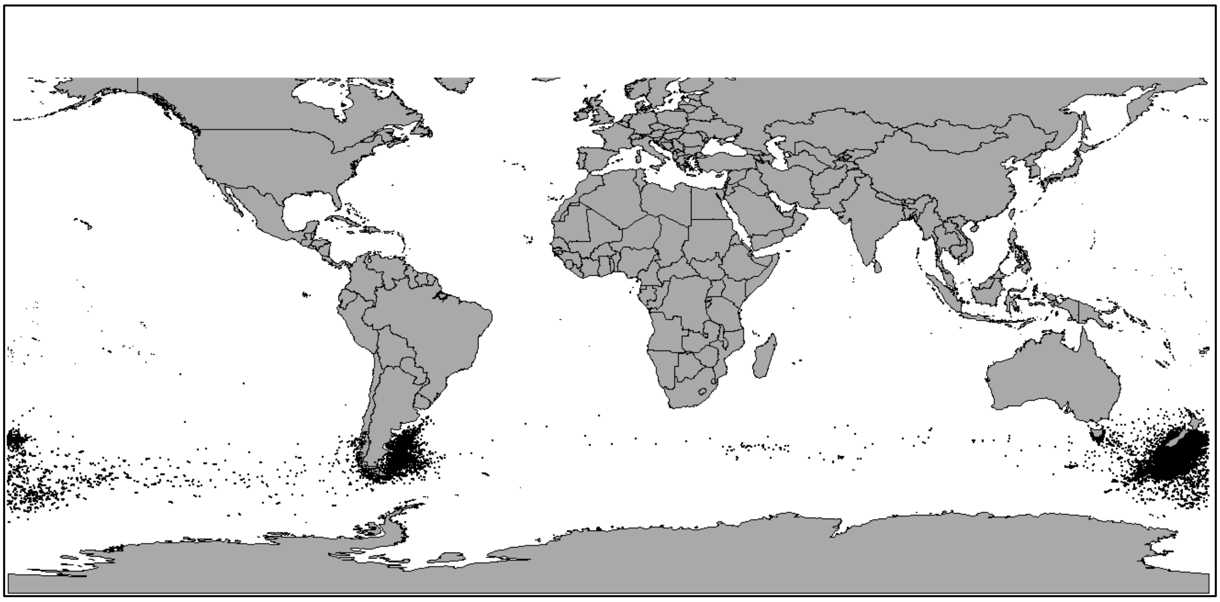


Figure C.9: Locations of ungroomed tracking data for all life stages, where different colours indicate different colonies.

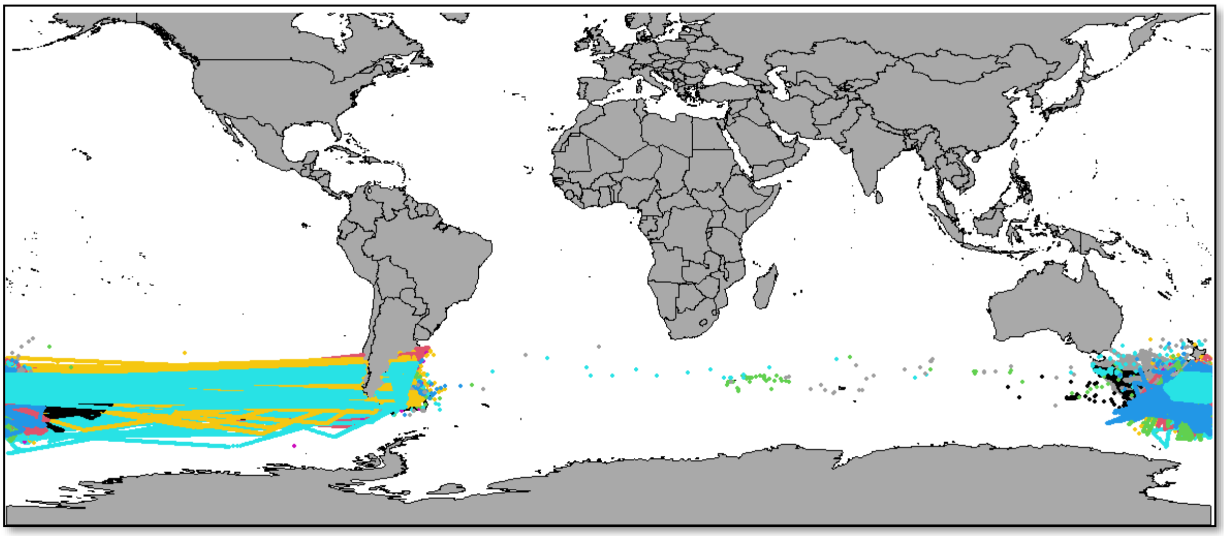


Figure C.10: Groomed and interpolated individual tracks for adult or unknown life stages, where different colours indicate different bird identifiers (noting that colours will repeat).

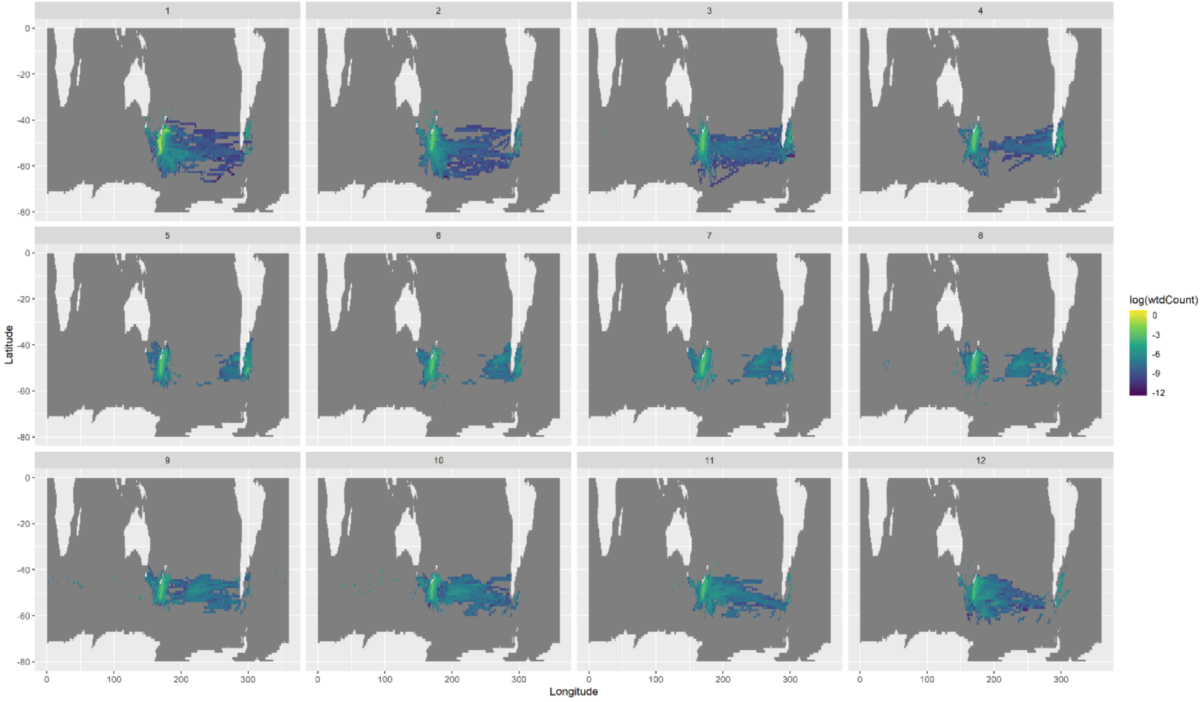


Figure C.11: Log relative density by month, aggregated by 1 ° lat-lon grid cell. Data were not weighted by mean colony size because only one colony was present.

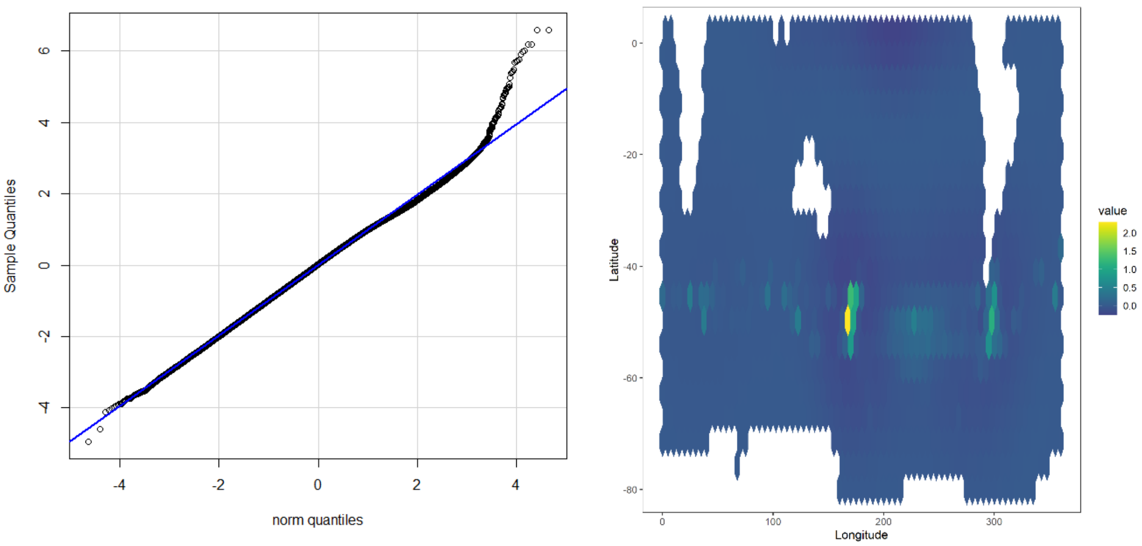


Figure C.12: Model diagnostic plots: residual QQ plot (left) and mean residual pattern by hexagonal grid cell (right).

Appendix D Atlantic yellow-nosed albatross

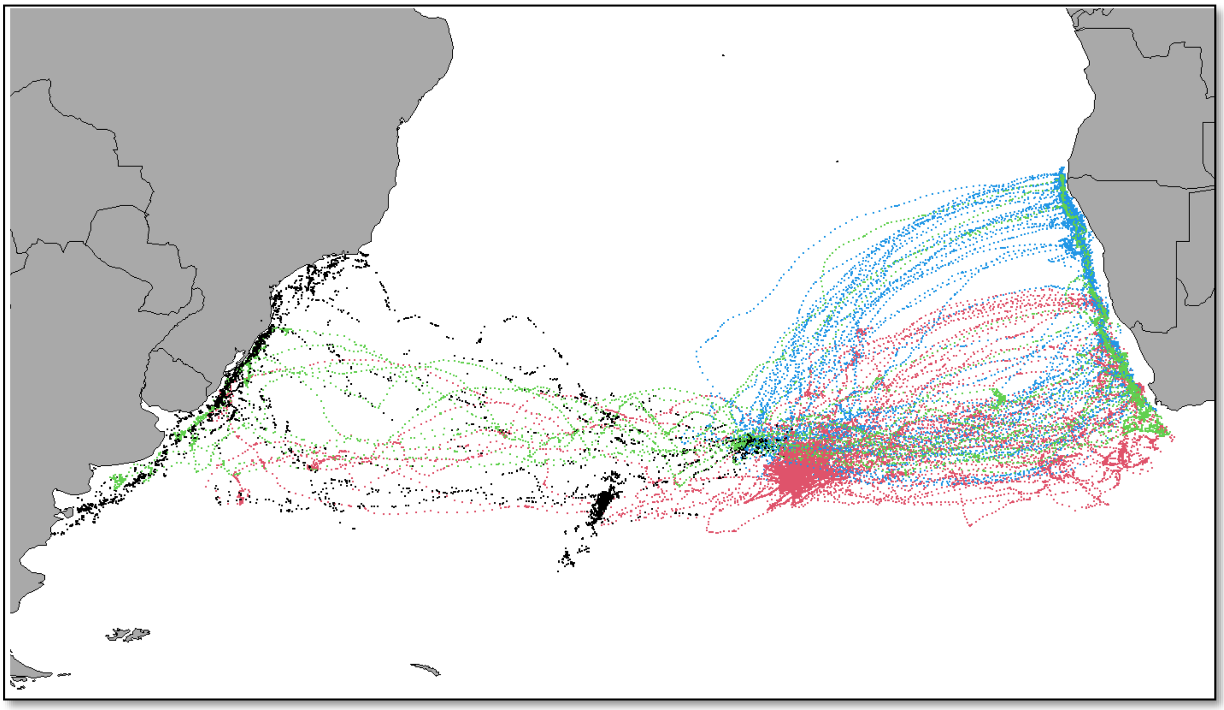


Figure D.13: Locations of ungroomed tracking data for all life stages, where different colours indicate different colonies.

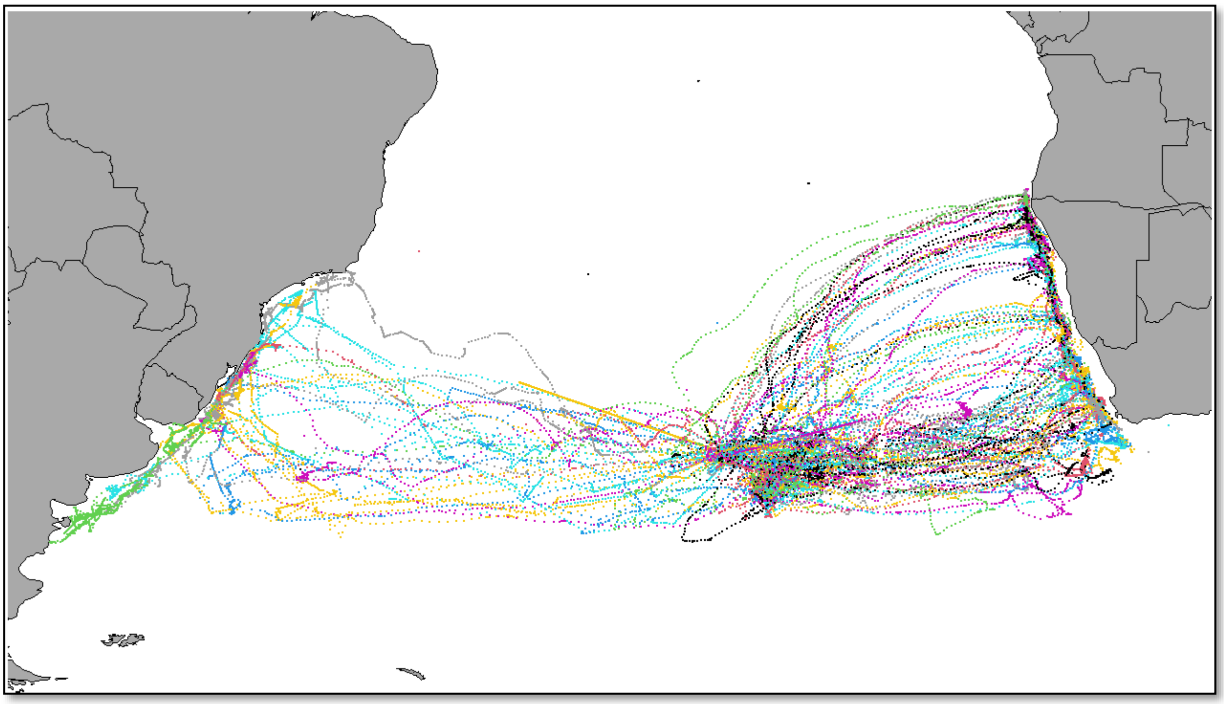


Figure D.14: Groomed and interpolated individual tracks for adult or unknown life stages, where different colours indicate different bird identifiers (noting that colours will repeat).

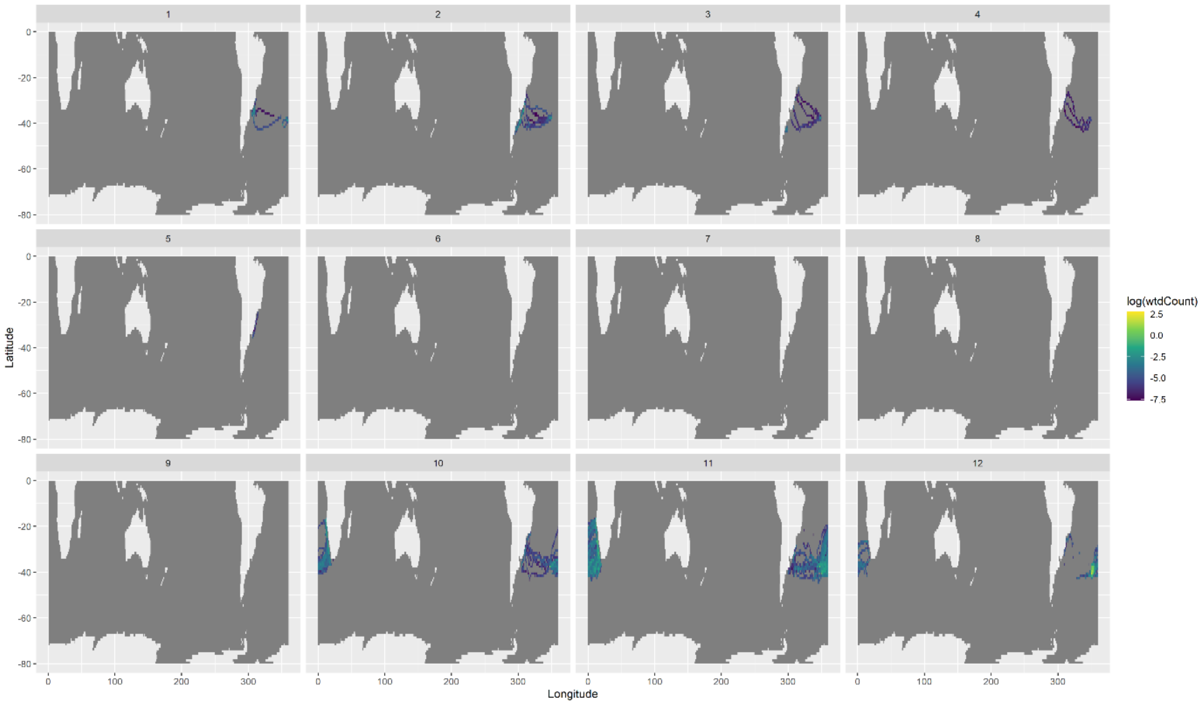


Figure D.15: Log mean weighted relative density by month, aggregated by 1 ° lat-lon grid cell.

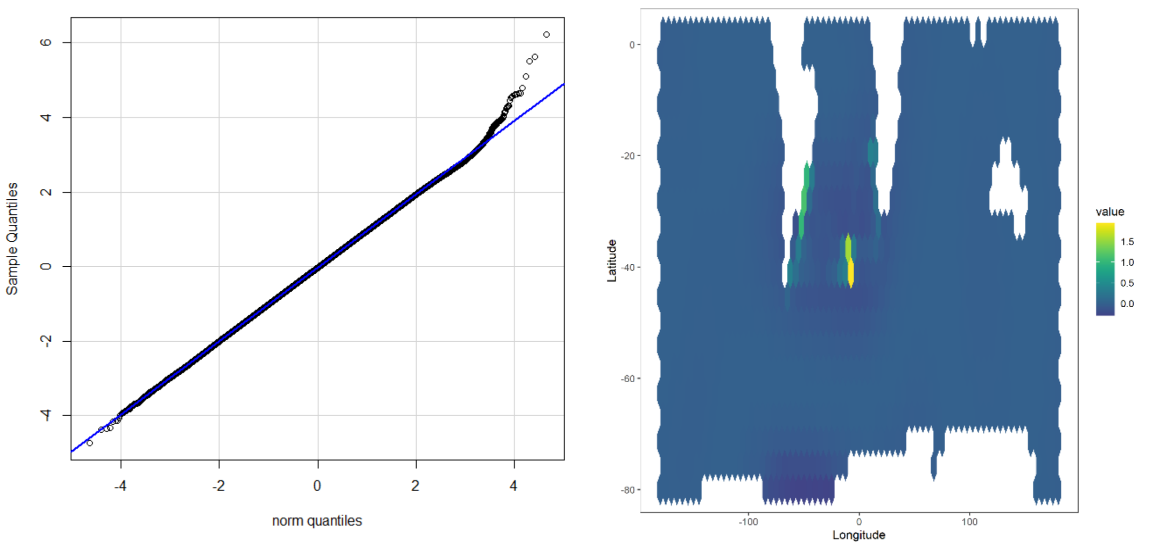


Figure D.16: Model diagnostic plots: residual QQ plot (left) and mean residual pattern by hexagonal grid cell (right).

Appendix E Black-browed albatross

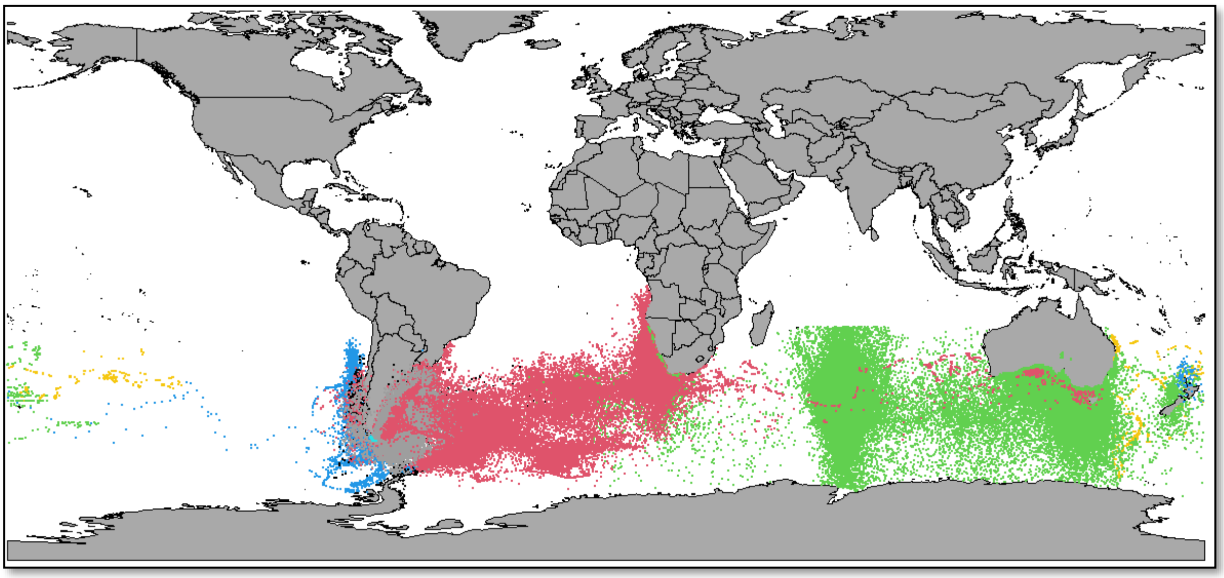


Figure E.17: Locations of ungroomed tracking data for all life stages, where different colours indicate different colonies.

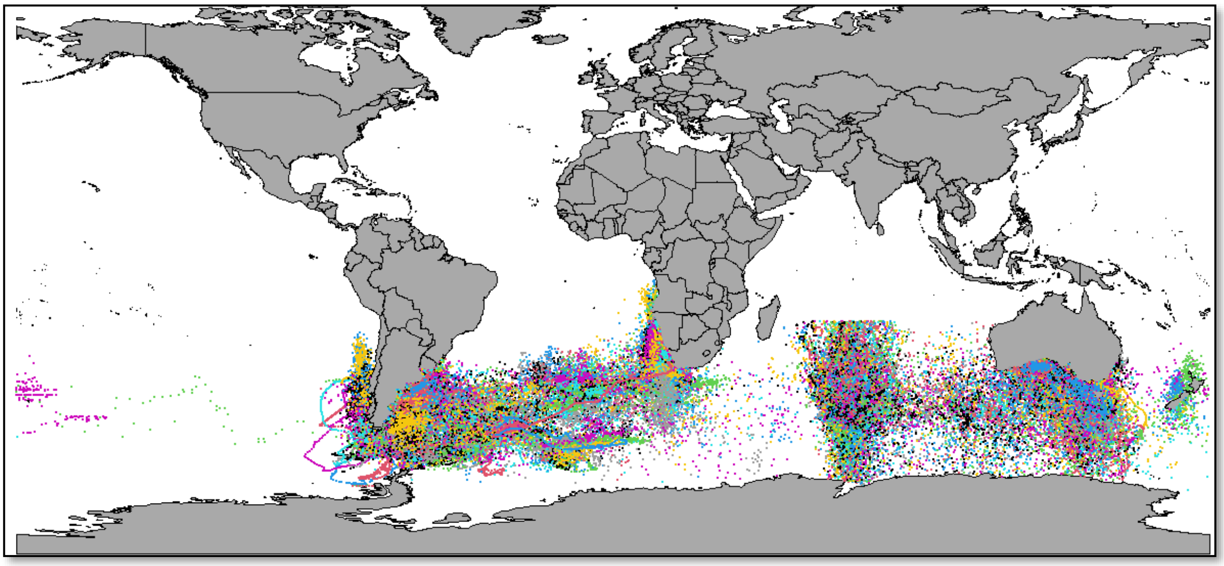


Figure E.18: Groomed and interpolated individual tracks for adult or unknown life stages, where different colours indicate different bird identifiers (noting that colours will repeat).

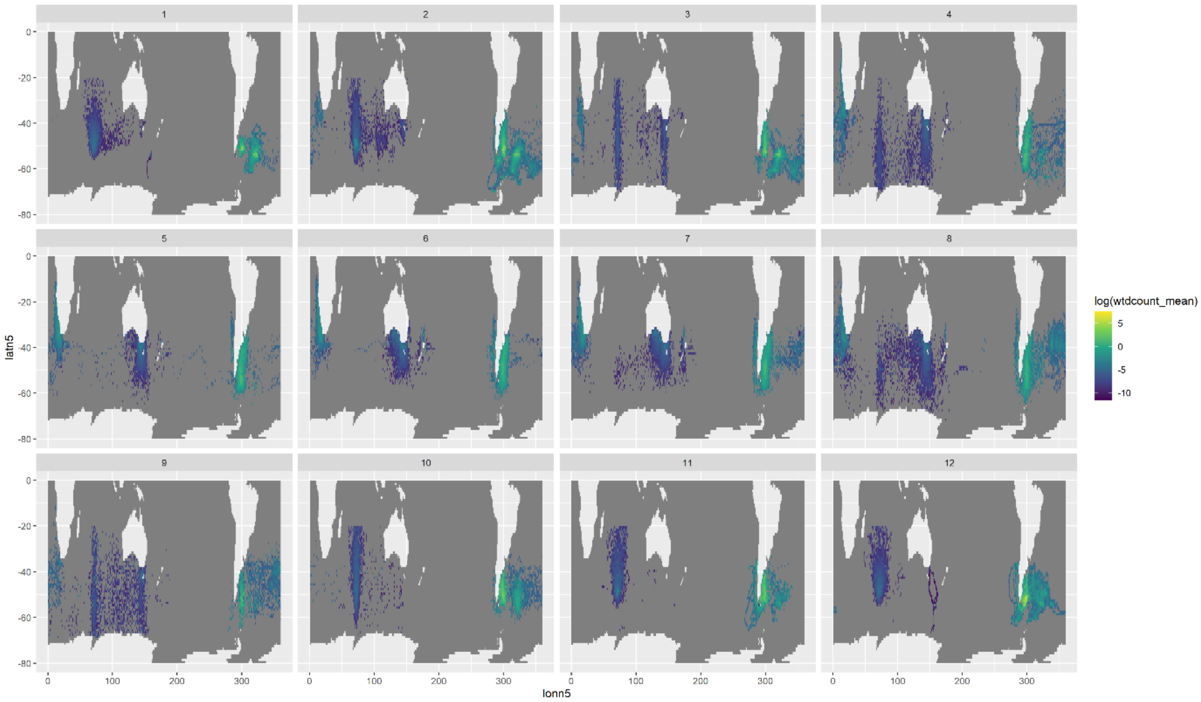


Figure E.19: Log mean weighted relative density by month, aggregated by 1 ° lat-lon grid cell.

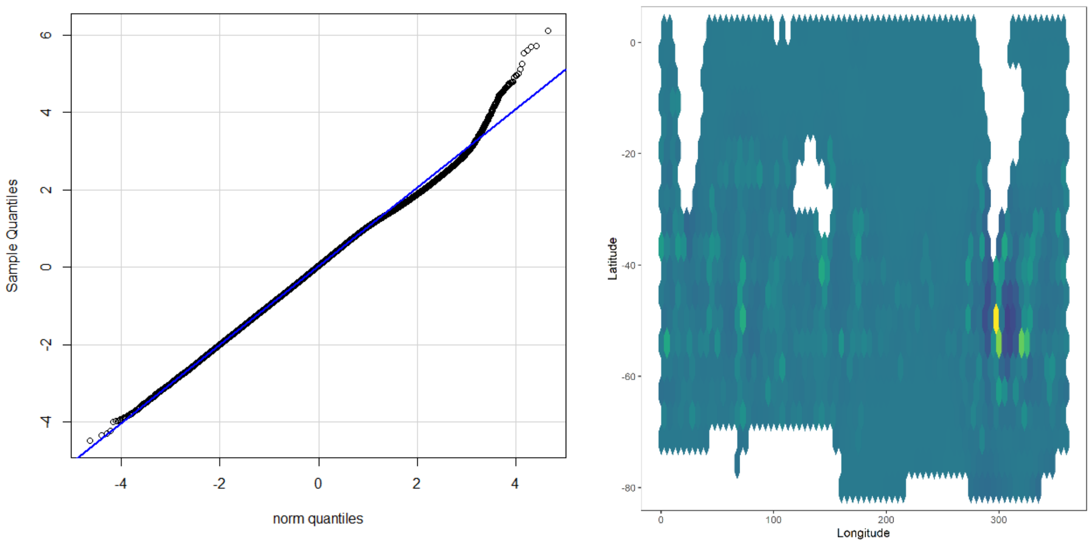


Figure E.20: Model diagnostic plots: residual QQ plot (left) and mean residual pattern by hexagonal grid cell (right).

Appendix F Campbell black-browed albatross

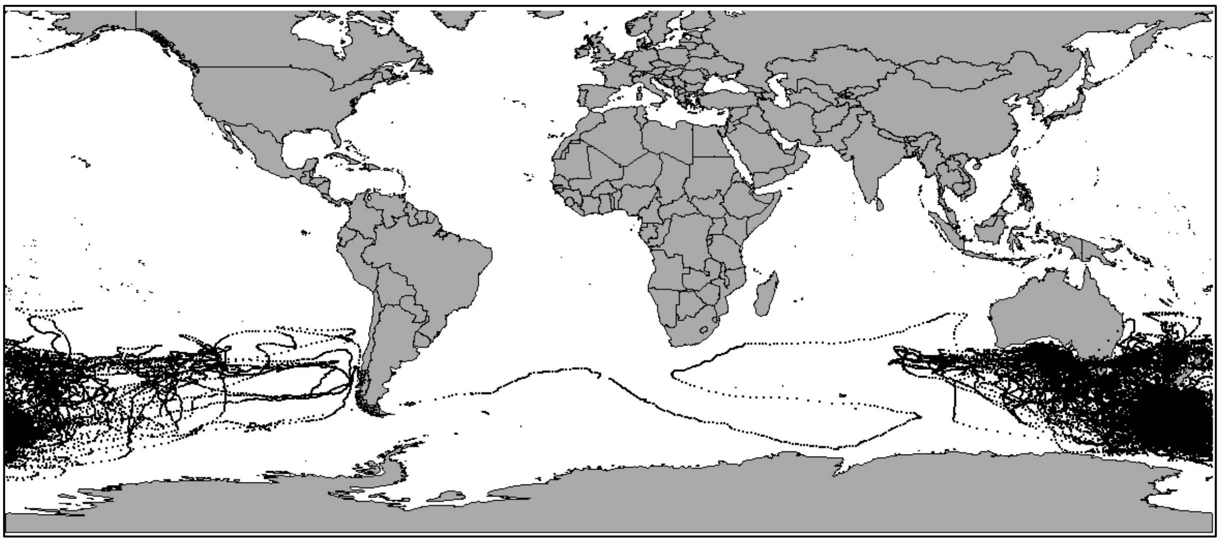


Figure F.21: Locations of ungroomed tracking data for all life stages, where different colours indicate different colonies.

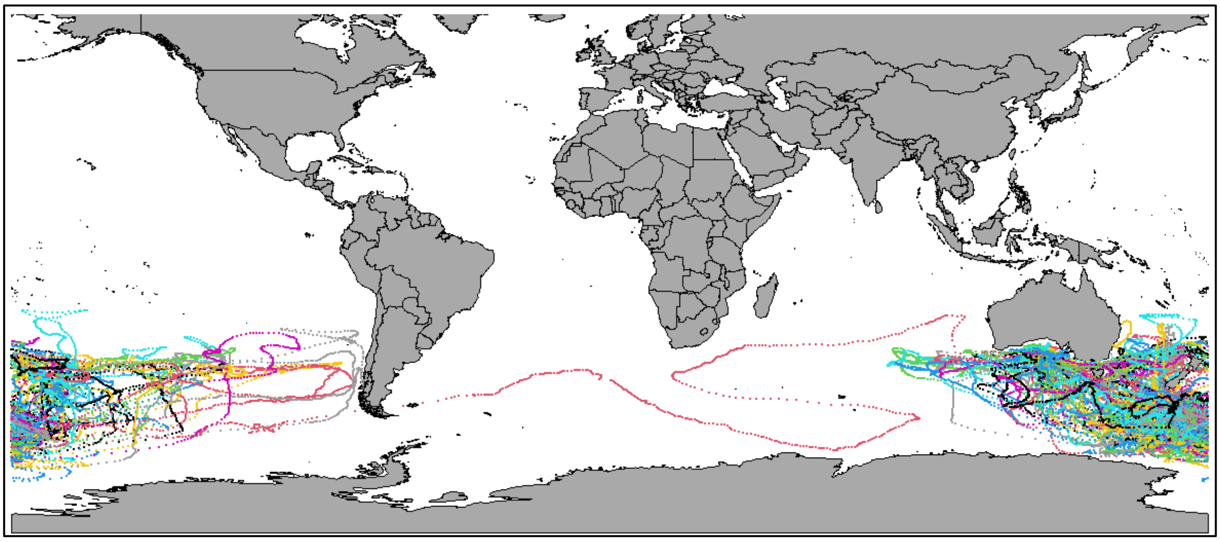


Figure F.22: Groomed and interpolated individual tracks for adult or unknown life stages, where different colours indicate different bird identifiers (noting that colours will repeat).

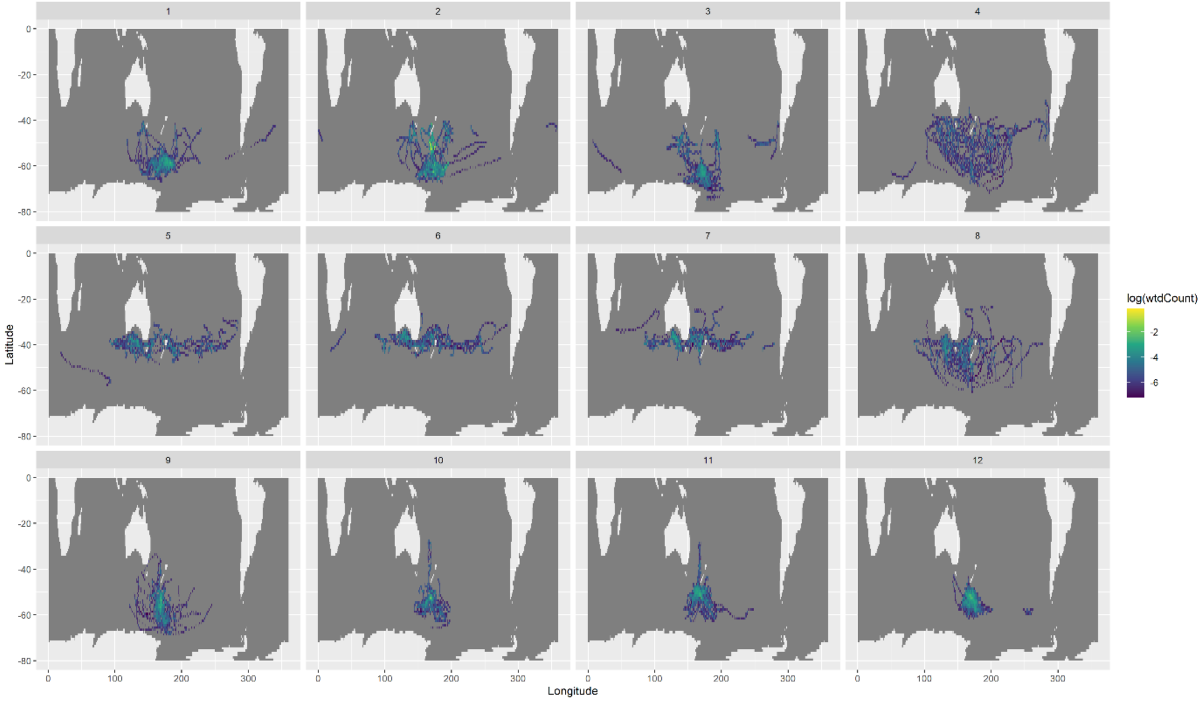


Figure F.23: Log relative density by month, aggregated by 1 ° lat-lon grid cell. Data were not weighted by mean colony size because only one colony was present.

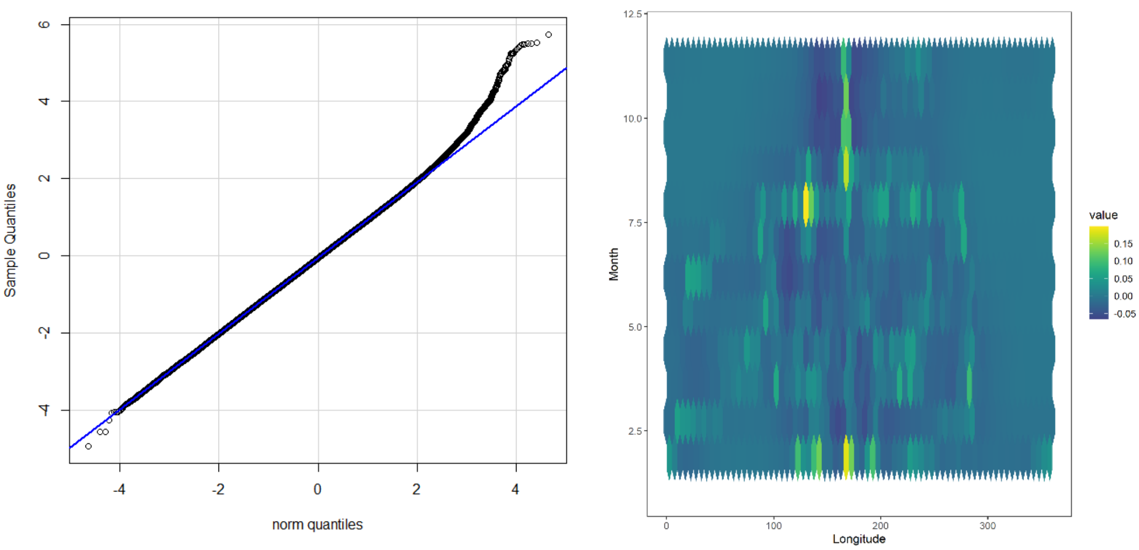


Figure F.24: Model diagnostic plots: residual QQ plot (left) and mean residual pattern by hexagonal grid cell (right).

Appendix G Shy albatross

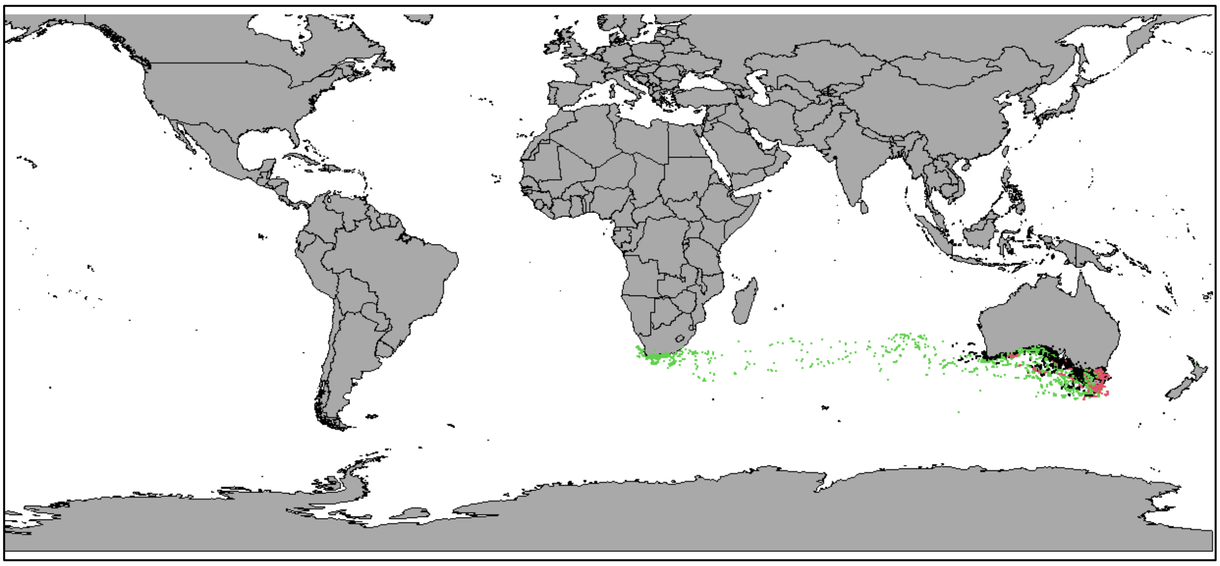


Figure G.25: Locations of ungroomed tracking data for all life stages, where different colours indicate different colonies.

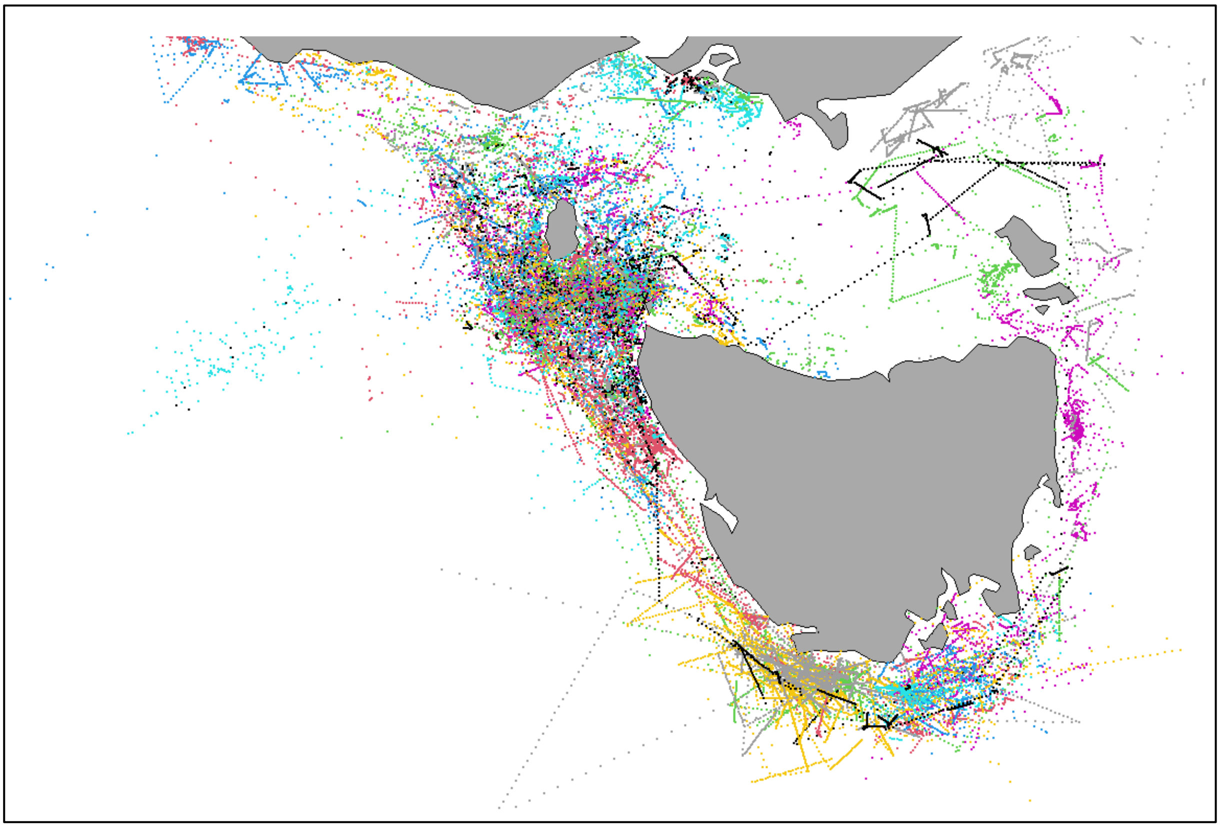


Figure G.26: Groomed and interpolated individual tracks for adult or unknown life stages, where different colours indicate different bird identifiers (noting that colours will repeat).

Figure G.27: Log mean weighted relative density by month, aggregated by 1 ° lat-lon grid cell.

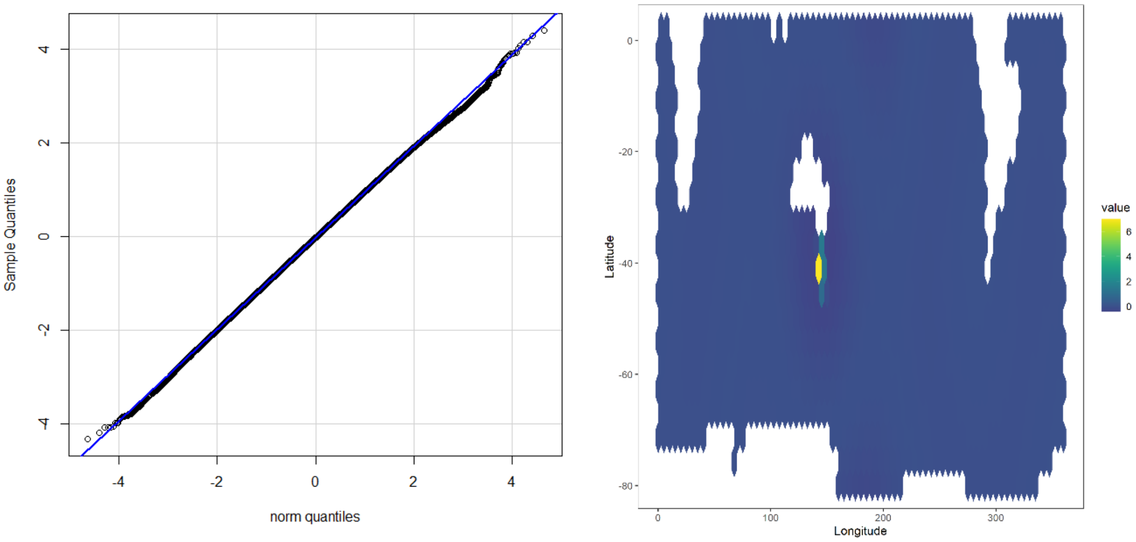


Figure G.28: Model diagnostic plots: residual QQ plot (left) and mean residual pattern by hexagonal grid cell (right).

Appendix H Grey-headed albatross

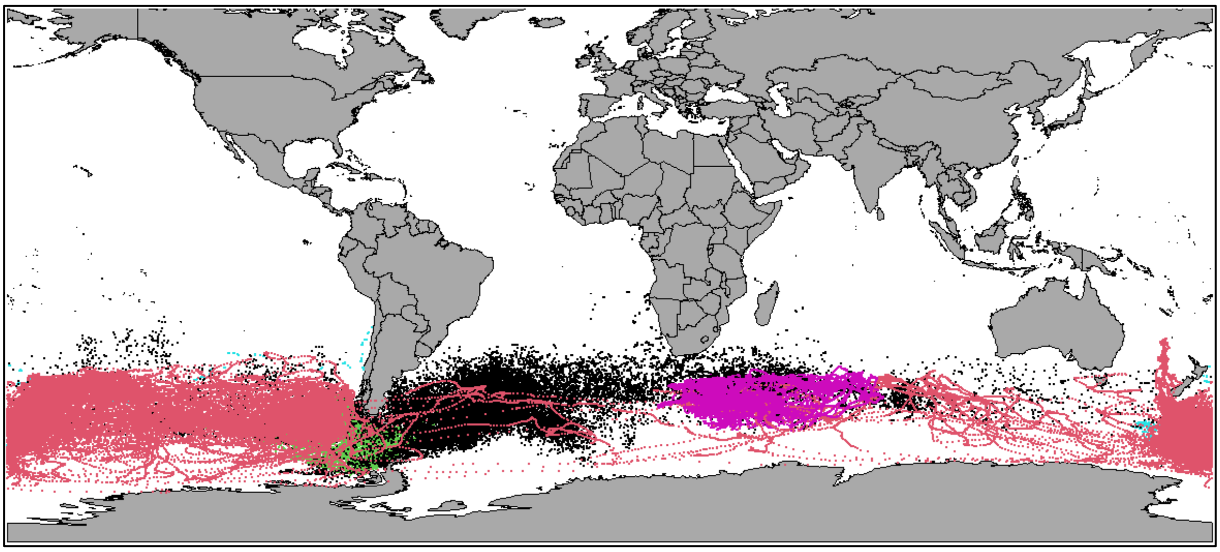


Figure H.29: Locations of ungroomed tracking data for all life stages, where different colours indicate different colonies.

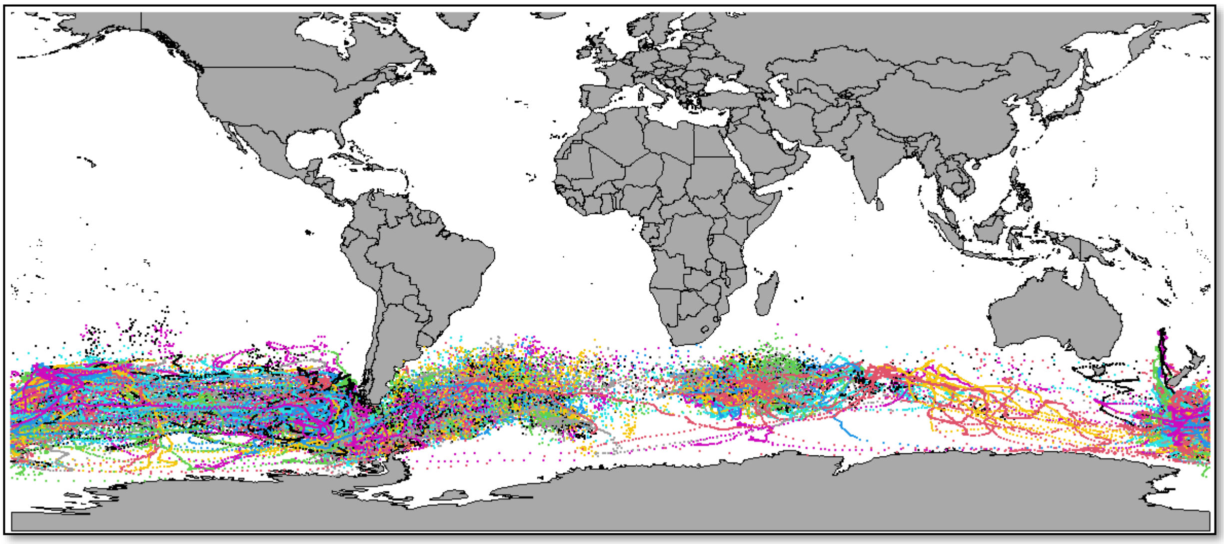


Figure H.30: Groomed and interpolated individual tracks for adult or unknown life stages, where different colours indicate different bird identifiers (noting that colours will repeat).

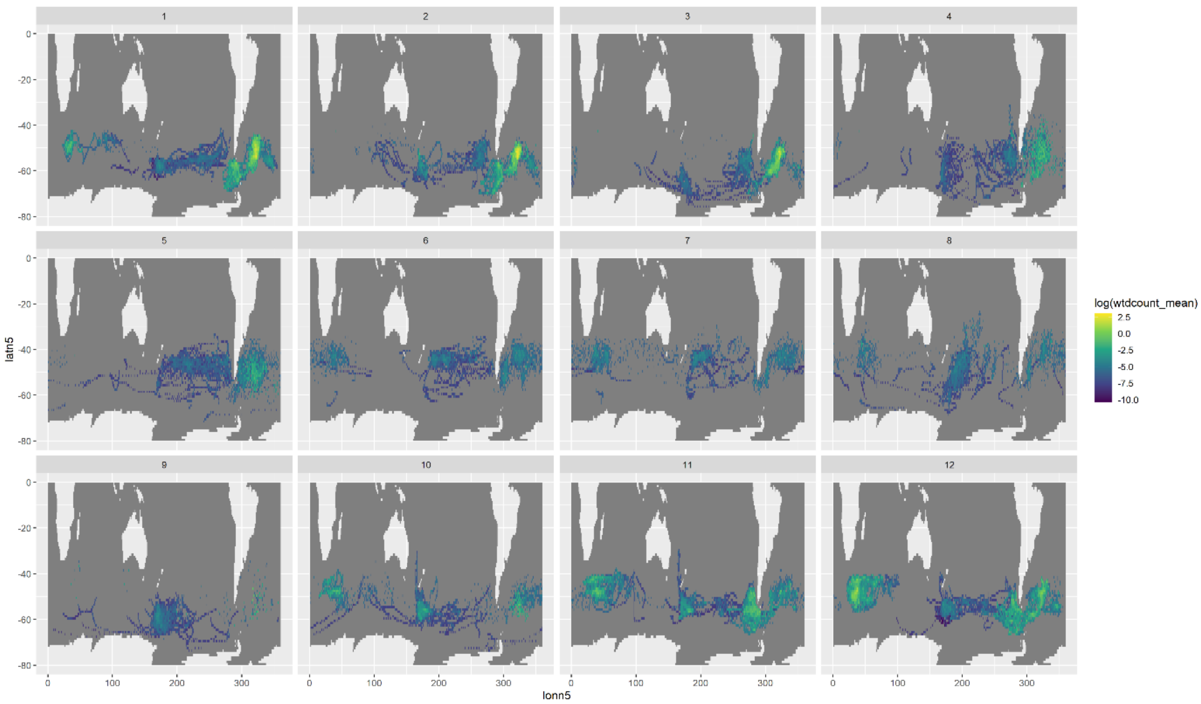


Figure H.31: Log mean weighted relative density by month, aggregated by 1 ° lat-lon grid cell.

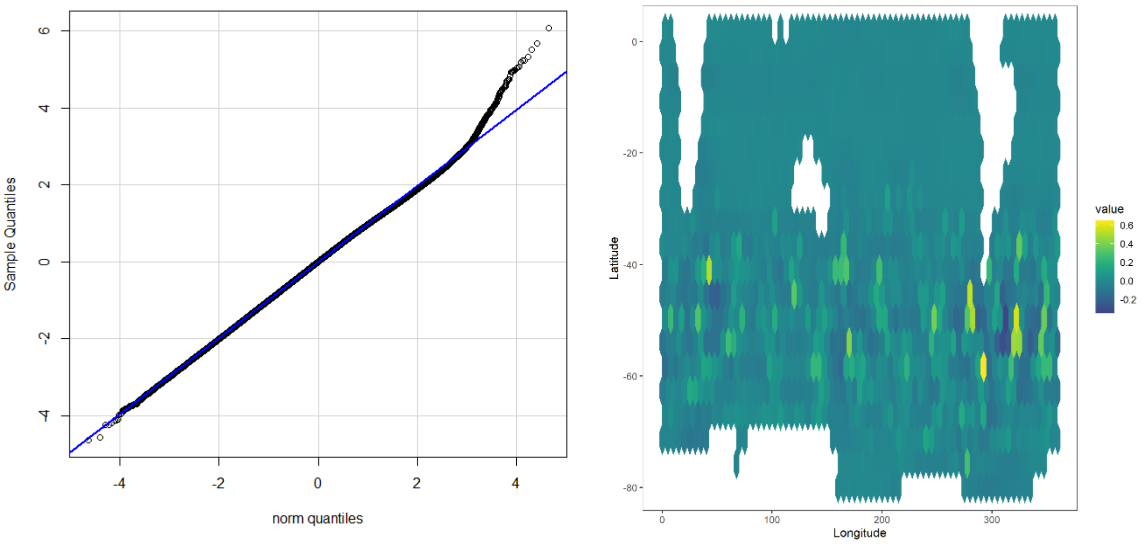


Figure H.32: Model diagnostic plots: residual QQ plot (left) and mean residual pattern by hexagonal grid cell (right).

Appendix I Southern Buller's albatross

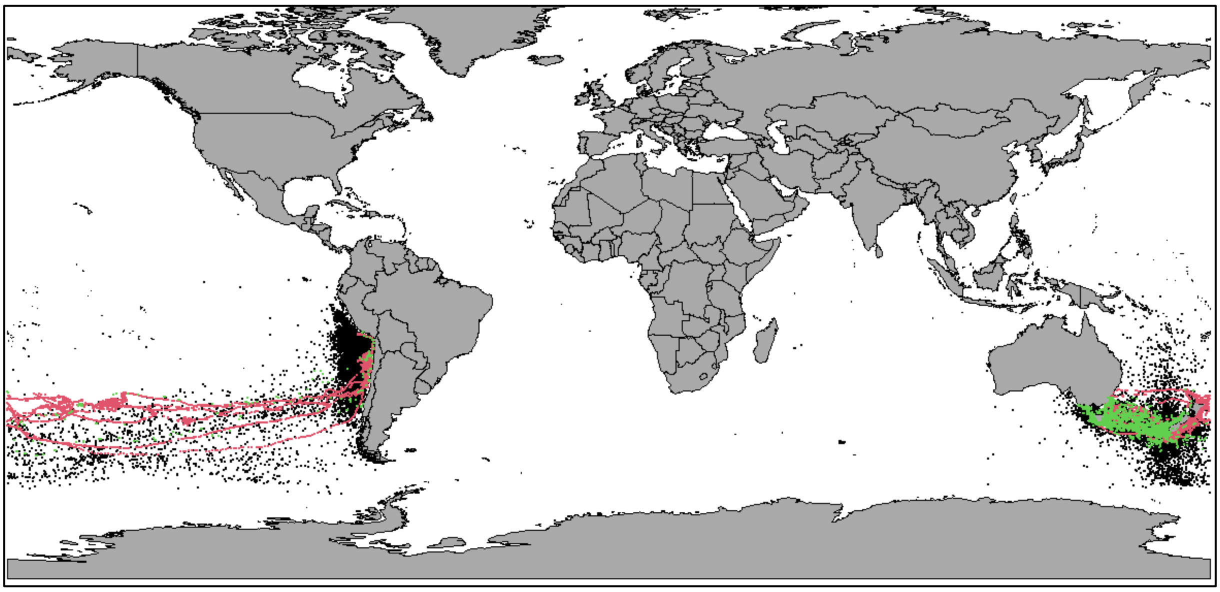


Figure I.33: Locations of ungroomed tracking data for all life stages, where different colours indicate different colonies.

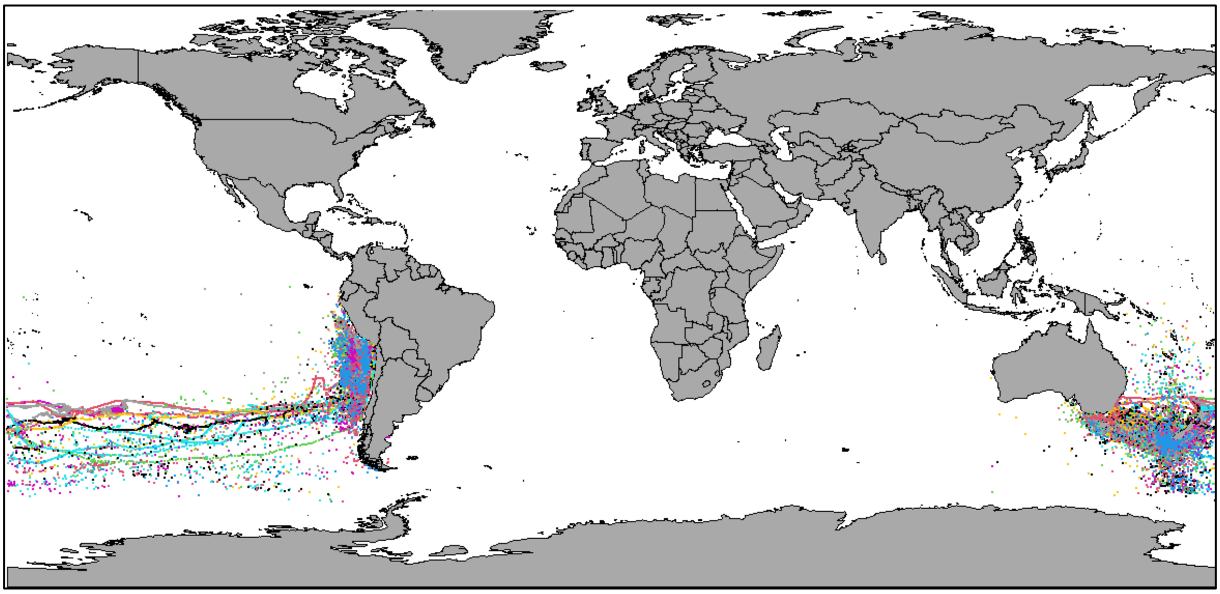


Figure I.34: Groomed and interpolated individual tracks for adult or unknown life stages, where different colours indicate different bird identifiers (noting that colours will repeat).

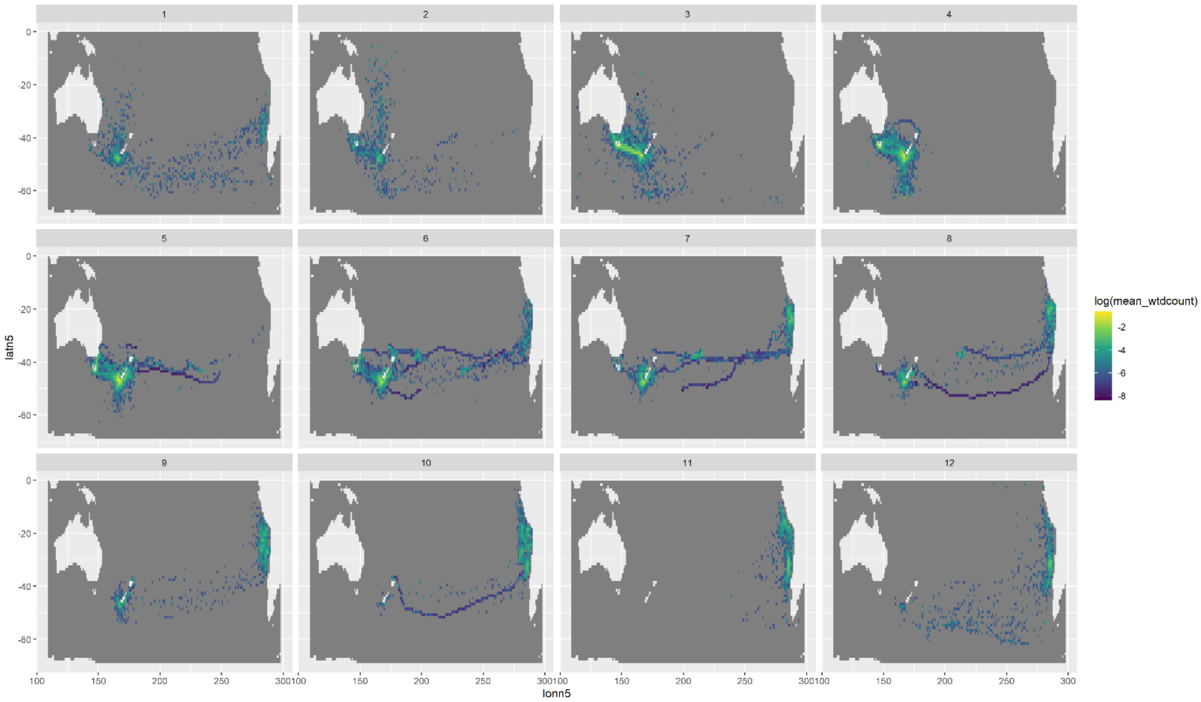


Figure I.35: Log mean weighted relative density by month, aggregated by 1 ° lat-lon grid cell.

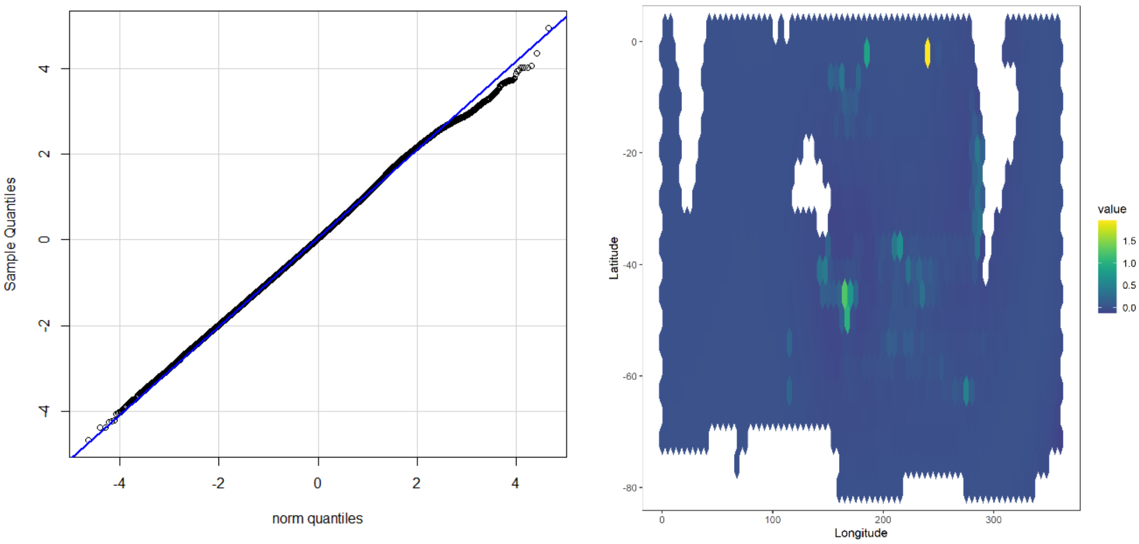


Figure I.36: Model diagnostic plots: residual QQ plot (left) and mean residual pattern by hexagonal grid cell (right).

Appendix J Northern Buller's albatross

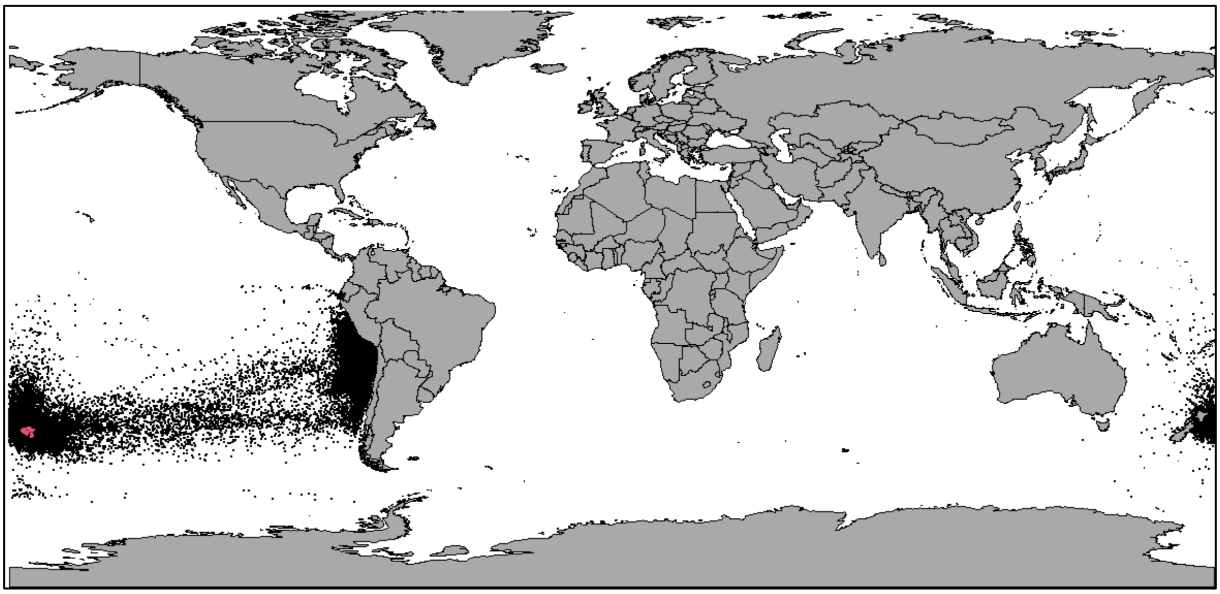


Figure J.37: Locations of ungroomed tracking data for all life stages, where different colours indicate different colonies.

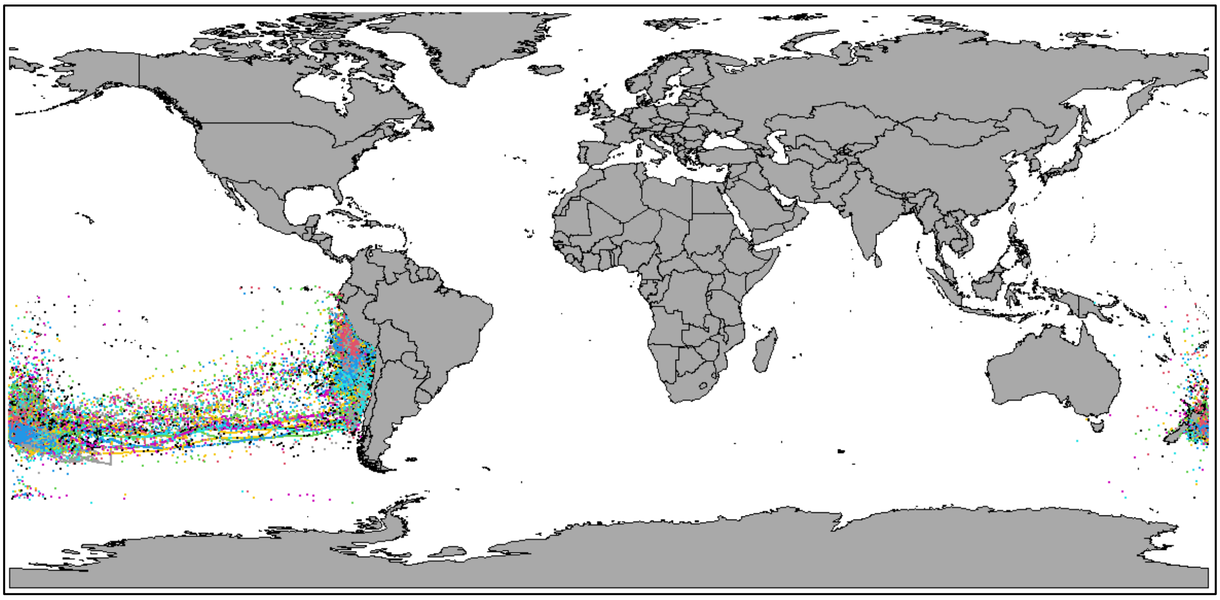


Figure J.38: Groomed and interpolated individual tracks for adult or unknown life stages, where different colours indicate different bird identifiers (noting that colours will repeat).

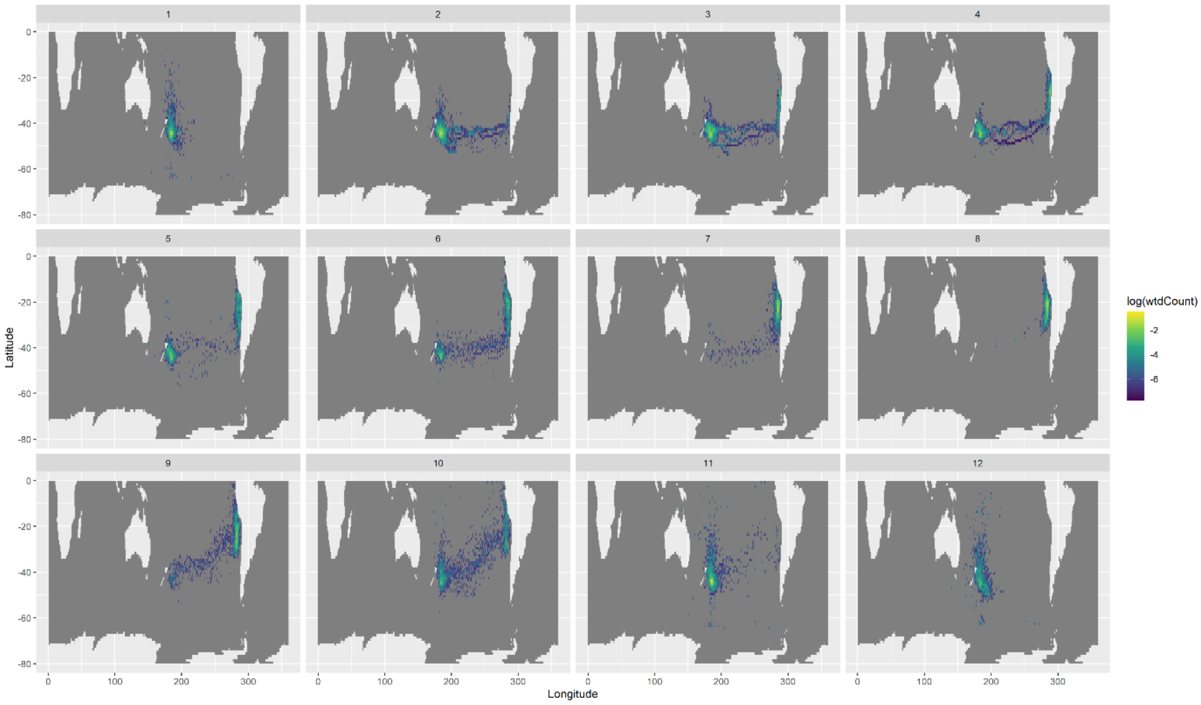


Figure J.39: Log relative density by month, aggregated by 1 ° lat-lon grid cell. Data were not weighted by mean colony size because only one colony was present.

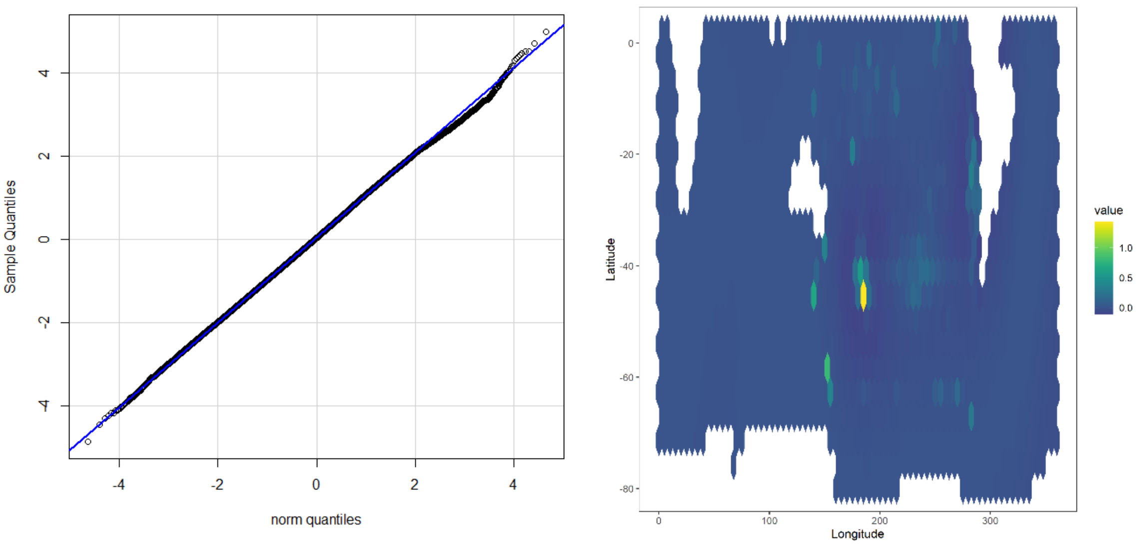


Figure J.40: Model diagnostic plots: residual QQ plot (left) and mean residual pattern by hexagonal grid cell (right).

Appendix K Sooty albatross

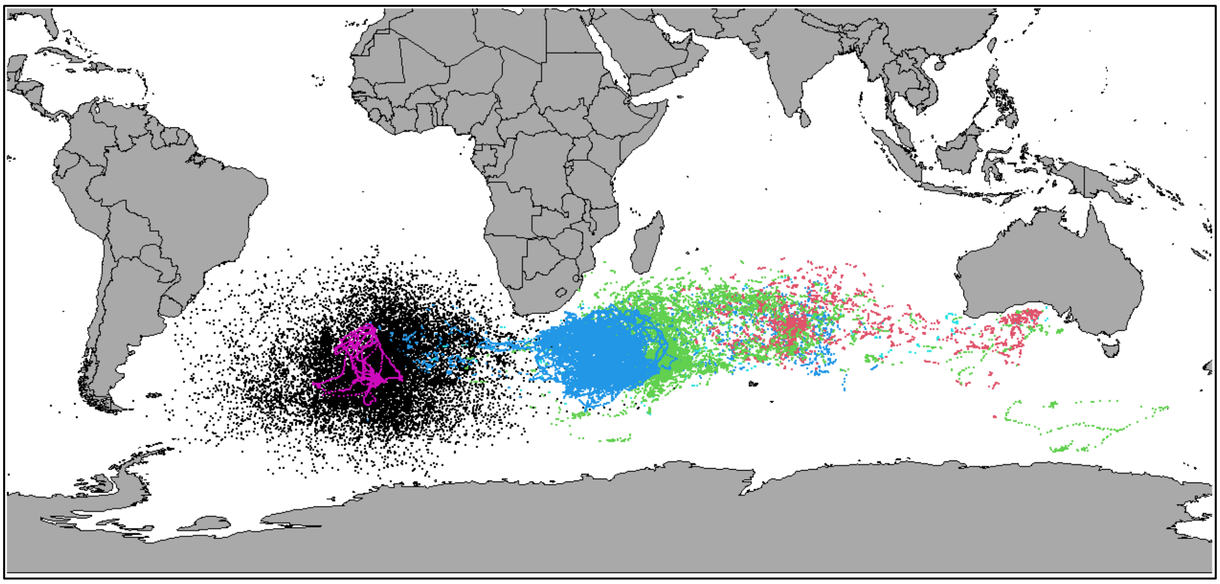


Figure K.41: Locations of ungroomed tracking data for all life stages, where different colours indicate different colonies.

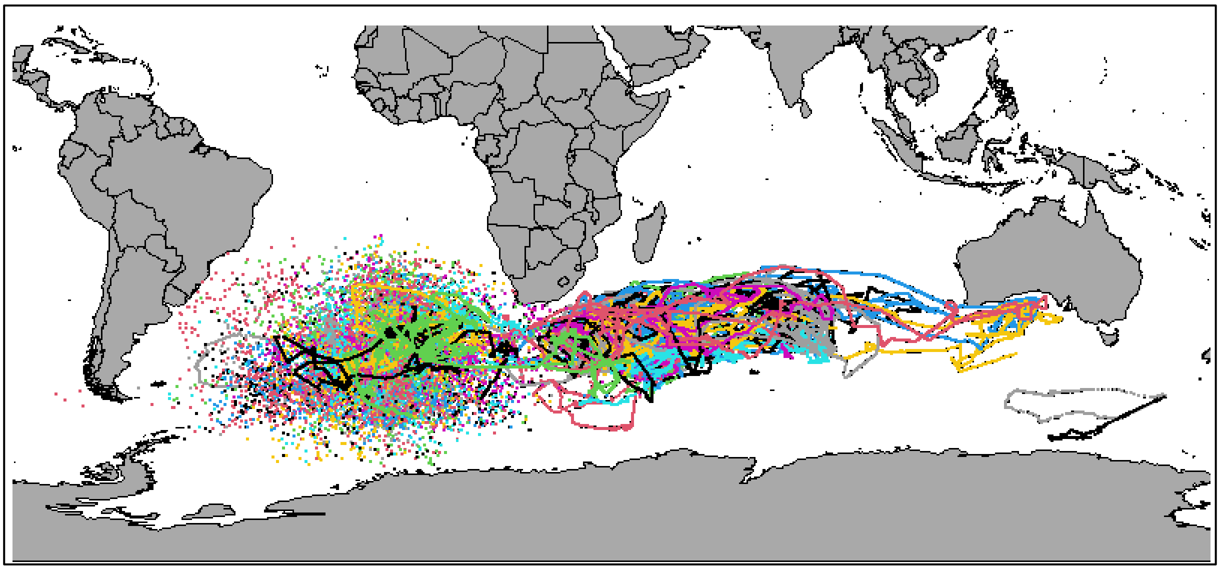


Figure K.42: Groomed and interpolated individual tracks for adult or unknown life stages, where different colours indicate different bird identifiers (noting that colours will repeat).

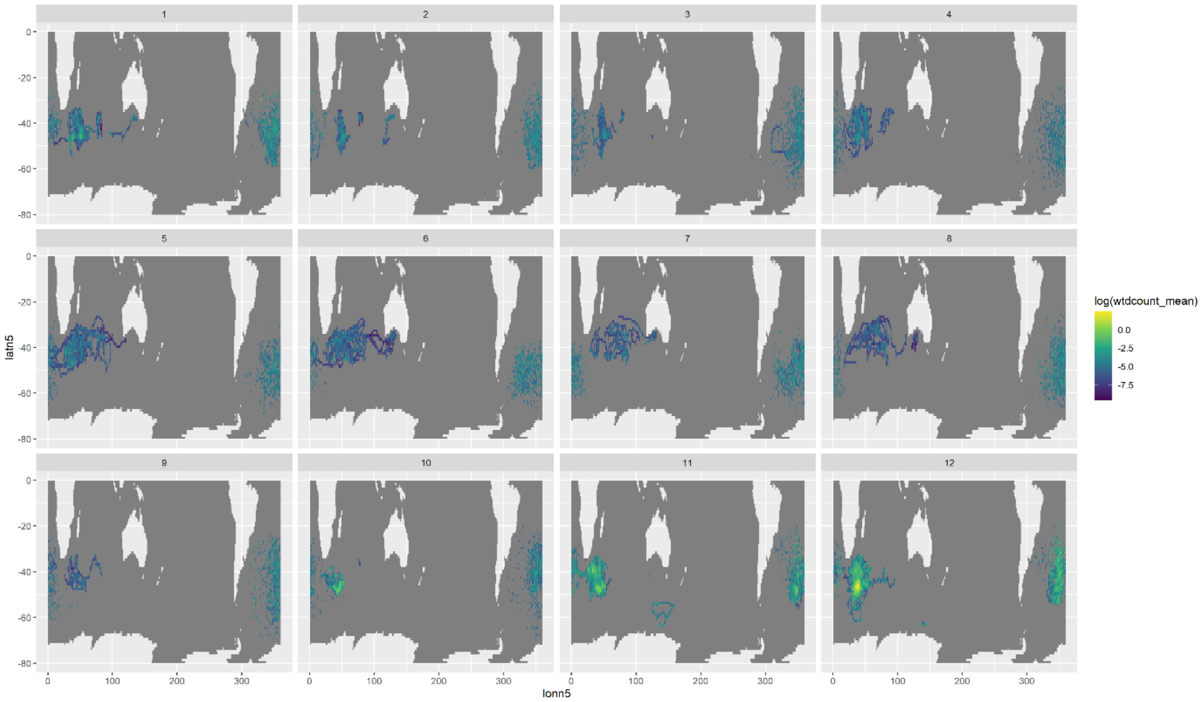


Figure K.43: Log mean weighted relative density by month, aggregated by 1 ° lat-lon grid cell.

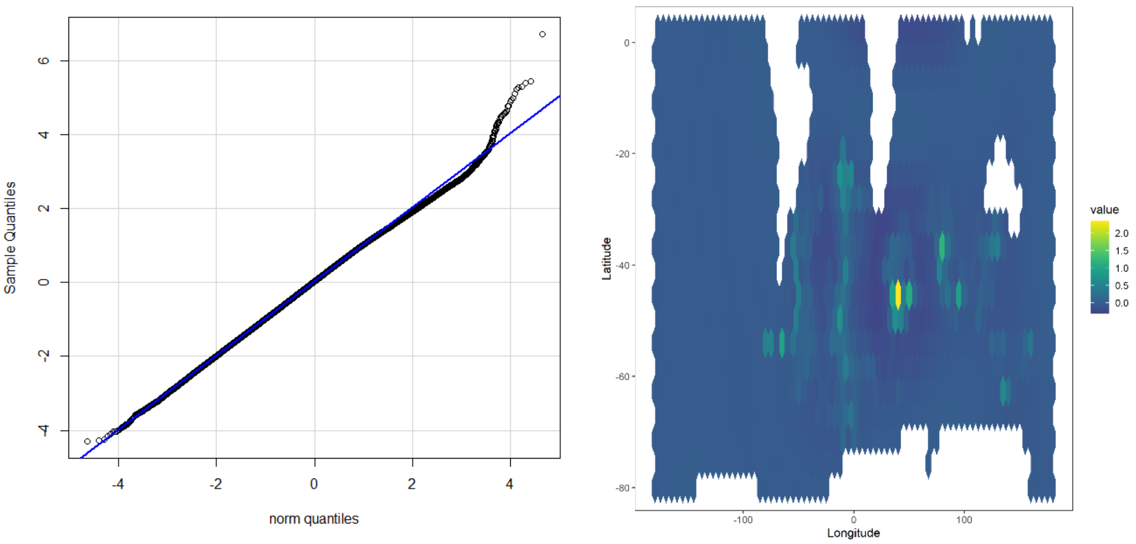


Figure K.44: Model diagnostic plots: residual QQ plot (left) and mean residual pattern by hexagonal grid cell (right).

Appendix L Light-mantled sooty albatross

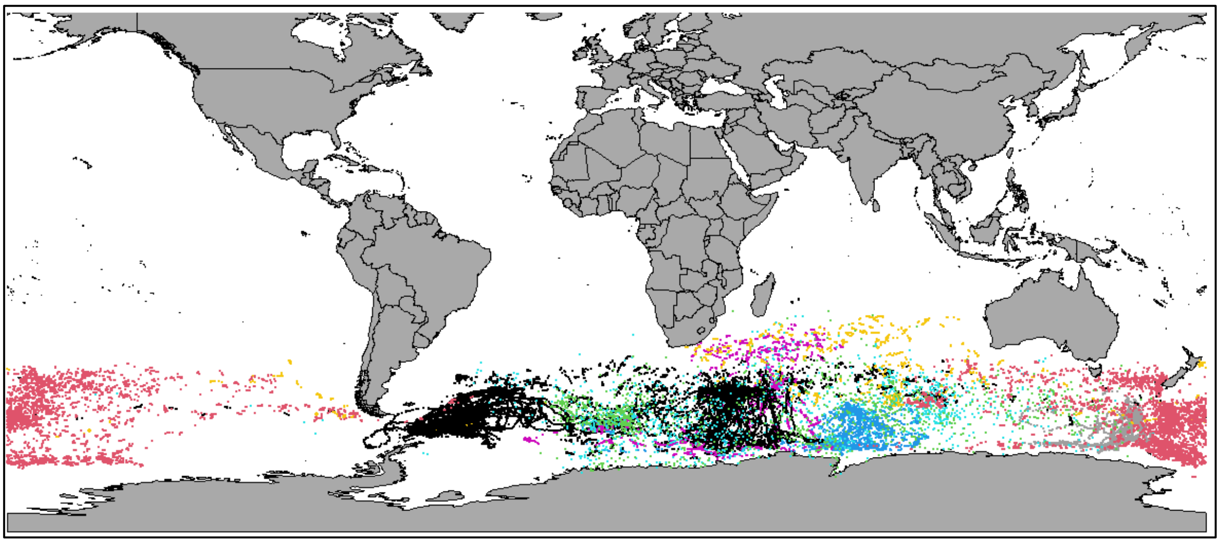


Figure L.45: Locations of ungroomed tracking data for all life stages, where different colours indicate different colonies.

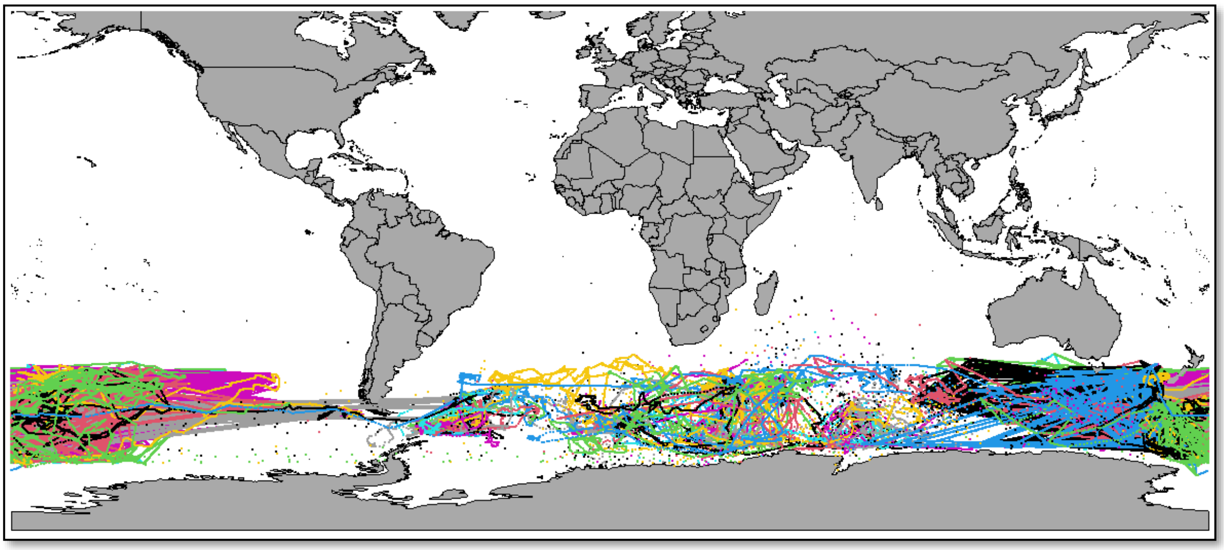


Figure L.46: Groomed and interpolated individual tracks for adult or unknown life stages, where different colours indicate different bird identifiers (noting that colours will repeat).

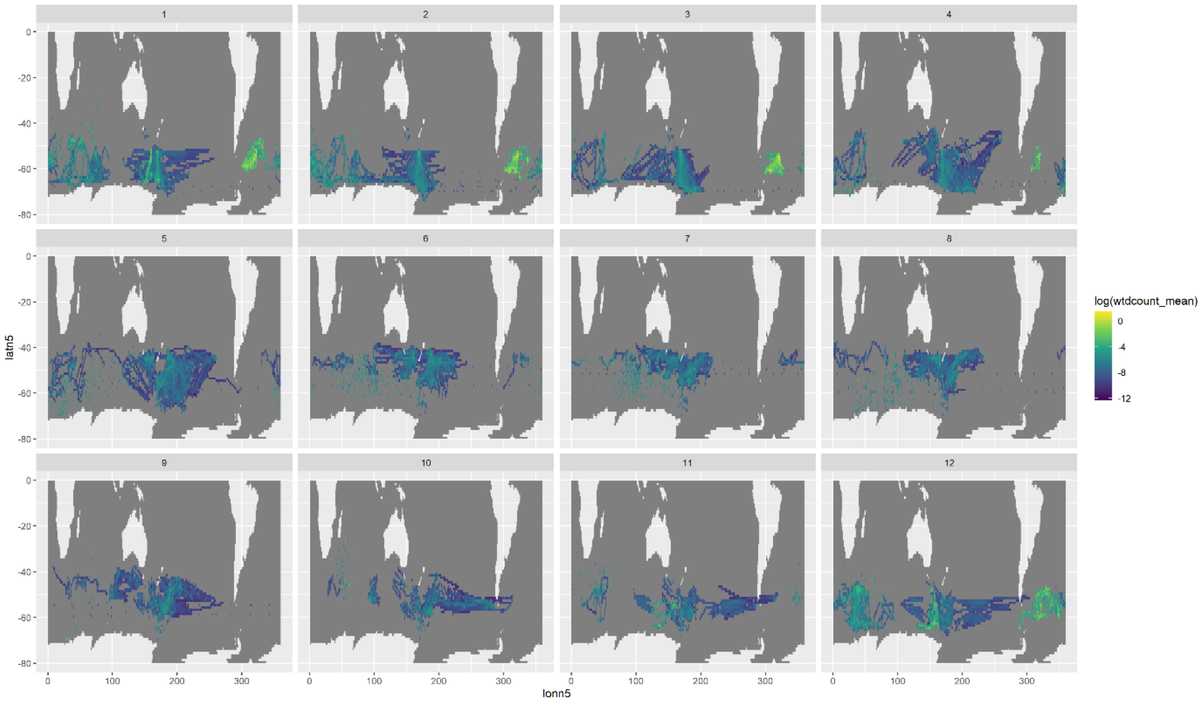


Figure L.47: Log mean weighted relative density by month, aggregated by 1 ° lat-lon grid cell.

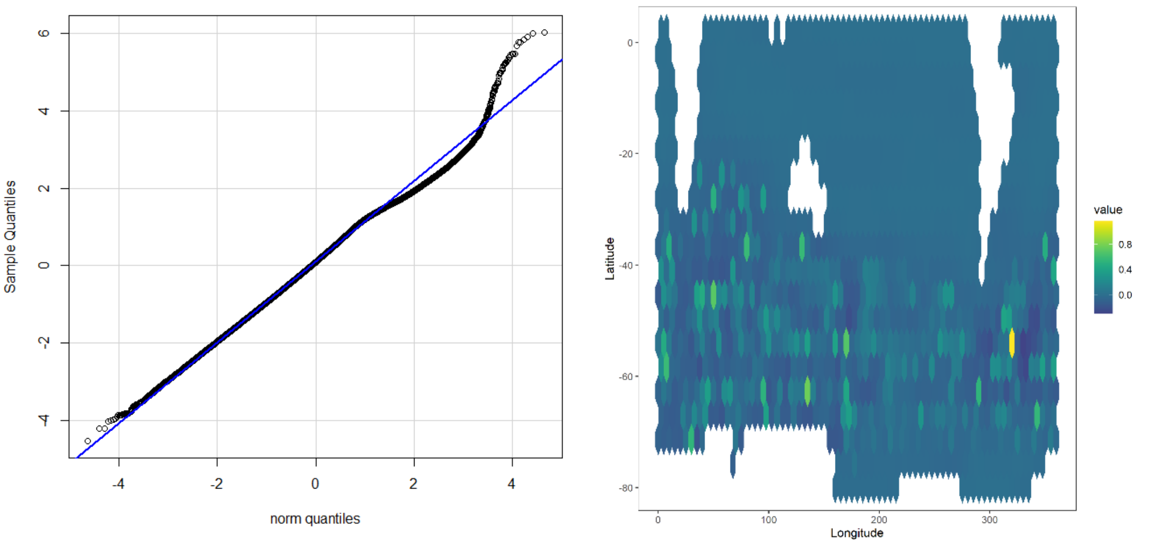


Figure L.48: Model diagnostic plots: residual QQ plot (left) and mean residual pattern by hexagonal grid cell (right).

Appendix M Grey petrel

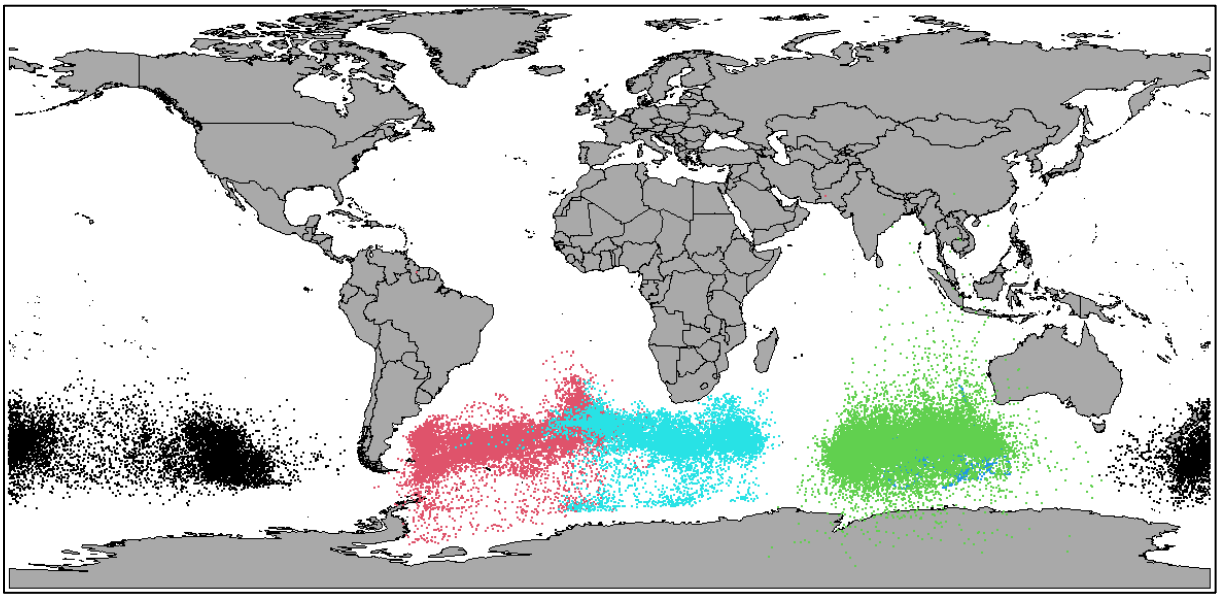


Figure M.49: Locations of ungroomed tracking data for all life stages, where different colours indicate different colonies.

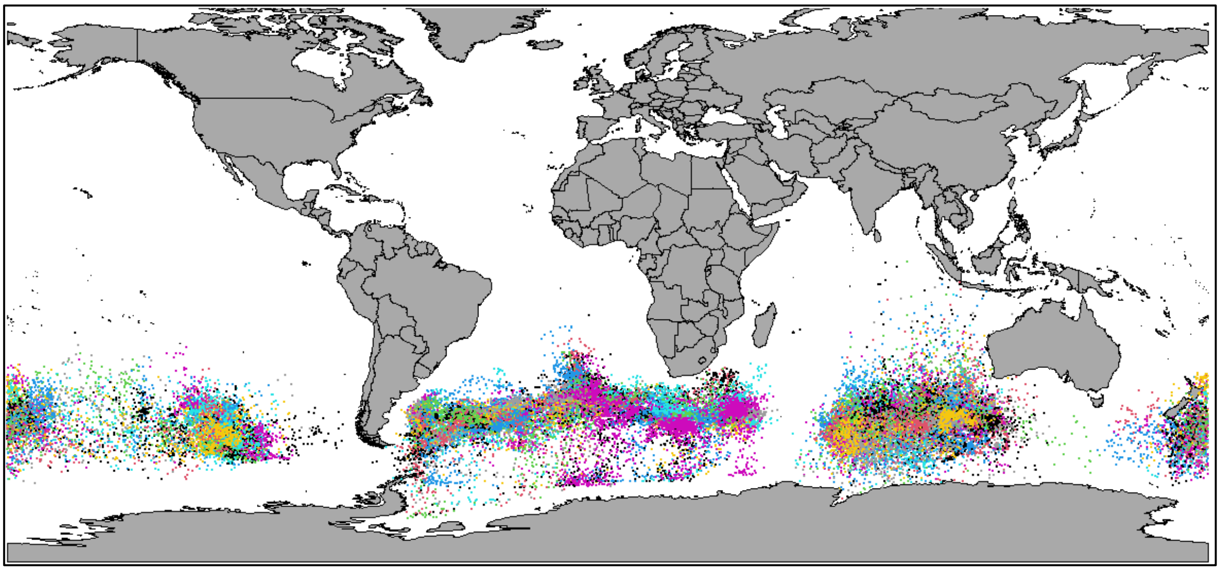


Figure M.50: Groomed and interpolated individual tracks for adult or unknown life stages, where different colours indicate different bird identifiers (noting that colours will repeat).

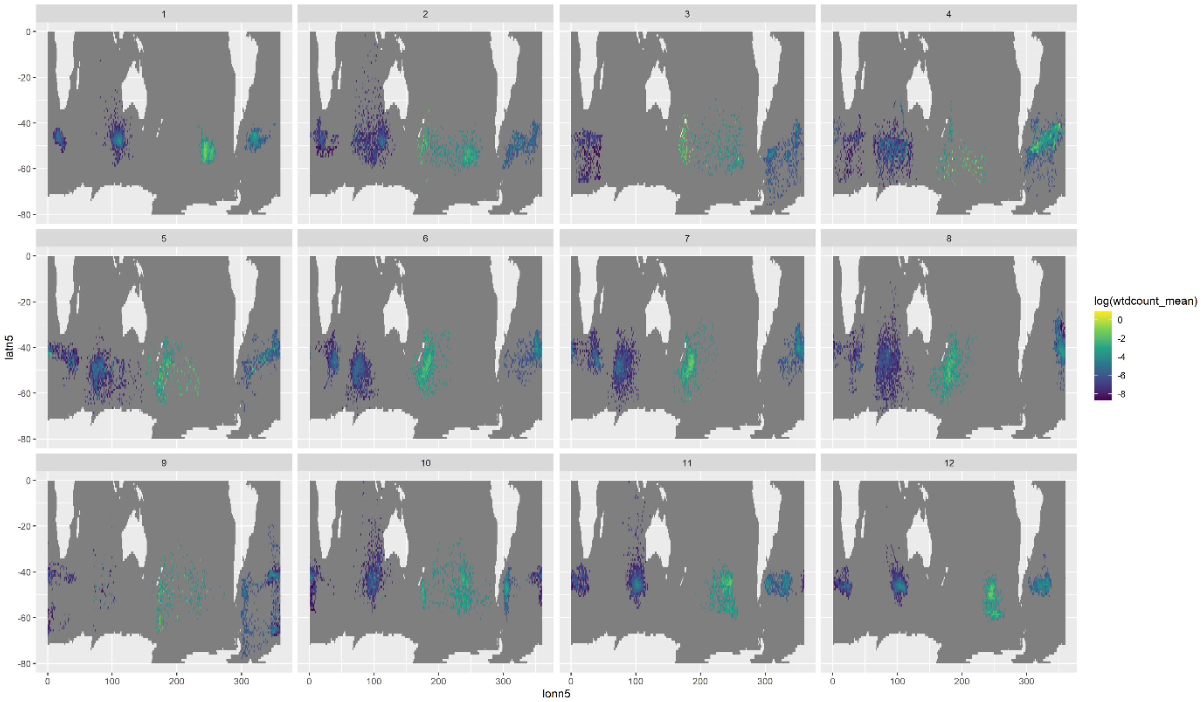


Figure M.51: Log mean weighted relative density by month, aggregated by 1 ° lat-lon grid cell.

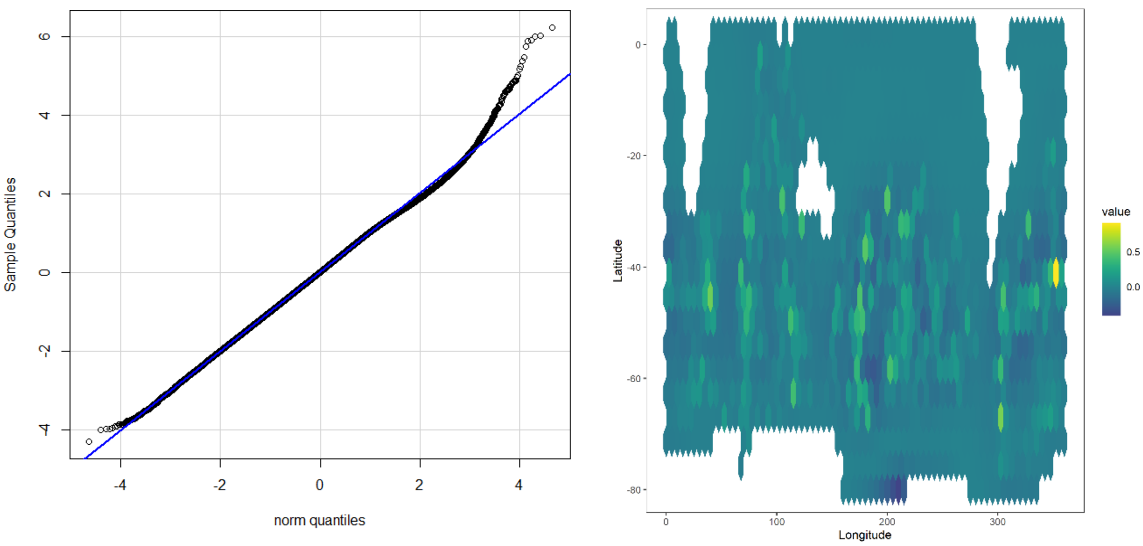


Figure M.52: Model diagnostic plots: residual QQ plot (left) and mean residual pattern by hexagonal grid cell (right).

Appendix N Black petrel

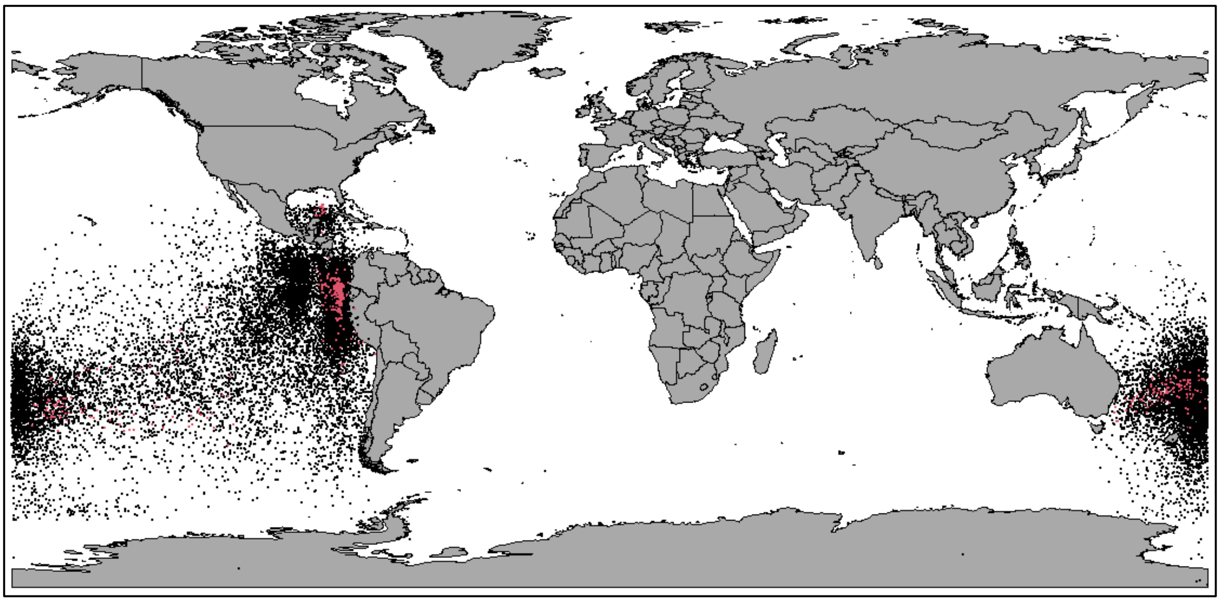


Figure N.53: Locations of ungroomed tracking data for all life stages, where different colours indicate different colonies.

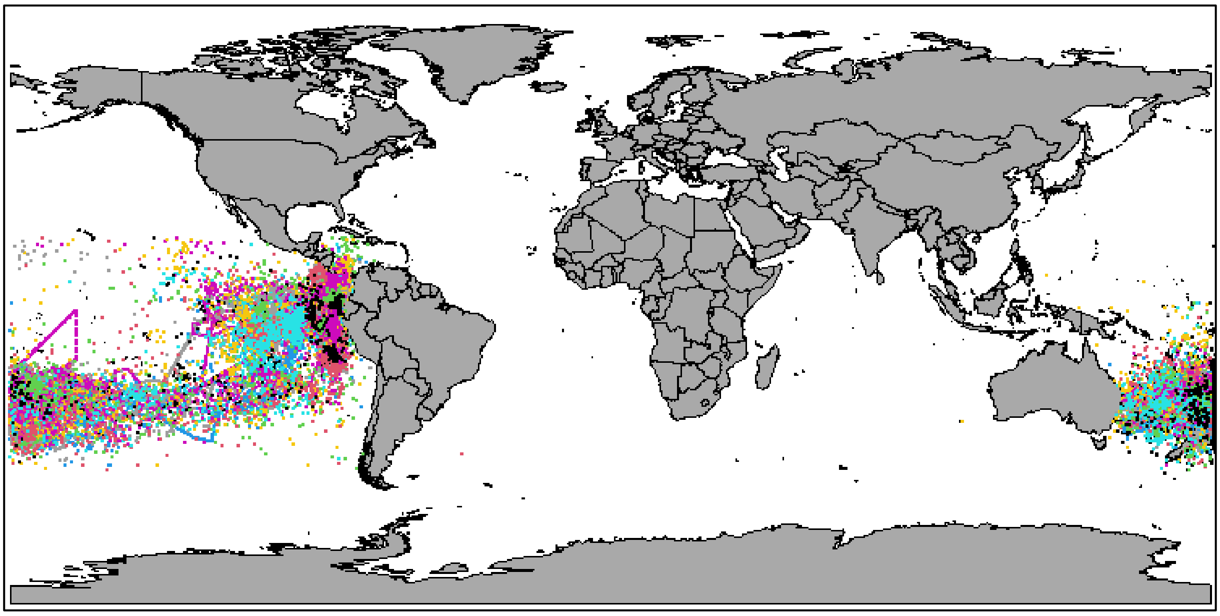


Figure N.54: Groomed and interpolated individual tracks for adult or unknown life stages, where different colours indicate different bird identifiers (noting that colours will repeat).

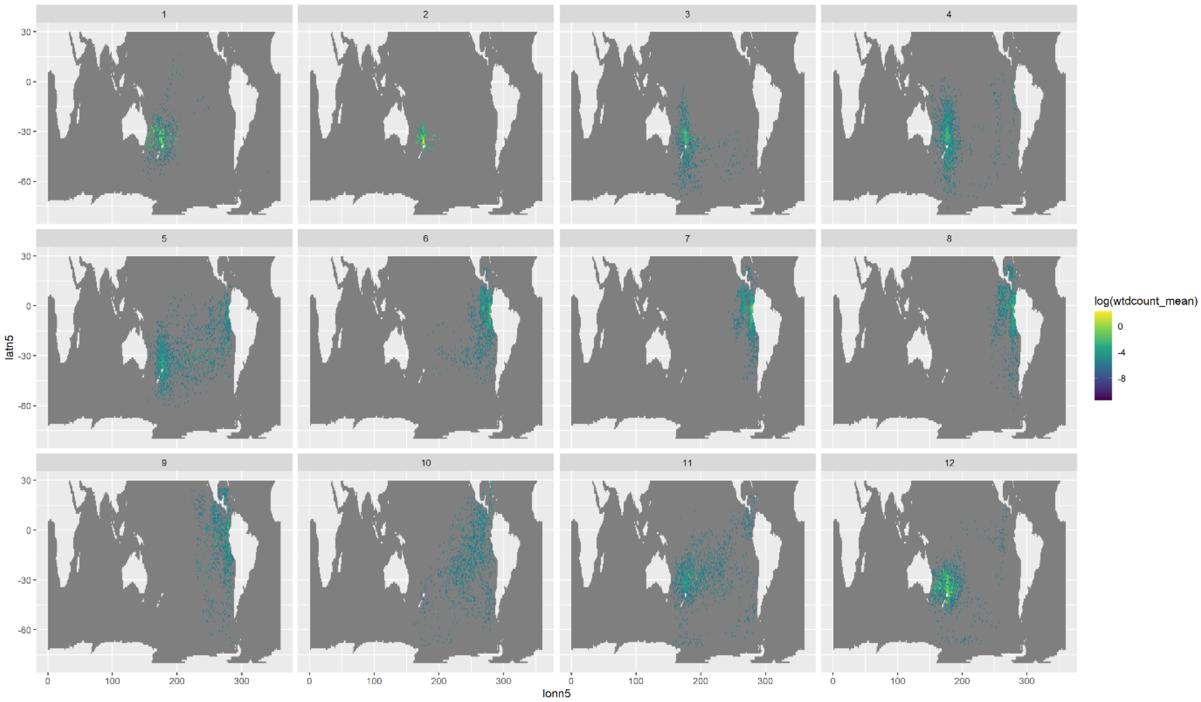


Figure N.55: Log mean weighted relative density by month, aggregated by 1 ° lat-lon grid cell.

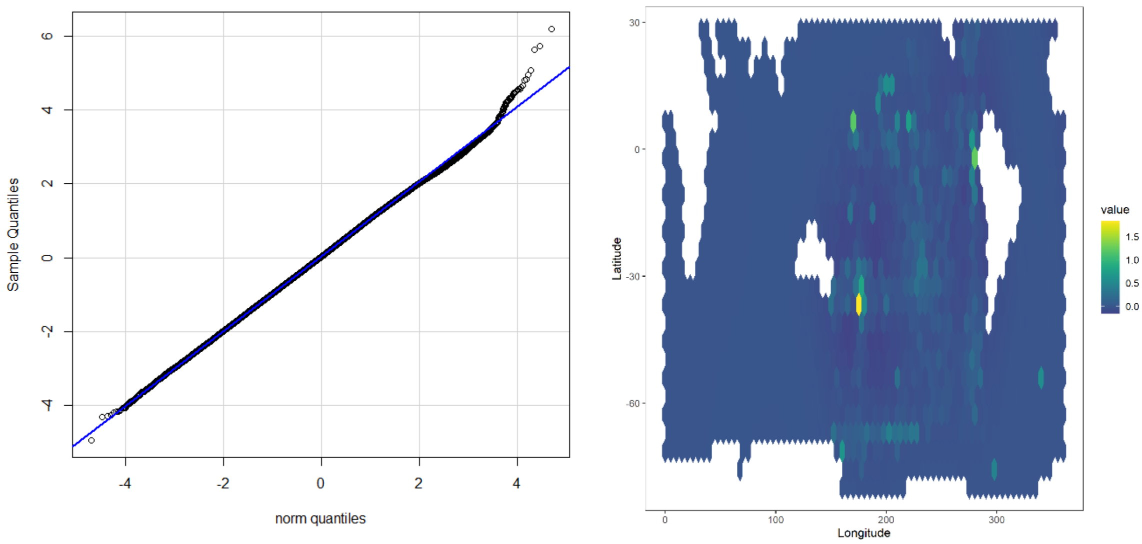


Figure N.56: Model diagnostic plots: residual QQ plot (left) and mean residual pattern by hexagonal grid cell (right).

Appendix O Westland petrel

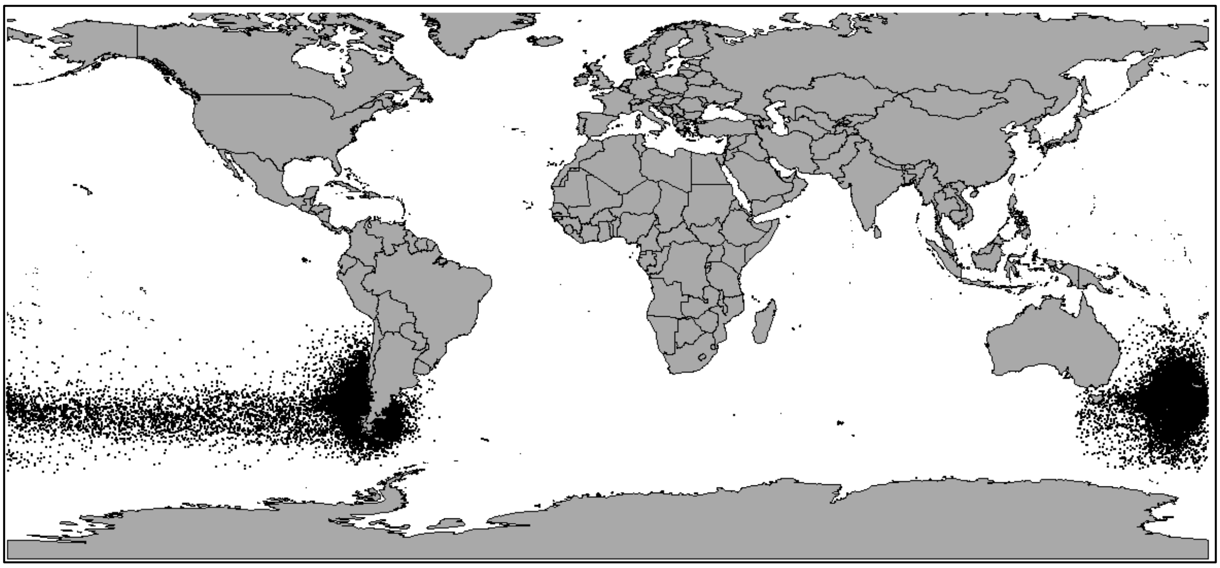


Figure O.57: Locations of ungroomed tracking data for all life stages, where different colours indicate different colonies.

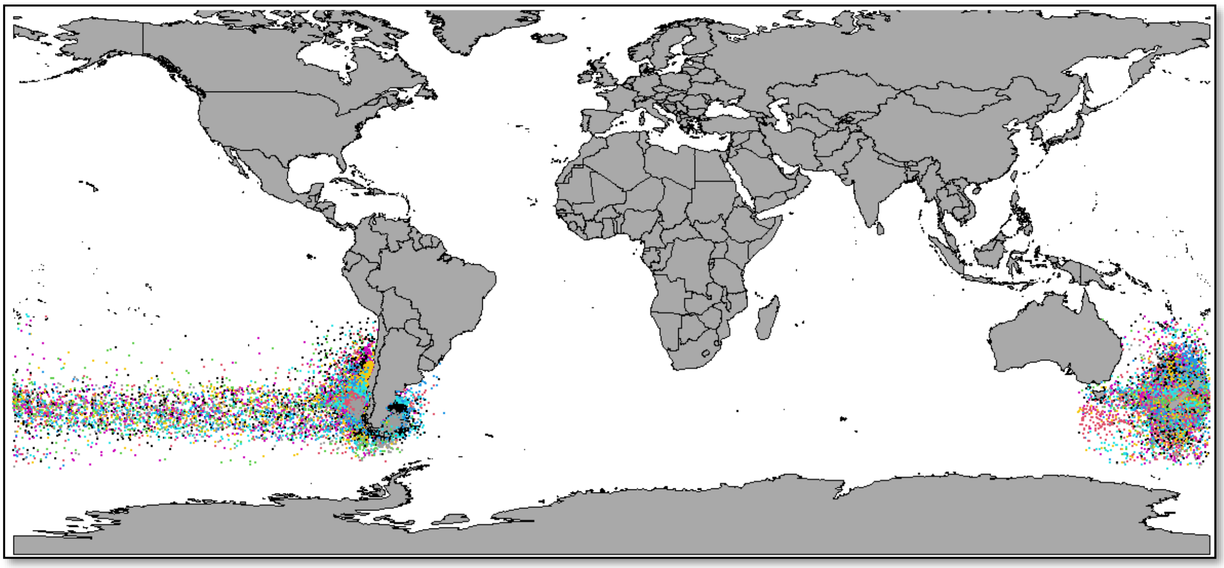


Figure O.58: Groomed and interpolated individual tracks for adult or unknown life stages, where different colours indicate different bird identifiers (noting that colours will repeat).

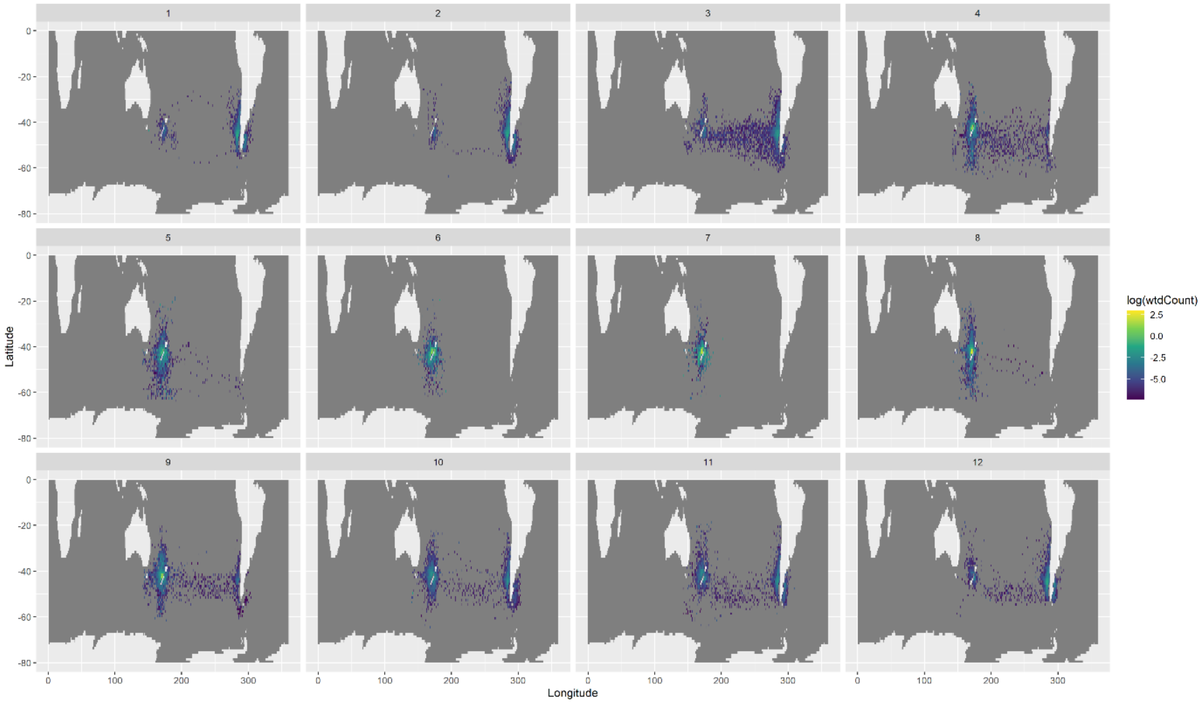


Figure O.59: Log relative density by month, aggregated by 1 ° lat-lon grid cell. Data were not weighted by mean colony size because only one colony was present.

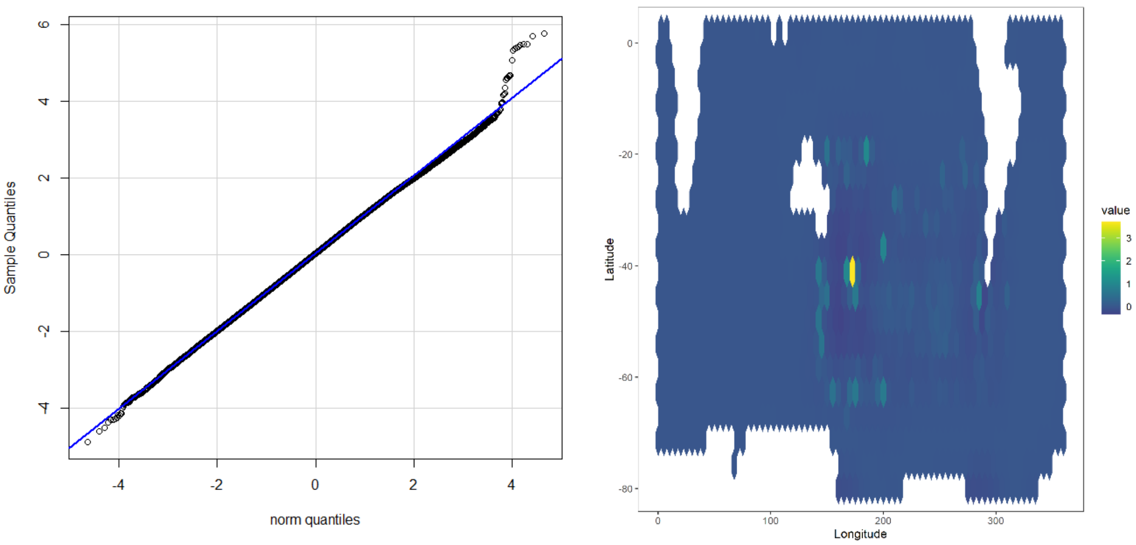


Figure O.60: Model diagnostic plots: residual QQ plot (left) and mean residual pattern by hexagonal grid cell (right).

Appendix P White-chinned petrel

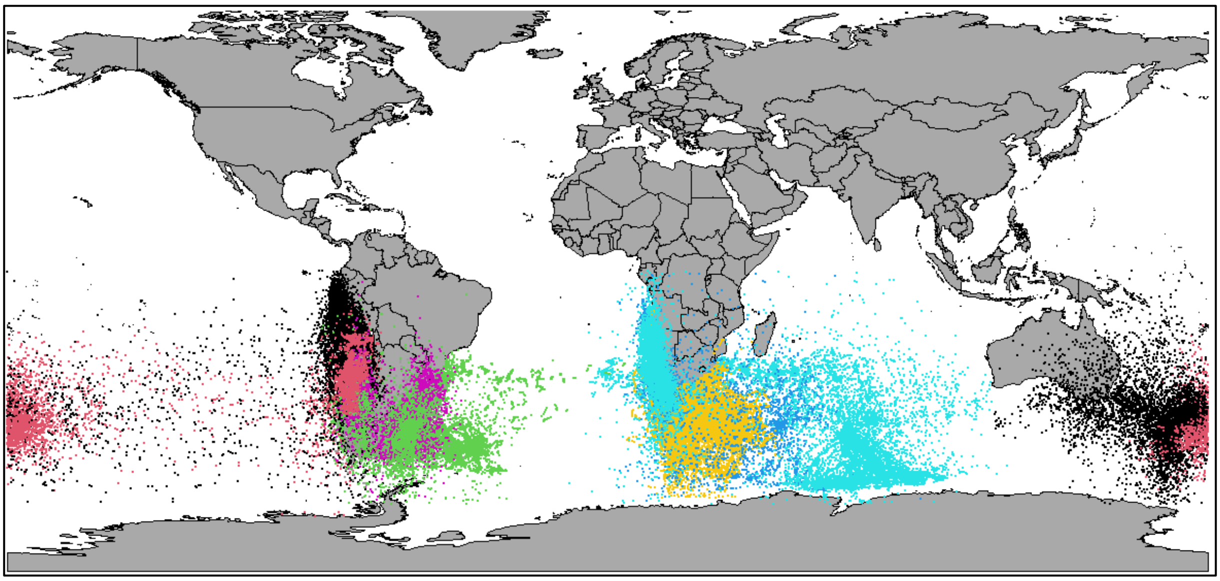


Figure P.61: Locations of ungroomed tracking data for all life stages, where different colours indicate different colonies.

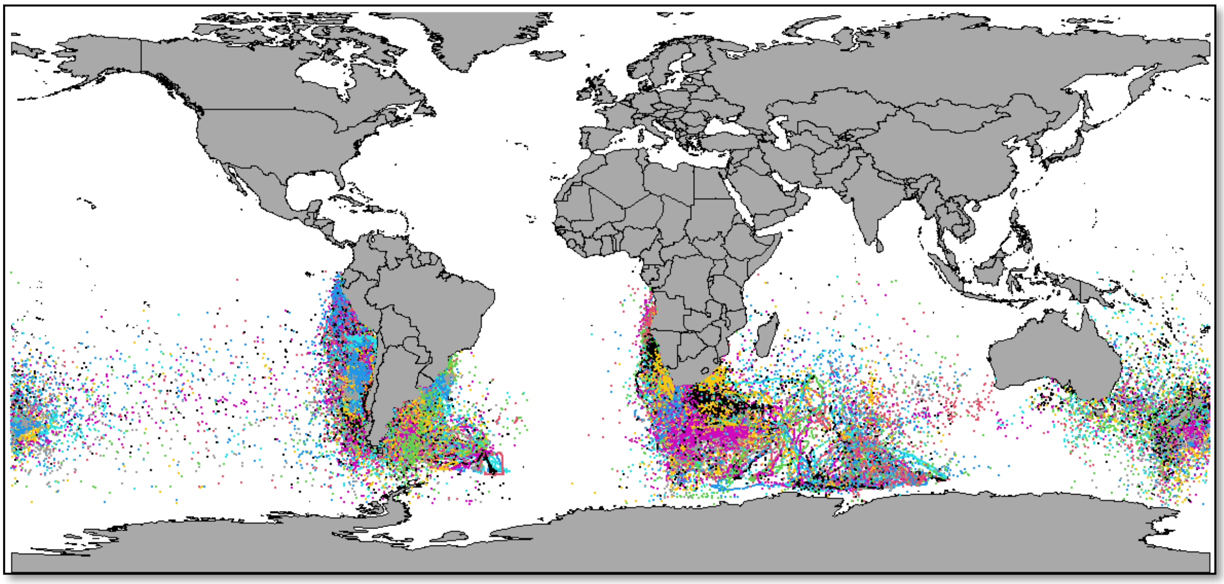


Figure P.62: Groomed and interpolated individual tracks for adult or unknown life stages, where different colours indicate different bird identifiers (noting that colours will repeat).

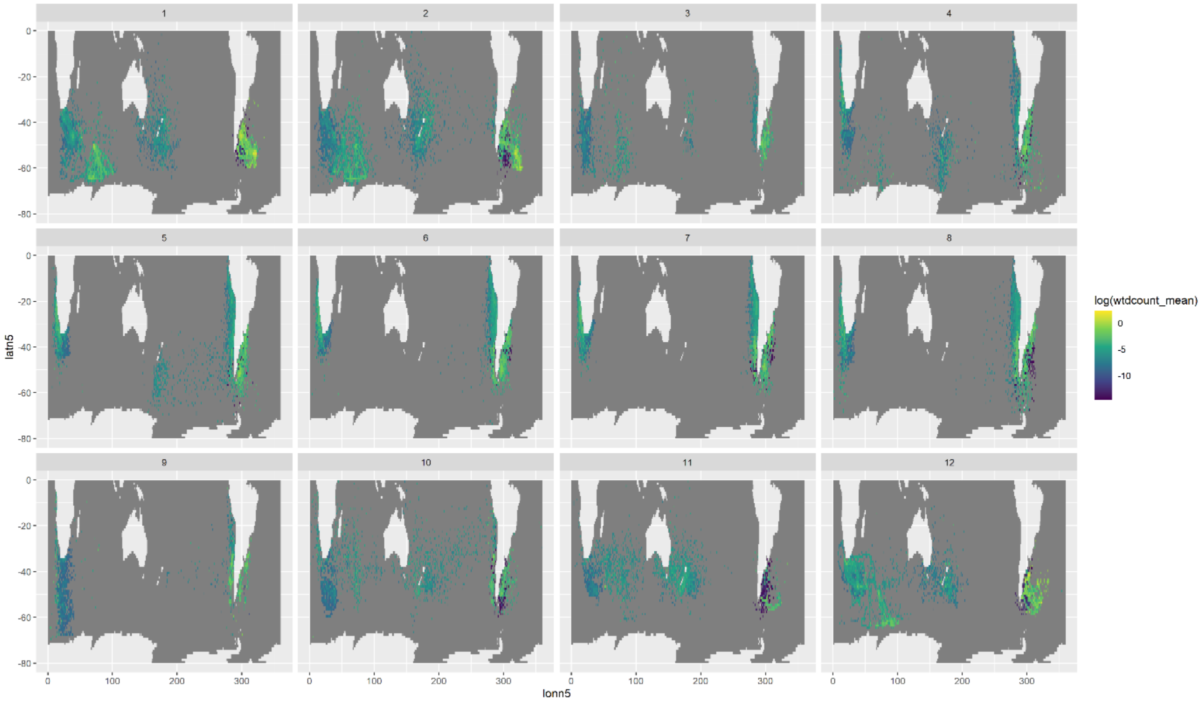


Figure P.63: Log mean weighted relative density by month, aggregated by 1 ° lat-lon grid cell.

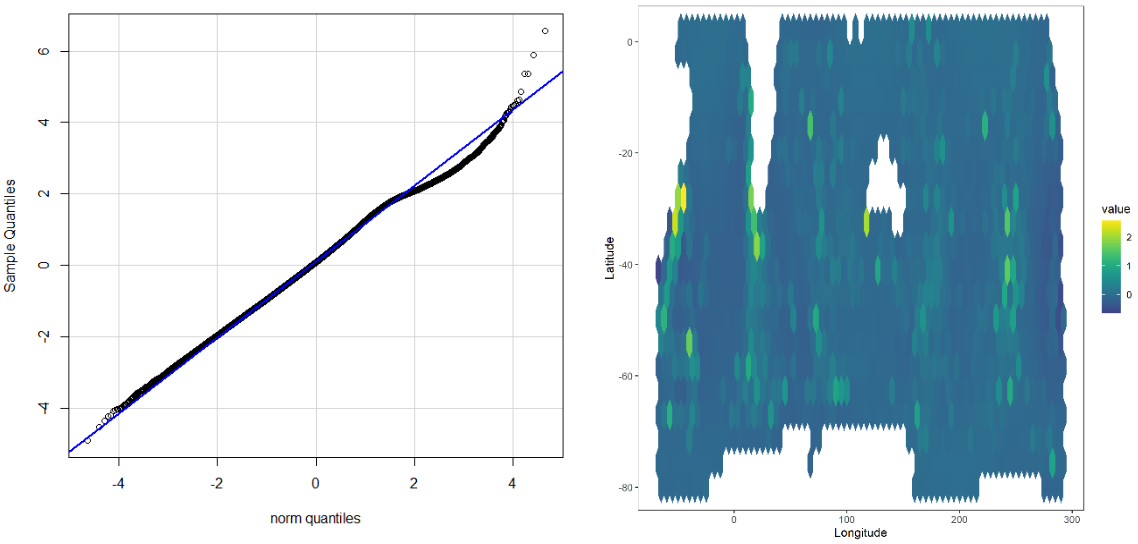


Figure P.64: Model diagnostic plots: residual QQ plot (left) and mean residual pattern by hexagonal grid cell (right).

Data inputs for the 2025 CCSBT collaborative seabird risk assessment

C. Edwards & T. Peatman

April 3, 2025

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1. Introduction

This documents provides a summary of biological and fishery inputs stored in the sefraData repository. The sefraInputs R-package must be installed on your local machine.

2. Biological Inputs Tables

2.1. Species in risk assessment

Table 1: Species used in the 2025 CCSBT collaborative seabird risk assessment model. Species codes are from the FAO-ASFIS species list where possible (`https://www.fao.org/fishery/en/species/search`).

Code	Common name	Scientific name
DIW	Gibson's albatross	*Diomedea antipodensis gibsoni*
DQS	Antipodean albatross	*Diomedea antipodensis antipodensis*
DIX	Wandering albatross	*Diomedea exulans*
DBN	Tristan albatross	*Diomedea dabbenena*
DAM	Amsterdam albatross	*Diomedea amsterdamensis*
DIP	Southern royal albatross	*Diomedea epomophora*
DIQ	Northern royal albatross	*Diomedea sanfordi*
DCR	Atlantic yellow-nosed albatross	*Thalassarche chlororhynchos*
TQH	Indian yellow-nosed albatross	*Thalassarche carteri*
DIM	Black-browed albatross	*Thalassarche melanophris*
TQW	Campbell black-browed albatross	*Thalassarche impavida*
DCU	Shy albatross	*Thalassarche cauta*
TWD	New Zealand white-capped albatross	*Thalassarche cauta steadi*
DKS	Salvin's albatross	*Thalassarche salvini*
DER	Chatham Island albatross	*Thalassarche eremita*
DIC	Grey-headed albatross	*Thalassarche chrysostoma*
DSB	Southern Buller's albatross	*Thalassarche bulleri bulleri*
DNB	Northern Buller's albatross	*Thalassarche bulleri platei*
PHU	Sooty albatross	*Phoebetria fusca*
PHE	Light-mantled sooty albatross	*Phoebetria palpebrata*
PCI	Grey petrel	*Procellaria cinerea*
PRK	Black petrel	*Procellaria parkinsoni*
PCW	Westland petrel	*Procellaria westlandica*
PRO	White-chinned petrel	*Procellaria aequinoctialis*
PCN	Spectacled petrel	*Procellaria conspicillata*

2.2. Fixed input covariate probabilities

Table 2: Proportion of breeding adults on nest by month ($P^{nest}_{s,m}$). Darker shaded cells indicate a higher probability.

Common name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gibson's albatross	0.50	0.50	0.50	0.40	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.22
Antipodean albatross	0.40	0.50	0.45	0.45	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.20
Wandering albatross	0.50	0.50	0.40	0.20	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.40
Tristan albatross	0.60	0.50	0.50	0.50	0.30	0.30	0.05	0.05	0.05	0.05	0.05	0.40
Amsterdam albatross	0.05	0.40	0.50	0.50	0.40	0.30	0.05	0.05	0.05	0.05	0.05	0.05
Southern royal albatross	0.50	0.50	0.40	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0.40	0.50
Northern royal albatross	0.50	0.40	0.30	0.05	0.05	0.05	0.05	0.05	0.00	0.40	0.50	0.50
Atlantic yellow-nosed albatross	0.30	0.20	0.10	0.05	0.00	0.00	0.00	0.50	0.60	0.50	0.50	0.50
Indian yellow-nosed albatross	0.20	0.10	0.05	0.05	0.00	0.00	0.00	0.10	0.50	0.50	0.40	0.40
Black-browed albatross	0.20	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.40	0.50	0.50	0.40
Campbell black-browed albatross	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.20	0.50	0.50	0.40	0.30
Shy albatross	0.10	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.50	0.50	0.40	0.40
New Zealand white-capped albatross	0.40	0.10	0.05	0.05	0.05	0.05	0.05	0.00	0.00	0.25	0.50	0.50
Salvin's albatross	0.05	0.05	0.05	0.00	0.00	0.00	0.10	0.30	0.50	0.50	0.40	0.10
Chatham Island albatross	0.10	0.05	0.05	0.05	0.00	0.00	0.20	0.40	0.50	0.50	0.40	0.30
Grey-headed albatross	0.30	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.10	0.50	0.50	0.40
Southern Buller's albatross	0.20	0.50	0.45	0.30	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00
Northern Buller's albatross	0.45	0.40	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.40	0.50
Sooty albatross	0.20	0.05	0.05	0.05	0.05	0.00	0.00	0.50	0.70	0.70	0.50	0.50
Light-mantled sooty albatross	0.40	0.10	0.05	0.05	0.05	0.05	0.00	0.00	0.10	0.50	0.50	0.40
Grey petrel	0.00	0.50	0.50	0.50	0.40	0.30	0.05	0.05	0.05	0.05	0.05	0.00
Black petrel	0.50	0.40	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.05	0.30	0.50
Westland petrel	0.00	0.15	0.30	0.40	0.50	0.50	0.45	0.40	0.05	0.05	0.05	0.00
White-chinned petrel	0.40	0.30	0.05	0.05	0.00	0.00	0.00	0.00	0.30	0.40	0.50	0.50
Spectacled petrel	0.10	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.40	0.30

Table 3: Proportion of adults in the southern hemisphere by month ($P^{SH}_{s,m}$). Darker shaded cells indicate a higher probability.

Common name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gibson's albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Antipodean albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Wandering albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Tristan albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Amsterdam albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Southern royal albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Northern royal albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Atlantic yellow-nosed albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Indian yellow-nosed albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Black-browed albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Campbell black-browed albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Shy albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
New Zealand white-capped albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Salvin's albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Chatham Island albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Grey-headed albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Southern Buller's albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Northern Buller's albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sooty albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Light-mantled sooty albatross	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Grey petrel	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Black petrel	1.00	1.00	1.00	1.00	1.00	0.80	0.80	0.80	0.80	0.80	1.00	1.00
Westland petrel	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
White-chinned petrel	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Spectacled petrel	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

2.3. Prior distributions of demographic parameters

Table 4: Prior distributions for numbers of breeding pairs (N_s^{BP}).

Common name	Distribution	Parameter a	Parameter b
Gibson's albatross	log-normal	4425.00	0.050
Antipodean albatross	log-normal	3383.00	0.050
Wandering albatross	log-normal	10130.00	0.050
Tristan albatross	weibull	9.25	1710
Amsterdam albatross	log-normal	60.00	0.100
Southern royal albatross	log-normal	5814.00	0.070
Northern royal albatross	log-normal	4261.00	0.110
Atlantic yellow-nosed albatross	log-normal	26800.00	0.100
Indian yellow-nosed albatross	log-normal	33988.00	0.100
Black-browed albatross	log-normal	670960.00	0.050
Campbell black-browed albatross	log-normal	14129.00	0.050
Shy albatross	log-normal	15335.00	0.100
New Zealand white-capped albatross	log-normal	85820.00	0.120
Salvin's albatross	log-normal	35242.00	0.050
Chatham Island albatross	log-normal	5294.00	0.010
Grey-headed albatross	log-normal	63055.00	0.050
Southern Buller's albatross	log-normal	13493.00	0.050
Northern Buller's albatross	log-normal	19354.00	0.050
Sooty albatross	weibull	23.20	13660
Light-mantled sooty albatross	log-normal	20927.00	0.100
Grey petrel	log-normal	105617.00	0.150
Black petrel	log-normal	5456.00	0.057
Westland petrel	log-normal	6223.00	0.061
White-chinned petrel	log-normal	1317300.00	0.100
Spectacled petrel	log-normal	42000.00	0.096

Table 5: Prior distributions for proportion of adults breeding (P_s^B).

Common name	Distribution	Parameter a	Parameter b
Gibson's albatross	beta	0.595	170.00
Antipodean albatross	beta	0.450	91.30
Wandering albatross	logit-normal	0.494	0.05
Tristan albatross	beta	0.349	51.30
Amsterdam albatross	logit-normal	0.600	0.05
Southern royal albatross	beta	0.531	22.20
Northern royal albatross	beta	0.531	22.20
Atlantic yellow-nosed albatross	beta	0.596	4100.00
Indian yellow-nosed albatross	logit-normal	0.596	0.05
Black-browed albatross	beta	0.844	174.00
Campbell black-browed albatross	logit-normal	0.900	0.05
Shy albatross	logit-normal	0.747	0.05
New Zealand white-capped albatross	beta	0.680	63.90
Salvin's albatross	beta	0.821	29.70
Chatham Island albatross	logit-normal	0.773	0.05
Grey-headed albatross	beta	0.406	17.50
Southern Buller's albatross	beta	0.804	34.90
Northern Buller's albatross	logit-normal	0.800	0.05
Sooty albatross	logit-normal	0.730	0.05
Light-mantled sooty albatross	beta	0.730	15.80
Grey petrel	logit-normal	0.900	0.05
Black petrel	beta	0.610	143.00
Westland petrel	beta	0.480	45.40
White-chinned petrel	logit-normal	0.750	0.05
Spectacled petrel	logit-normal	0.797	0.05

Table 6: Prior distributions for current age at first reproduction (A_s^{curr}).

Common name	Distribution	Parameter a	Parameter b
Gibson's albatross	log-normal	11.90	0.165
Antipodean albatross	log-normal	13.90	0.142
Wandering albatross	log-normal	9.91	0.150
Tristan albatross	log-normal	9.18	0.177
Amsterdam albatross	log-normal	9.91	0.150
Southern royal albatross	log-normal	9.19	0.189
Northern royal albatross	log-normal	8.90	0.023
Atlantic yellow-nosed albatross	log-normal	8.90	0.165
Indian yellow-nosed albatross	log-normal	8.90	0.165
Black-browed albatross	log-normal	9.91	0.150
Campbell black-browed albatross	log-normal	9.19	0.189
Shy albatross	log-normal	8.82	0.206
New Zealand white-capped albatross	log-normal	8.82	0.206
Salvin's albatross	log-normal	11.20	0.145
Chatham Island albatross	log-normal	9.90	0.118
Grey-headed albatross	log-normal	12.90	0.116
Southern Buller's albatross	log-normal	11.90	0.125
Northern Buller's albatross	log-normal	11.90	0.125
Sooty albatross	log-normal	9.20	0.189
Light-mantled sooty albatross	log-normal	9.20	0.189
Grey petrel	log-normal	6.94	0.142
Black petrel	log-normal	7.40	0.031
Westland petrel	log-normal	6.95	0.160
White-chinned petrel	log-normal	6.59	0.178
Spectacled petrel	log-normal	6.59	0.178

Table 7: Prior distributions for optimum age at first reproduction (A_s^{opt}).

Common name	Distribution	Parameter a	Parameter b
Gibson's albatross	log-normal	11.90	0.165
Antipodean albatross	log-normal	13.90	0.142
Wandering albatross	log-normal	9.91	0.150
Tristan albatross	log-normal	9.18	0.177
Amsterdam albatross	log-normal	9.91	0.150
Southern royal albatross	log-normal	9.19	0.189
Northern royal albatross	log-normal	8.90	0.023
Atlantic yellow-nosed albatross	log-normal	8.90	0.165
Indian yellow-nosed albatross	log-normal	8.90	0.165
Black-browed albatross	log-normal	9.91	0.150
Campbell black-browed albatross	log-normal	9.19	0.189
Shy albatross	log-normal	8.82	0.206
New Zealand white-capped albatross	log-normal	8.82	0.206
Salvin's albatross	log-normal	11.20	0.145
Chatham Island albatross	log-normal	9.90	0.118
Grey-headed albatross	log-normal	12.90	0.116
Southern Buller's albatross	log-normal	11.90	0.125
Northern Buller's albatross	log-normal	11.90	0.125
Sooty albatross	log-normal	9.20	0.189
Light-mantled sooty albatross	log-normal	9.20	0.189
Grey petrel	log-normal	6.94	0.142
Black petrel	log-normal	7.40	0.031
Westland petrel	log-normal	6.95	0.160
White-chinned petrel	log-normal	6.59	0.178
Spectacled petrel	log-normal	6.59	0.178

Table 8: Prior distributions for current adult survival rate (S_s^{curr}).

Common name	Distribution	Parameter a	Parameter b
Gibson's albatross	beta	0.912	5.99e+01
Antipodean albatross	beta	0.907	1.38e+02
Wandering albatross	beta	0.918	1.59e+02
Tristan albatross	beta	0.948	1.23e+03
Amsterdam albatross	logit-normal	0.971	1.00e-03
Southern royal albatross	beta	0.920	1.38e+02
Northern royal albatross	beta	0.950	2.26e+03
Atlantic yellow-nosed albatross	beta	0.923	1.47e+03
Indian yellow-nosed albatross	logit-normal	0.902	2.00e-02
Black-browed albatross	beta	0.931	1.47e+02
Campbell black-browed albatross	logit-normal	0.945	7.00e-03
Shy albatross	beta	0.961	1.79e+03
New Zealand white-capped albatross	logit-normal	0.920	1.00e-02
Salvin's albatross	beta	0.951	9.00e+00
Chatham Island albatross	logit-normal	0.925	3.00e-02
Grey-headed albatross	beta	0.950	9.64e+01
Southern Buller's albatross	beta	0.891	1.06e+02
Northern Buller's albatross	logit-normal	0.925	2.50e-02
Sooty albatross	logit-normal	0.920	2.50e-02
Light-mantled sooty albatross	beta	0.930	1.03e+04
Grey petrel	logit-normal	0.897	2.50e-02
Black petrel	beta	0.864	2.15e+03
Westland petrel	beta	0.954	1.90e+02
White-chinned petrel	logit-normal	0.874	2.00e-02
Spectacled petrel	logit-normal	0.874	2.50e-02

Table 9: Prior distributions for optimum adult survival rate (S_s^{opt}).

Common name	Distribution	Parameter a	Parameter b
Gibson's albatross	uniform	0.950	0.980
Antipodean albatross	uniform	0.950	0.980
Wandering albatross	uniform	0.950	0.980
Tristan albatross	uniform	0.950	0.980
Amsterdam albatross	uniform	0.950	0.980
Southern royal albatross	uniform	0.950	0.980
Northern royal albatross	uniform	0.950	0.980
Atlantic yellow-nosed albatross	uniform	0.930	0.970
Indian yellow-nosed albatross	uniform	0.930	0.970
Black-browed albatross	uniform	0.930	0.970
Campbell black-browed albatross	uniform	0.930	0.970
Shy albatross	uniform	0.935	0.975
New Zealand white-capped albatross	uniform	0.935	0.975
Salvin's albatross	uniform	0.935	0.975
Chatham Island albatross	uniform	0.935	0.975
Grey-headed albatross	uniform	0.950	0.980
Southern Buller's albatross	uniform	0.930	0.970
Northern Buller's albatross	uniform	0.930	0.970
Sooty albatross	uniform	0.950	0.980
Light-mantled sooty albatross	uniform	0.950	0.980
Grey petrel	uniform	0.920	0.950
Black petrel	uniform	0.920	0.950
Westland petrel	uniform	0.930	0.960
White-chinned petrel	uniform	0.920	0.950
Spectacled petrel	uniform	0.920	0.950

2.4. Summary statistics for prior distributions of demographic parameters

Table 10: Prior values for the annual number of breeding pairs (N_s^{BP}), proportion of adults breeding (P_s^B), age at first reproduction (A_s^{curr}), and optimum survivorship (S_s^{opt}), simulated from distributions listed in Table 4, 5, 6, and 9.

		N_s^{BP}		P_s^B		A_s^{curr}		S_s^{opt}	
Code	Common name	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
DIW	Gibson's albatross	4 421	4 000-4 864	0.60	0.52-0.67	11.9	8.5-16.1	0.96	0.95-0.98
DQS	Antipodean albatross	3 381	3 065-3 725	0.45	0.35-0.55	13.9	10.5-18.2	0.97	0.95-0.98
DIX	Wandering albatross	10 131	9 175-11 134	0.49	0.40-0.59	9.9	7.3-13.3	0.97	0.95-0.98
DBN	Tristan albatross	1 623	1 146-1 973	0.35	0.23-0.48	9.2	6.5-12.7	0.96	0.95-0.98
DAM	Amsterdam albatross	60	49-73	0.60	0.50-0.69	9.9	7.3-13.2	0.96	0.95-0.98
DIP	Southern royal albatross	5 818	5 043-6 653	0.53	0.33-0.72	9.2	6.2-13.0	0.96	0.95-0.98
DIQ	Northern royal albatross	4 257	3 413-5 239	0.53	0.33-0.73	8.9	8.5-9.3	0.97	0.95-0.98
DCR	Atlantic yellow-nosed albatross	26 808	22 001-32 403	0.60	0.58-0.61	8.9	6.4-12.2	0.95	0.93-0.97
TQH	Indian yellow-nosed albatross	34 002	27 855-41 039	0.60	0.49-0.69	8.9	6.3-12.1	0.95	0.93-0.97
DIM	Black-browed albatross	671 369	607 619-738 568	0.84	0.79-0.89	9.9	7.3-13.1	0.95	0.93-0.97
TQW	Campbell black-browed albatross	14 119	12 768-15 549	0.89	0.75-0.96	9.2	6.2-13.1	0.95	0.93-0.97
DCU	Shy albatross	15 339	12 529-18 518	0.74	0.64-0.83	8.8	5.8-13.0	0.95	0.94-0.97
TWD	New Zealand white-capped albatross	85 808	67 480-107 569	0.68	0.56-0.79	8.8	5.8-13.0	0.95	0.94-0.97
DKS	Salvin's albatross	35 238	31 960-38 794	0.82	0.67-0.94	11.2	8.4-14.7	0.95	0.94-0.97
DER	Chatham Island albatross	5 294	5 188-5 400	0.77	0.66-0.86	9.9	7.8-12.3	0.96	0.94-0.97
DIC	Grey-headed albatross	63 034	57 057-69 504	0.41	0.19-0.63	12.9	10.2-16.1	0.96	0.95-0.98
DSB	Southern Buller's albatross	13 499	12 211-14 878	0.80	0.66-0.92	11.9	9.2-15.1	0.95	0.93-0.97
DNB	Northern Buller's albatross	19 362	17 529-21 341	0.80	0.69-0.88	11.9	9.3-15.1	0.95	0.93-0.97
PHU	Sooty albatross	13 359	11 705-14 451	0.73	0.62-0.82	9.2	6.3-13.1	0.97	0.95-0.98
PHE	Light-mantled sooty albatross	20 905	17 136-25 231	0.73	0.49-0.91	9.2	6.3-13.1	0.97	0.95-0.98
PCI	Grey petrel	105 660	77 870-140 105	0.89	0.75-0.96	6.9	5.2-9.0	0.94	0.92-0.95
PRK	Black petrel	5 458	4 873-6 083	0.61	0.53-0.69	7.4	7.0-7.9	0.93	0.92-0.95
PCW	Westland petrel	6 225	5 514-6 987	0.48	0.34-0.63	7.0	5.0-9.4	0.95	0.93-0.96
PRO	White-chinned petrel	1 316 786	1 074 335-1 593 474	0.75	0.64-0.83	6.6	4.6-9.2	0.93	0.92-0.95
PCN	Spectacled petrel	41 988	34 447-50 333	0.79	0.68-0.88	6.6	4.6-9.1	0.94	0.92-0.95

Table 11: Prior productivity estimates and population size used to estimate PST reference points for each species, assuming $\phi = 0.5$.

		N_s (thousand)		r_s		PST_s	
Code	Common name	Mean	95% CI	Mean	95% CI	Mean	95% CI
DIW	Gibson's albatross	14 909	12 750-17 458	0.04	0.03-0.05	153	109-208
DQS	Antipodean albatross	15 263	11 956-19 727	0.04	0.03-0.05	140	97-198
DIX	Wandering albatross	41 429	33 352-51 892	0.05	0.03-0.06	478	332-668
DBN	Tristan albatross	9 690	5 900-15 107	0.05	0.04-0.06	119	65-198
DAM	Amsterdam albatross	202	156-260	0.05	0.03-0.06	2	2-3
DIP	Southern royal albatross	22 877	15 534-36 179	0.05	0.04-0.07	281	165-477
DIQ	Northern royal albatross	16 704	10 850-27 135	0.05	0.04-0.06	205	126-343
DCR	Atlantic yellow-nosed albatross	89 992	73 818-108 954	0.06	0.04-0.07	1 280	896-1 768
TQH	Indian yellow-nosed albatross	115 030	88 811-147 884	0.06	0.04-0.07	1 643	1 116-2 376
DIM	Black-browed albatross	1 593 207	1 422 033-1 791 582	0.05	0.04-0.07	21 014	15 600-27 531
TQW	Campbell black-browed albatross	31 907	27 687-38 369	0.06	0.04-0.07	446	314-620
DCU	Shy albatross	41 464	32 765-52 255	0.06	0.04-0.08	575	372-846
TWD	New Zealand white-capped albatross	254 551	189 506-338 493	0.06	0.04-0.08	3 529	2 221-5 425
DKS	Salvin's albatross	86 384	72 536-107 411	0.05	0.04-0.06	1 006	720-1 382
DER	Chatham Island albatross	13 835	12 342-16 052	0.05	0.04-0.06	175	131-228
DIC	Grey-headed albatross	340 458	195 740-648 759	0.04	0.03-0.05	3 286	1 758-6 508
DSB	Southern Buller's albatross	33 852	28 455-41 829	0.05	0.04-0.06	391	288-529
DNB	Northern Buller's albatross	48 877	41 987-58 026	0.05	0.04-0.06	564	421-744
PHU	Sooty albatross	36 871	30 880-44 041	0.05	0.04-0.07	450	311-633
PHE	Light-mantled sooty albatross	58 790	42 233-88 017	0.05	0.04-0.07	720	445-1 158
PCI	Grey petrel	238 644	172 197-326 322	0.07	0.06-0.09	4 453	2 955-6 472
PRK	Black petrel	17 981	15 118-21 433	0.07	0.06-0.08	317	258-387
PCW	Westland petrel	26 630	19 309-37 730	0.07	0.05-0.09	467	308-699
PRO	White-chinned petrel	3 543 560	2 799 132-4 491 550	0.08	0.06-0.10	68 954	47 562-96 220
PCN	Spectacled petrel	106 495	84 283-133 438	0.08	0.06-0.10	2 071	1 435-2 901

3. Summaries of biological inputs by species

3.1. Gibson's albatross (*Diomedea antipodensis gibsoni*)

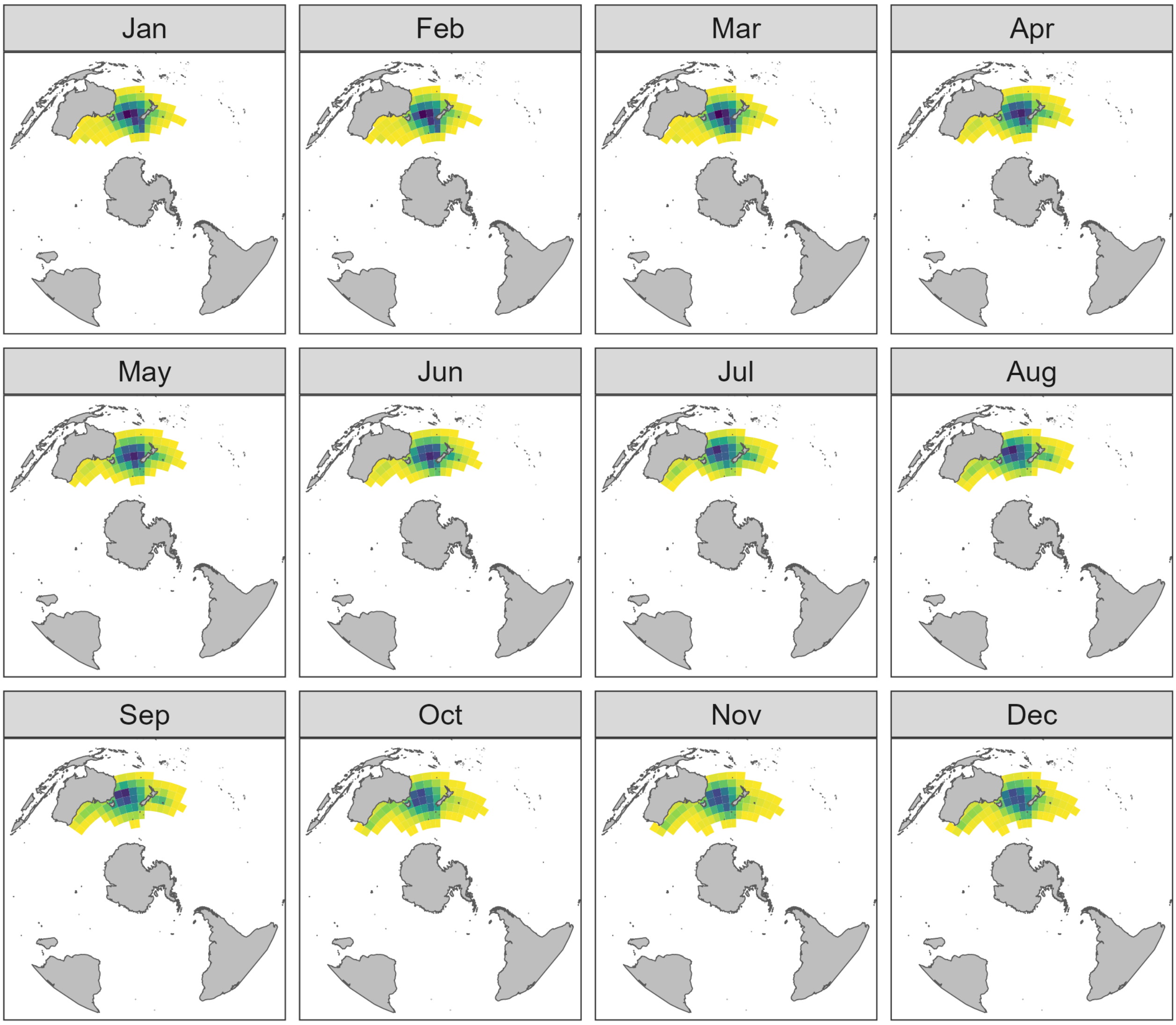

Figure 1: Relative density maps of adult Gibson's albatross (DIW) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 12: Input covariate probabilities for Gibson's albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.50
Feb	1.00	0.50
Mar	1.00	0.50
Apr	1.00	0.40
May	1.00	0.05
Jun	1.00	0.05
Jul	1.00	0.05
Aug	1.00	0.05
Sep	1.00	0.05
Oct	1.00	0.05
Nov	1.00	0.05
Dec	1.00	0.22

Table 13: Prior distributions of demographic parameters for Gibson's albatross.

Parameter	Distribution	Parameter *a*	Parameter *b*
Annual breeding pairs	log-normal	4425	0.050
Proportion of adults breeding	beta	0.595	170
Age at first reproduction	log-normal	11.9	0.165
Current adult survival rate	beta	0.912	59.9
Optimal adult survival rate	uniform	0.95	0.98

Table 14: Summary statistics for prior distributions of demographic parameters for Gibson's albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	4 421	4 000-4 864	Pairs
Proportion of adults breeding	0.60	0.52-0.67	Proportion
Age at first reproduction	11.9	8.5-16.1	Years
Current adult survival rate	0.91	0.83-0.97	Proportion
Optimal adult survival rate	0.96	0.95-0.98	Proportion
Population size (adults)	14 909	12 750-17 458	Individuals

3.2. Antipodean albatross (*Diomedea antipodensis antipodensis*)

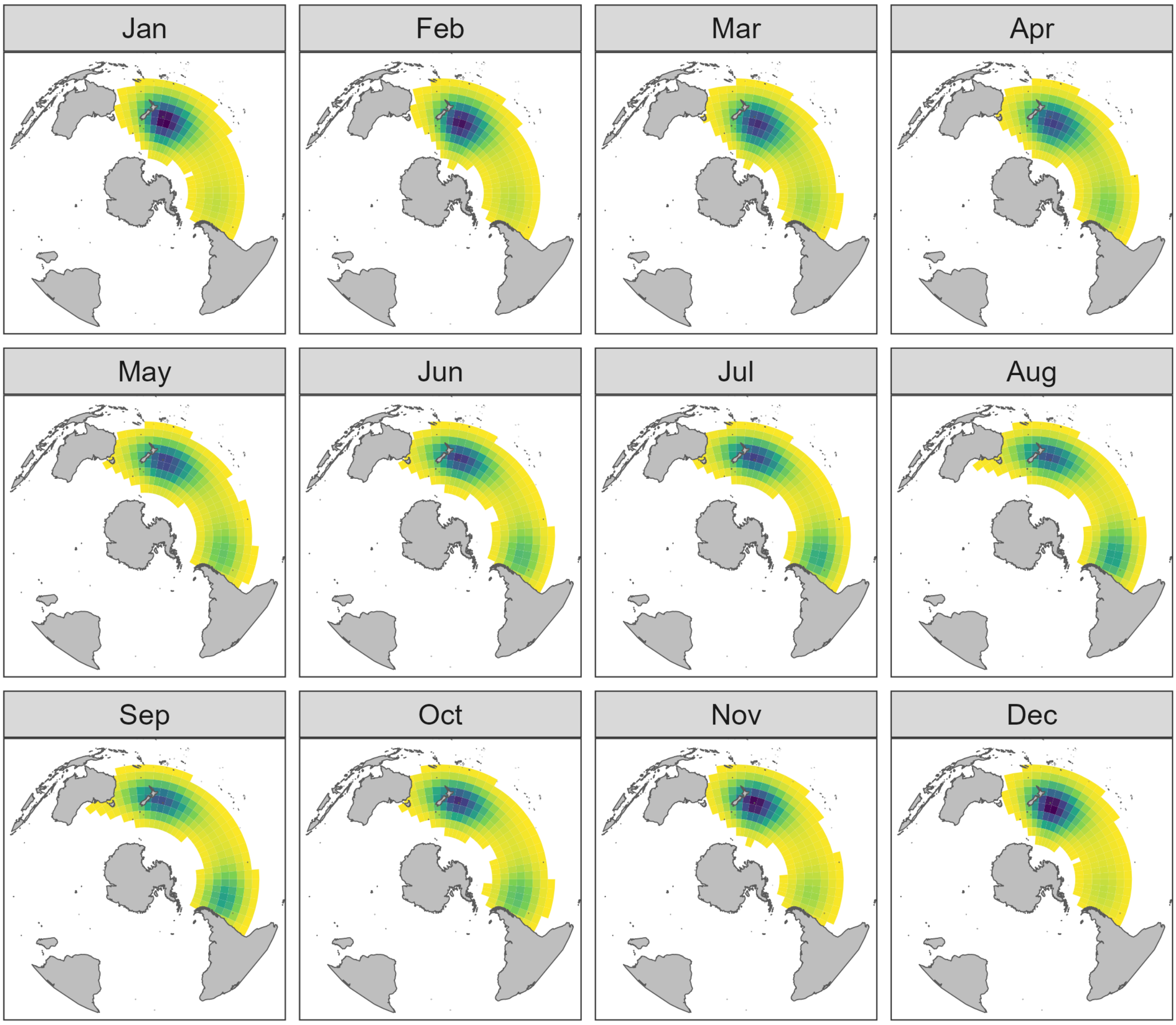

Figure 2: Relative density maps of adult Antipodean albatross (DQS) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 15: Input covariate probabilities for Antipodean albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.40
Feb	1.00	0.50
Mar	1.00	0.45
Apr	1.00	0.45
May	1.00	0.05
Jun	1.00	0.05
Jul	1.00	0.05
Aug	1.00	0.05
Sep	1.00	0.05
Oct	1.00	0.05
Nov	1.00	0.05
Dec	1.00	0.20

Table 16: Prior distributions of demographic parameters for Antipodean albatross.

Parameter	Distribution	Parameter *a*	Parameter *b*
Annual breeding pairs	log-normal	3383	0.050
Proportion of adults breeding	beta	0.45	91.3
Age at first reproduction	log-normal	13.9	0.142
Current adult survival rate	beta	0.907	138
Optimal adult survival rate	uniform	0.95	0.98

Table 17: Summary statistics for prior distributions of demographic parameters for Antipodean albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	3 381	3 065-3 725	Pairs
Proportion of adults breeding	0.45	0.35-0.55	Proportion
Age at first reproduction	13.9	10.5-18.2	Years
Current adult survival rate	0.91	0.85-0.95	Proportion
Optimal adult survival rate	0.97	0.95-0.98	Proportion
Population size (adults)	15 263	11 956-19 727	Individuals

3.3. Wandering albatross (*Diomedea exulans*)

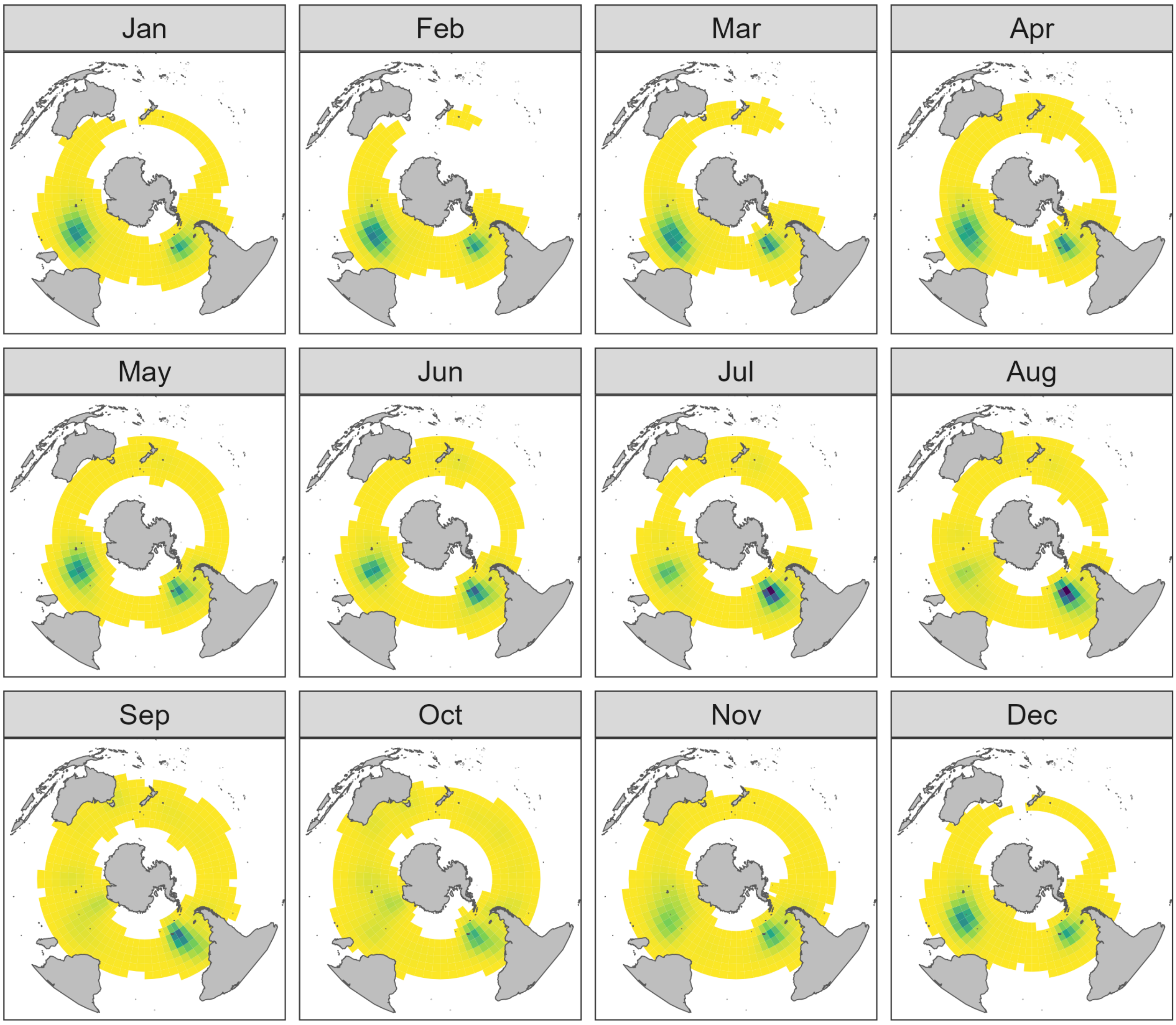

Figure 3: Relative density maps of adult Wandering albatross (DIX) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 18: Input covariate probabilities for Wandering albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.50
Feb	1.00	0.50
Mar	1.00	0.40
Apr	1.00	0.20
May	1.00	0.05
Jun	1.00	0.05
Jul	1.00	0.05
Aug	1.00	0.05
Sep	1.00	0.05
Oct	1.00	0.05
Nov	1.00	0.05
Dec	1.00	0.40

Table 19: Prior distributions of demographic parameters for Wandering albatross.

Parameter	Distribution	Parameter *a*	Parameter *b*
Annual breeding pairs	log-normal	1.013×10^4	0.050
Proportion of adults breeding	logit-normal	0.494	0.05
Age at first reproduction	log-normal	9.91	0.15
Current adult survival rate	beta	0.918	159
Optimal adult survival rate	uniform	0.95	0.98

Table 20: Summary statistics for prior distributions of demographic parameters for Wandering albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	10 131	9 175-11 134	Pairs
Proportion of adults breeding	0.49	0.40-0.59	Proportion
Age at first reproduction	9.9	7.3-13.3	Years
Current adult survival rate	0.92	0.87-0.96	Proportion
Optimal adult survival rate	0.97	0.95-0.98	Proportion
Population size (adults)	41 429	33 352-51 892	Individuals

3.4. Tristan albatross (*Diomedea dabbenena*)

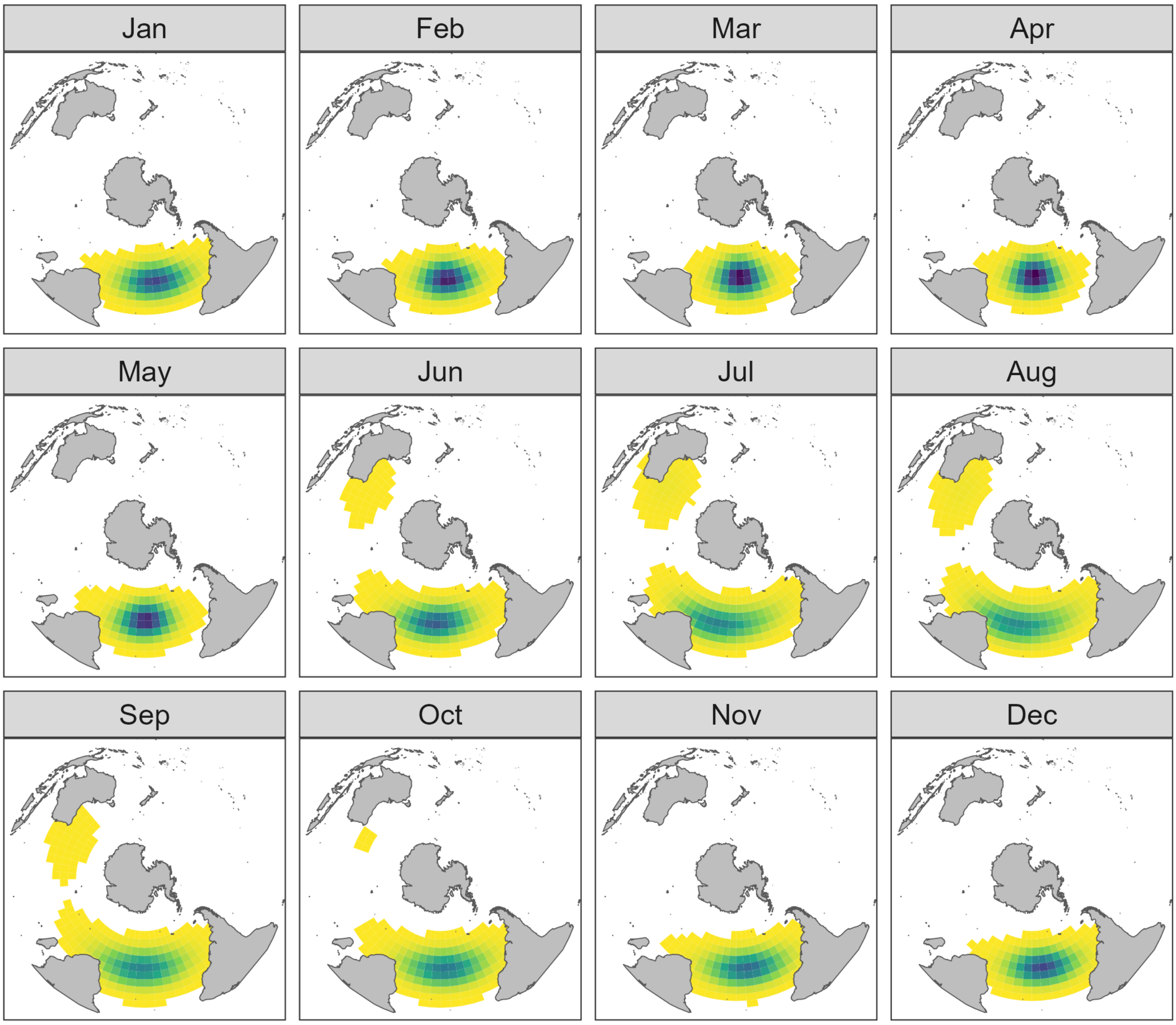

Figure 4: Relative density maps of adult Tristan albatross (DBN) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 21: Input covariate probabilities for Tristan albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.60
Feb	1.00	0.50
Mar	1.00	0.50
Apr	1.00	0.50
May	1.00	0.30
Jun	1.00	0.30
Jul	1.00	0.05
Aug	1.00	0.05
Sep	1.00	0.05
Oct	1.00	0.05
Nov	1.00	0.05
Dec	1.00	0.40

Table 22: Prior distributions of demographic parameters for Tristan albatross.

Parameter	Distribution	Parameter *a*	Parameter *b*
Annual breeding pairs	weibull	9.25	1710
Proportion of adults breeding	beta	0.349	51.3
Age at first reproduction	log-normal	9.18	0.177
Current adult survival rate	beta	0.948	1230
Optimal adult survival rate	uniform	0.95	0.98

Table 23: Summary statistics for prior distributions of demographic parameters for Tristan albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	1 623	1 146-1 973	Pairs
Proportion of adults breeding	0.35	0.23-0.48	Proportion
Age at first reproduction	9.2	6.5-12.7	Years
Current adult survival rate	0.95	0.93-0.96	Proportion
Optimal adult survival rate	0.96	0.95-0.98	Proportion
Population size (adults)	9 690	5 900-15 107	Individuals

3.5. Amsterdam albatross (*Diomedea amsterdamensis*)

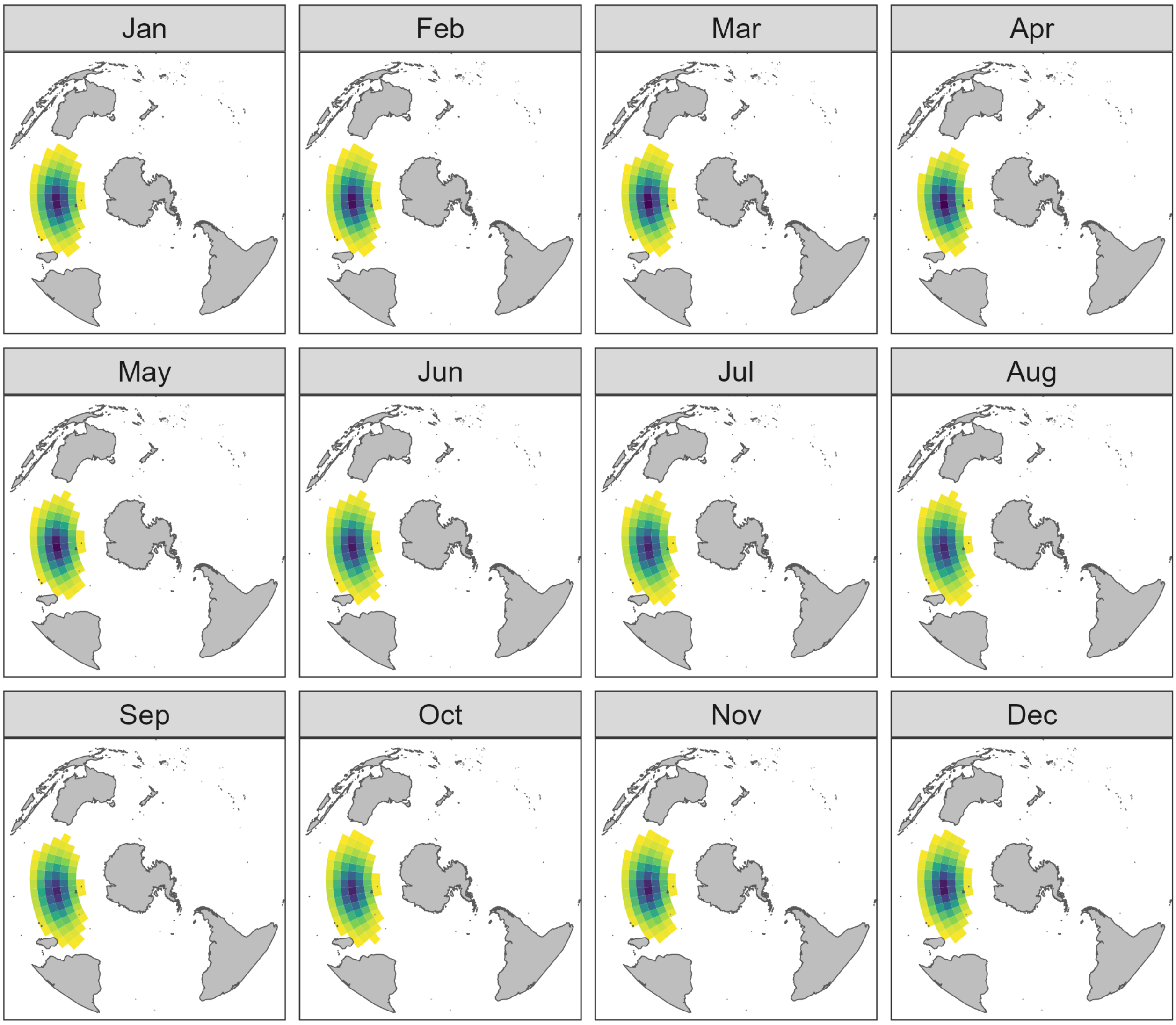

Figure 5: Relative density maps of adult Amsterdam albatross (DAM) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 24: Input covariate probabilities for Amsterdam albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.05
Feb	1.00	0.40
Mar	1.00	0.50
Apr	1.00	0.50
May	1.00	0.40
Jun	1.00	0.30
Jul	1.00	0.05
Aug	1.00	0.05
Sep	1.00	0.05
Oct	1.00	0.05
Nov	1.00	0.05
Dec	1.00	0.05

Table 25: Prior distributions of demographic parameters for Amsterdam albatross.

Parameter	Distribution	Parameter *a*	Parameter *b*
Annual breeding pairs	log-normal	60	0.100
Proportion of adults breeding	logit-normal	0.6	0.05
Age at first reproduction	log-normal	9.91	0.15
Current adult survival rate	logit-normal	0.971	0.001
Optimal adult survival rate	uniform	0.95	0.98

Table 26: Summary statistics for prior distributions of demographic parameters for Amsterdam albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	60	49-73	Pairs
Proportion of adults breeding	0.60	0.50-0.69	Proportion
Age at first reproduction	9.9	7.3-13.2	Years
Current adult survival rate	0.97	0.97-0.97	Proportion
Optimal adult survival rate	0.96	0.95-0.98	Proportion
Population size (adults)	202	156-260	Individuals

3.6. Southern royal albatross (*Diomedea epomophora*)

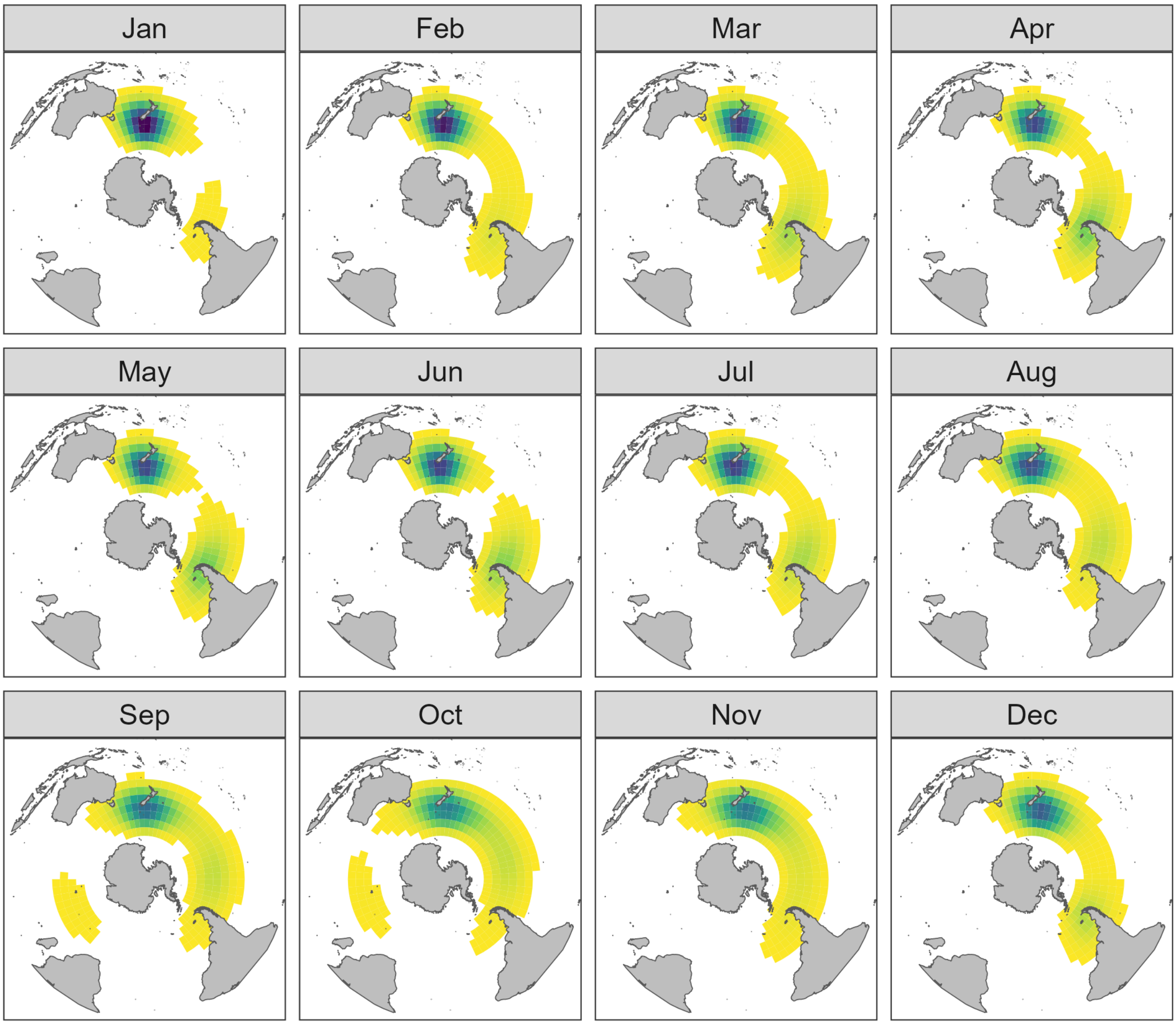

Figure 6: Relative density maps of adult Southern royal albatross (DIP) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 27: Input covariate probabilities for Southern royal albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.50
Feb	1.00	0.50
Mar	1.00	0.40
Apr	1.00	0.05
May	1.00	0.05
Jun	1.00	0.05
Jul	1.00	0.05
Aug	1.00	0.05
Sep	1.00	0.05
Oct	1.00	0.00
Nov	1.00	0.40
Dec	1.00	0.50

Table 28: Prior distributions of demographic parameters for Southern royal albatross.

Parameter	Distribution	Parameter *a*	Parameter *b*
Annual breeding pairs	log-normal	5814	0.070
Proportion of adults breeding	beta	0.531	22.2
Age at first reproduction	log-normal	9.19	0.189
Current adult survival rate	beta	0.92	138
Optimal adult survival rate	uniform	0.95	0.98

Table 29: Summary statistics for prior distributions of demographic parameters for Southern royal albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	5 818	5 043-6 653	Pairs
Proportion of adults breeding	0.53	0.33-0.72	Proportion
Age at first reproduction	9.2	6.2-13.0	Years
Current adult survival rate	0.92	0.87-0.96	Proportion
Optimal adult survival rate	0.96	0.95-0.98	Proportion
Population size (adults)	22 877	15 534-36 179	Individuals

3.7. Northern royal albatross (*Diomedea sanfordi*)

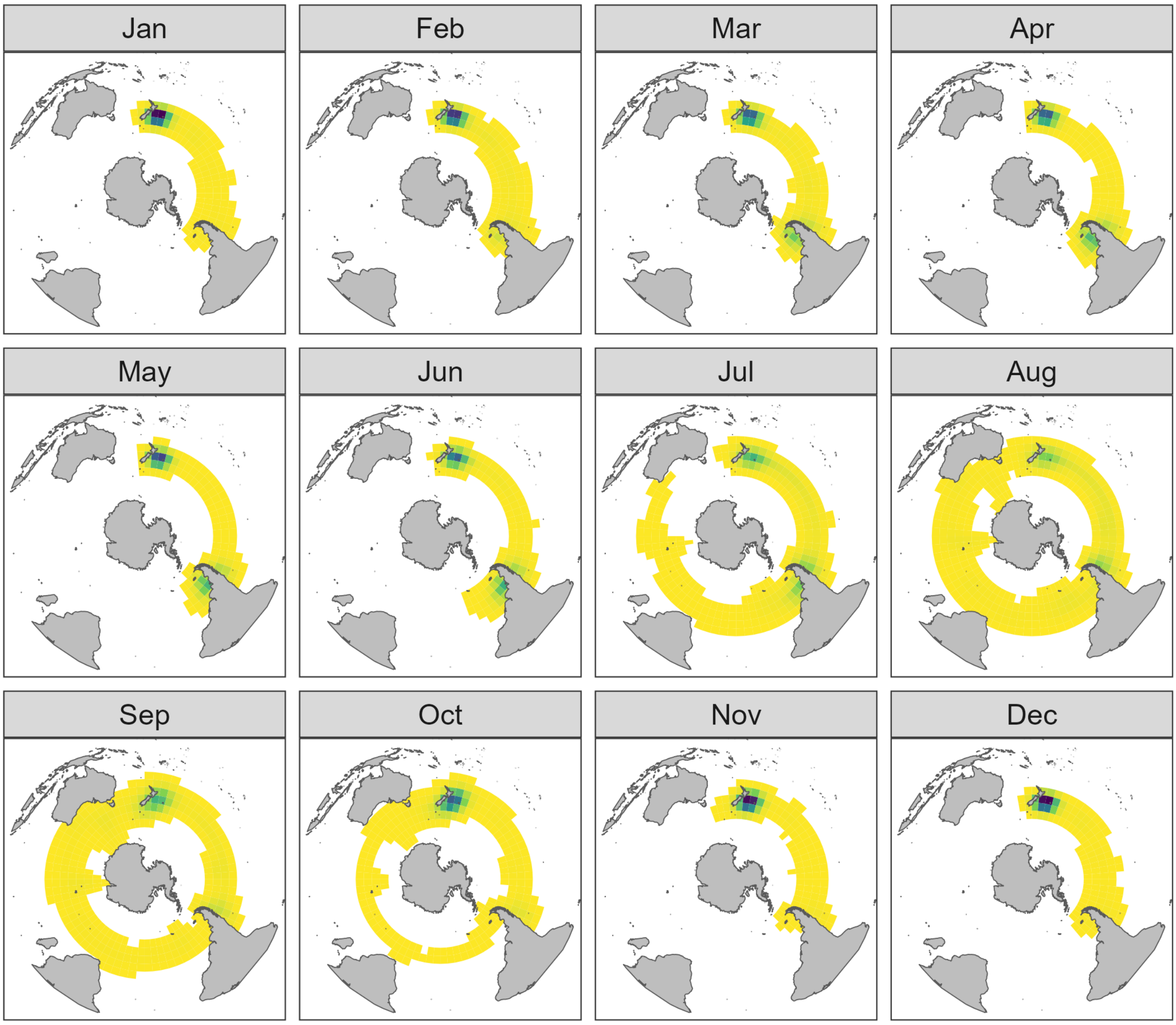

Figure 7: Relative density maps of adult Northern royal albatross (DIQ) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 30: Input covariate probabilities for Northern royal albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.50
Feb	1.00	0.40
Mar	1.00	0.30
Apr	1.00	0.05
May	1.00	0.05
Jun	1.00	0.05
Jul	1.00	0.05
Aug	1.00	0.05
Sep	1.00	0.00
Oct	1.00	0.40
Nov	1.00	0.50
Dec	1.00	0.50

Table 31: Prior distributions of demographic parameters for Northern royal albatross.

Parameter	Distribution	Parameter *a*	Parameter *b*
Annual breeding pairs	log-normal	4261	0.110
Proportion of adults breeding	beta	0.531	22.2
Age at first reproduction	log-normal	8.9	0.023
Current adult survival rate	beta	0.95	2260
Optimal adult survival rate	uniform	0.95	0.98

Table 32: Summary statistics for prior distributions of demographic parameters for Northern royal albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	4 257	3 413-5 239	Pairs
Proportion of adults breeding	0.53	0.33-0.73	Proportion
Age at first reproduction	8.9	8.5-9.3	Years
Current adult survival rate	0.95	0.94-0.96	Proportion
Optimal adult survival rate	0.97	0.95-0.98	Proportion
Population size (adults)	16 704	10 850-27 135	Individuals

3.8. Atlantic yellow-nosed albatross (*Thalassarche chlororhynchos*)

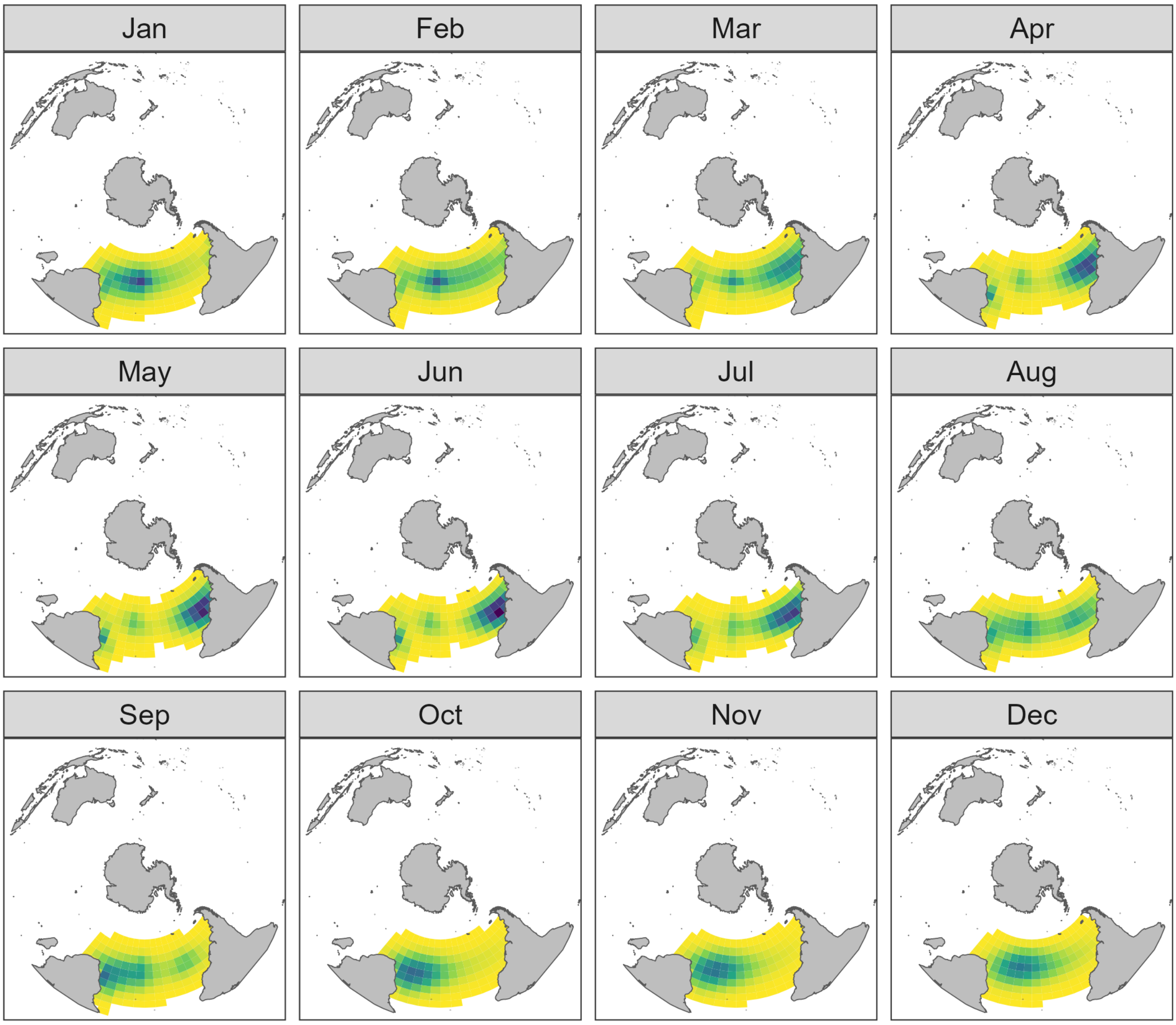

Figure 8: Relative density maps of adult Atlantic yellow-nosed albatross (DCR) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 33: Input covariate probabilities for Atlantic yellow-nosed albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.30
Feb	1.00	0.20
Mar	1.00	0.10
Apr	1.00	0.05
May	1.00	0.00
Jun	1.00	0.00
Jul	1.00	0.00
Aug	1.00	0.50
Sep	1.00	0.60
Oct	1.00	0.50
Nov	1.00	0.50
Dec	1.00	0.50

Table 34: Prior distributions of demographic parameters for Atlantic yellow-nosed albatross.

Parameter	Distribution	Parameter a	Parameter b
Annual breeding pairs	log-normal	2.68×10^4	0.100
Proportion of adults breeding	beta	0.596	4100
Age at first reproduction	log-normal	8.9	0.165
Current adult survival rate	beta	0.923	1470
Optimal adult survival rate	uniform	0.93	0.97

Table 35: Summary statistics for prior distributions of demographic parameters for Atlantic yellow-nosed albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	26 808	22 001-32 403	Pairs
Proportion of adults breeding	0.60	0.58-0.61	Proportion
Age at first reproduction	8.9	6.4-12.2	Years
Current adult survival rate	0.92	0.91-0.94	Proportion
Optimal adult survival rate	0.95	0.93-0.97	Proportion
Population size (adults)	89 992	73 818-108 954	Individuals

3.9. Indian yellow-nosed albatross (*Thalassarche carteri*)

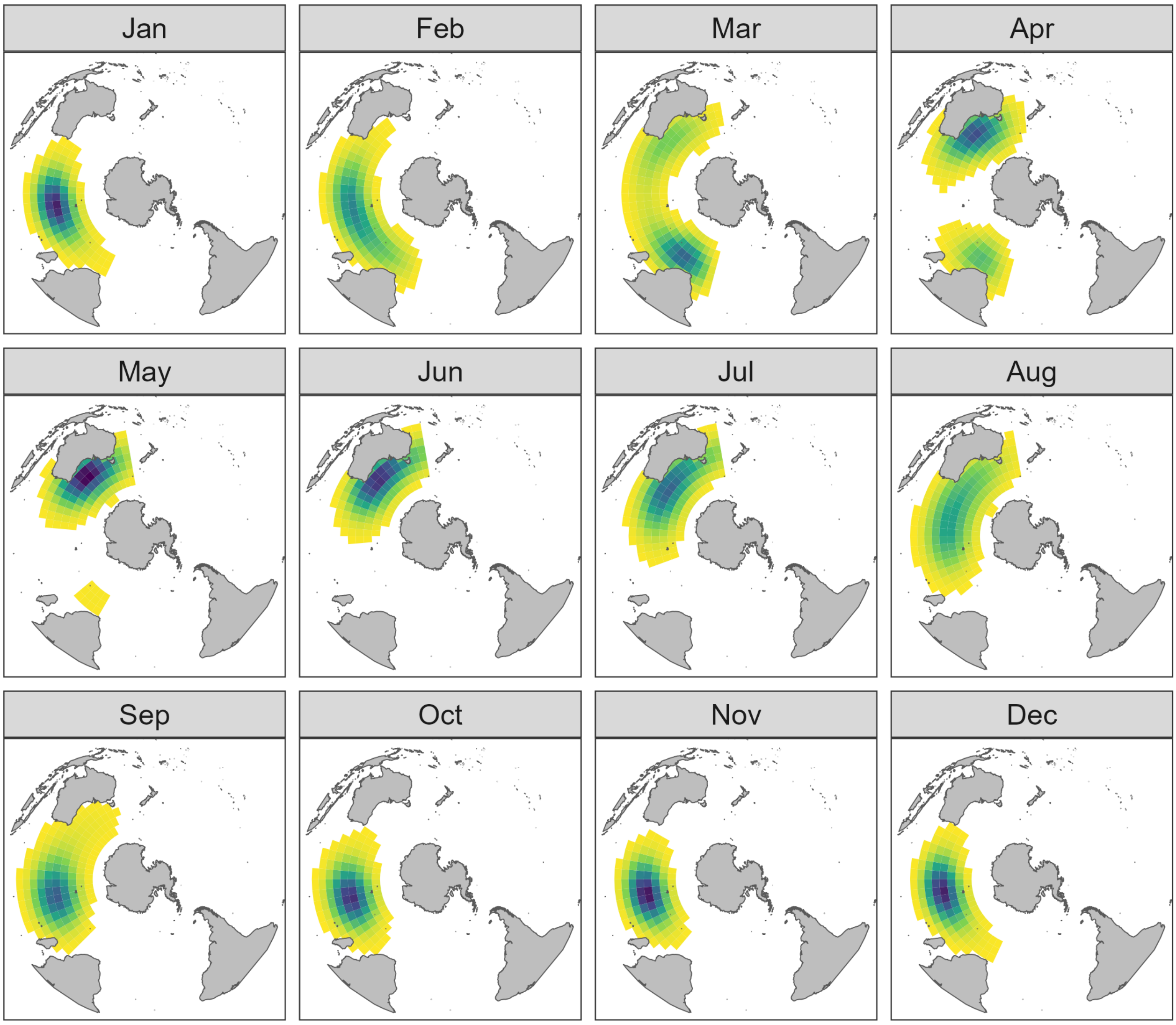

Figure 9: Relative density maps of adult Indian yellow-nosed albatross (TQH) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 36: Input covariate probabilities for Indian yellow-nosed albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.20
Feb	1.00	0.10
Mar	1.00	0.05
Apr	1.00	0.05
May	1.00	0.00
Jun	1.00	0.00
Jul	1.00	0.00
Aug	1.00	0.10
Sep	1.00	0.50
Oct	1.00	0.50
Nov	1.00	0.40
Dec	1.00	0.40

Table 37: Prior distributions of demographic parameters for Indian yellow-nosed albatross.

Parameter	Distribution	Parameter a	Parameter b
Annual breeding pairs	log-normal	3.3988×10^4	0.100
Proportion of adults breeding	logit-normal	0.596	0.05
Age at first reproduction	log-normal	8.9	0.165
Current adult survival rate	logit-normal	0.902	0.02
Optimal adult survival rate	uniform	0.93	0.97

Table 38: Summary statistics for prior distributions of demographic parameters for Indian yellow-nosed albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	34 002	27 855-41 039	Pairs
Proportion of adults breeding	0.60	0.49-0.69	Proportion
Age at first reproduction	8.9	6.3-12.1	Years
Current adult survival rate	0.90	0.86-0.93	Proportion
Optimal adult survival rate	0.95	0.93-0.97	Proportion
Population size (adults)	115 030	88 811-147 884	Individuals

3.10. Black-browed albatross (*Thalassarche melanophris*)

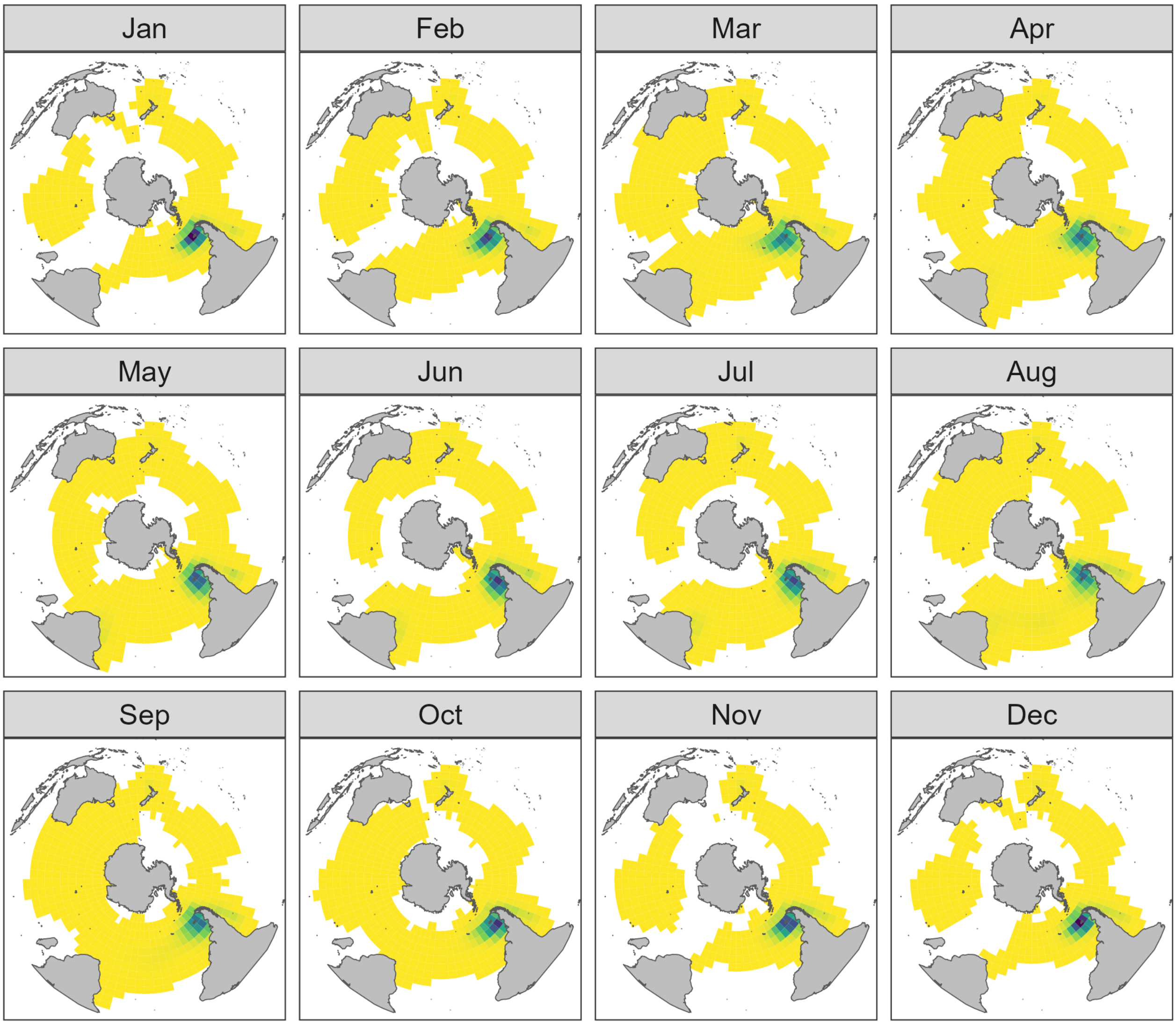

Figure 10: Relative density maps of adult Black-browed albatross (DIM) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 39: Input covariate probabilities for Black-browed albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.20
Feb	1.00	0.05
Mar	1.00	0.05
Apr	1.00	0.05
May	1.00	0.05
Jun	1.00	0.00
Jul	1.00	0.00
Aug	1.00	0.00
Sep	1.00	0.40
Oct	1.00	0.50
Nov	1.00	0.50
Dec	1.00	0.40

Table 40: Prior distributions of demographic parameters for Black-browed albatross.

Parameter	Distribution	Parameter *a*	Parameter *b*
Annual breeding pairs	log-normal	6.7096×10^5	0.050
Proportion of adults breeding	beta	0.844	174
Age at first reproduction	log-normal	9.91	0.15
Current adult survival rate	beta	0.931	147
Optimal adult survival rate	uniform	0.93	0.97

Table 41: Summary statistics for prior distributions of demographic parameters for Black-browed albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	671 369	607 619-738 568	Pairs
Proportion of adults breeding	0.84	0.79-0.89	Proportion
Age at first reproduction	9.9	7.3-13.1	Years
Current adult survival rate	0.93	0.88-0.97	Proportion
Optimal adult survival rate	0.95	0.93-0.97	Proportion
Population size (adults)	1 593 207	1 422 033-1 791 582	Individuals

3.11. Campbell black-browed albatross (*Thalassarche impavida*)

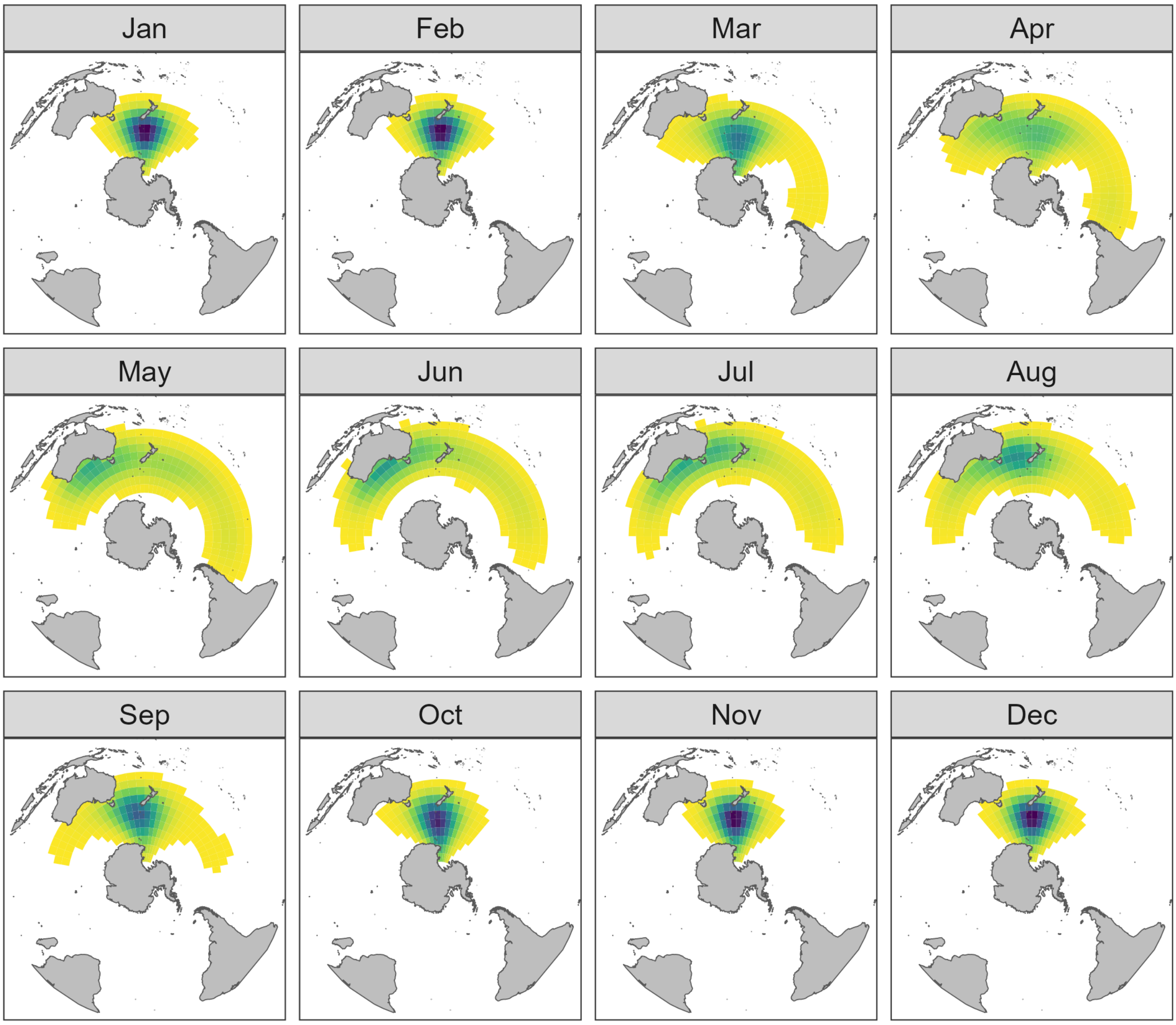

Figure 11: Relative density maps of adult Campbell black-browed albatross (TQW) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 42: Input covariate probabilities for Campbell black-browed albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.05
Feb	1.00	0.05
Mar	1.00	0.05
Apr	1.00	0.05
May	1.00	0.00
Jun	1.00	0.00
Jul	1.00	0.00
Aug	1.00	0.20
Sep	1.00	0.50
Oct	1.00	0.50
Nov	1.00	0.40
Dec	1.00	0.30

Table 43: Prior distributions of demographic parameters for Campbell black-browed albatross.

Parameter	Distribution	Parameter a	Parameter b
Annual breeding pairs	log-normal	1.4129×10^4	0.050
Proportion of adults breeding	logit-normal	0.9	0.05
Age at first reproduction	log-normal	9.19	0.189
Current adult survival rate	logit-normal	0.945	0.007
Optimal adult survival rate	uniform	0.93	0.97

Table 44: Summary statistics for prior distributions of demographic parameters for Campbell black-browed albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	14 119	12 768-15 549	Pairs
Proportion of adults breeding	0.89	0.75-0.96	Proportion
Age at first reproduction	9.2	6.2-13.1	Years
Current adult survival rate	0.94	0.93-0.96	Proportion
Optimal adult survival rate	0.95	0.93-0.97	Proportion
Population size (adults)	31 907	27 687-38 369	Individuals

3.12. Shy albatross (*Thalassarche cauta*)

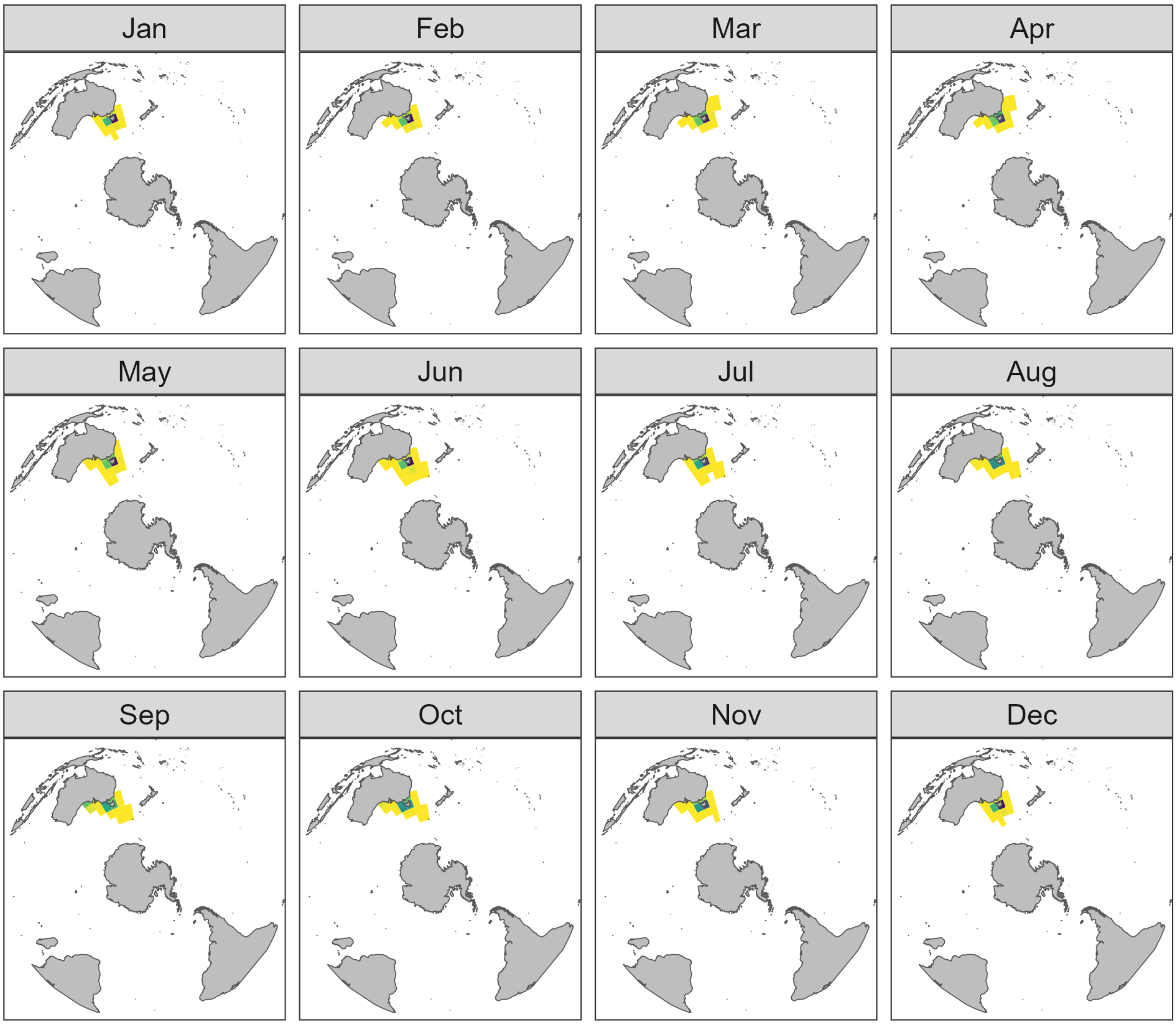

Figure 12: Relative density maps of adult Shy albatross (DCU) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 45: Input covariate probabilities for Shy albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.10
Feb	1.00	0.05
Mar	1.00	0.05
Apr	1.00	0.05
May	1.00	0.05
Jun	1.00	0.05
Jul	1.00	0.10
Aug	1.00	0.10
Sep	1.00	0.50
Oct	1.00	0.50
Nov	1.00	0.40
Dec	1.00	0.40

Table 46: Prior distributions of demographic parameters for Shy albatross.

Parameter	Distribution	Parameter a	Parameter b
Annual breeding pairs	log-normal	1.5335×10^4	0.100
Proportion of adults breeding	logit-normal	0.747	0.05
Age at first reproduction	log-normal	8.82	0.206
Current adult survival rate	beta	0.961	1790
Optimal adult survival rate	uniform	0.935	0.975

Table 47: Summary statistics for prior distributions of demographic parameters for Shy albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	15 339	12 529-18 518	Pairs
Proportion of adults breeding	0.74	0.64-0.83	Proportion
Age at first reproduction	8.8	5.8-13.0	Years
Current adult survival rate	0.96	0.95-0.97	Proportion
Optimal adult survival rate	0.95	0.94-0.97	Proportion
Population size (adults)	41 464	32 765-52 255	Individuals

3.13. New Zealand white-capped albatross (*Thalassarche cauta steadi*)

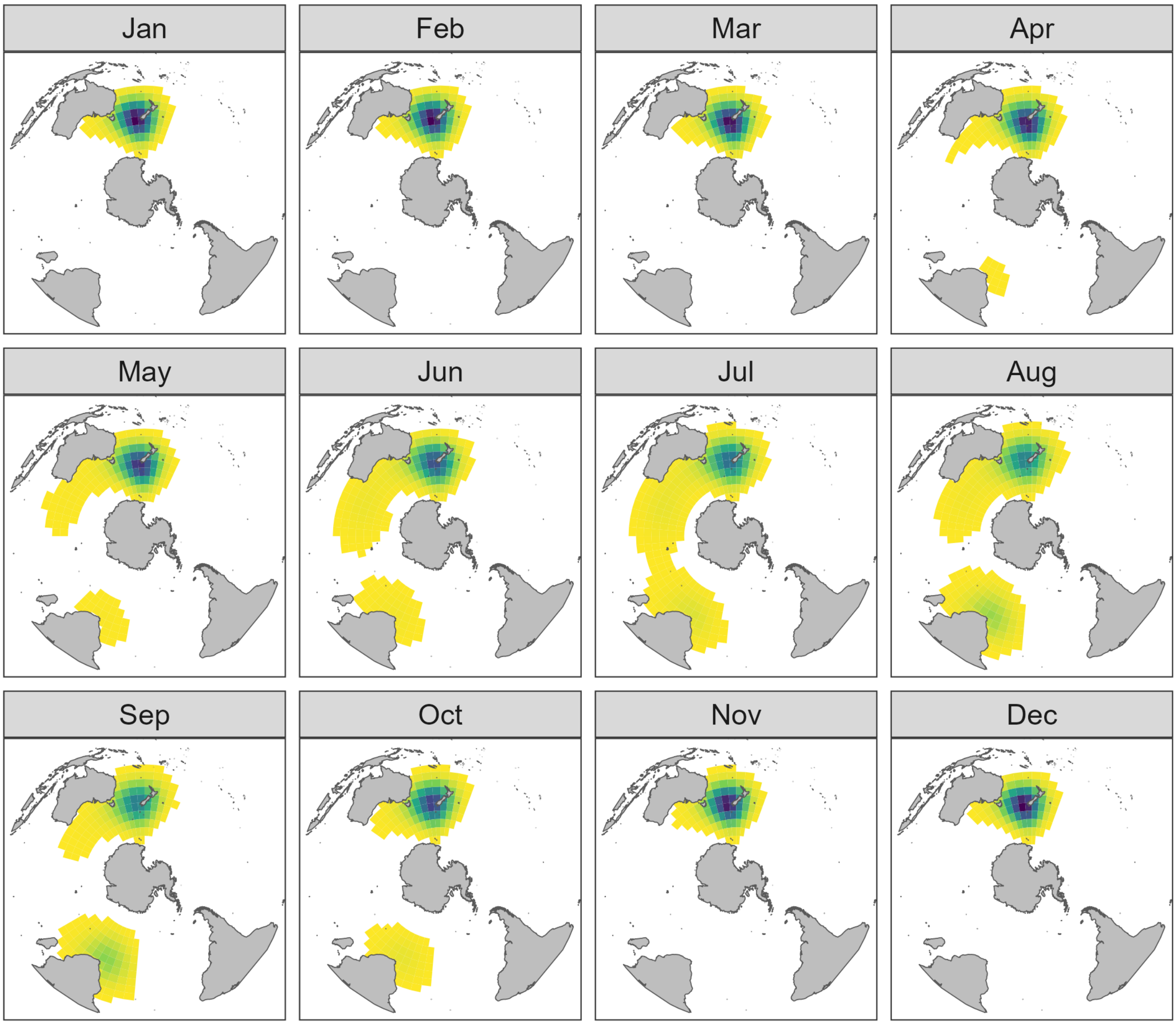

Figure 13: Relative density maps of adult New Zealand white-capped albatross (TWD) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 48: Input covariate probabilities for New Zealand white-capped albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.40
Feb	1.00	0.10
Mar	1.00	0.05
Apr	1.00	0.05
May	1.00	0.05
Jun	1.00	0.05
Jul	1.00	0.05
Aug	1.00	0.00
Sep	1.00	0.00
Oct	1.00	0.25
Nov	1.00	0.50
Dec	1.00	0.50

Table 49: Prior distributions of demographic parameters for New Zealand white-capped albatross.

Parameter	Distribution	Parameter *a*	Parameter *b*
Annual breeding pairs	log-normal	8.582×10^4	0.120
Proportion of adults breeding	beta	0.68	63.9
Age at first reproduction	log-normal	8.82	0.206
Current adult survival rate	logit-normal	0.92	0.01
Optimal adult survival rate	uniform	0.935	0.975

Table 50: Summary statistics for prior distributions of demographic parameters for New Zealand white-capped albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	85 808	67 480-107 569	Pairs
Proportion of adults breeding	0.68	0.56-0.79	Proportion
Age at first reproduction	8.8	5.8-13.0	Years
Current adult survival rate	0.92	0.90-0.94	Proportion
Optimal adult survival rate	0.95	0.94-0.97	Proportion
Population size (adults)	254 551	189 506-338 493	Individuals

3.14. Salvin's albatross (*Thalassarche salvini*)

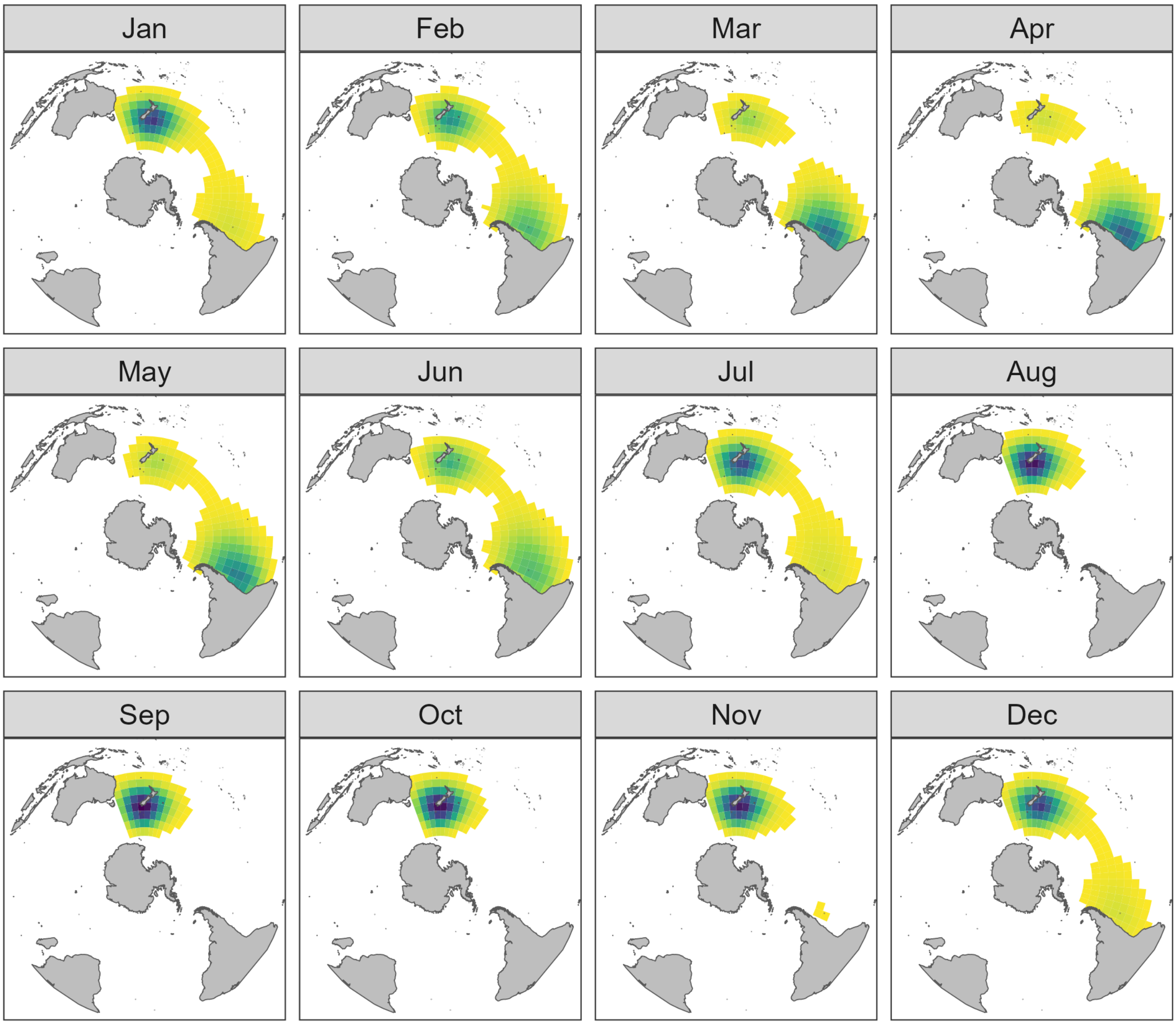

Figure 14: Relative density maps of adult Salvin's albatross (DKS) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 51: Input covariate probabilities for Salvin's albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.05
Feb	1.00	0.05
Mar	1.00	0.05
Apr	1.00	0.00
May	1.00	0.00
Jun	1.00	0.00
Jul	1.00	0.10
Aug	1.00	0.30
Sep	1.00	0.50
Oct	1.00	0.50
Nov	1.00	0.40
Dec	1.00	0.10

Table 52: Prior distributions of demographic parameters for Salvin's albatross.

Parameter	Distribution	Parameter a	Parameter b
Annual breeding pairs	log-normal	3.5242×10^4	0.050
Proportion of adults breeding	beta	0.821	29.7
Age at first reproduction	log-normal	11.2	0.145
Current adult survival rate	beta	0.951	9
Optimal adult survival rate	uniform	0.935	0.975

Table 53: Summary statistics for prior distributions of demographic parameters for Salvin's albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	35 238	31 960-38 794	Pairs
Proportion of adults breeding	0.82	0.67-0.94	Proportion
Age at first reproduction	11.2	8.4-14.7	Years
Current adult survival rate	0.95	0.76-1.00	Proportion
Optimal adult survival rate	0.95	0.94-0.97	Proportion
Population size (adults)	86 384	72 536-107 411	Individuals

3.15. Chatham Island albatross (*Thalassarche eremita*)

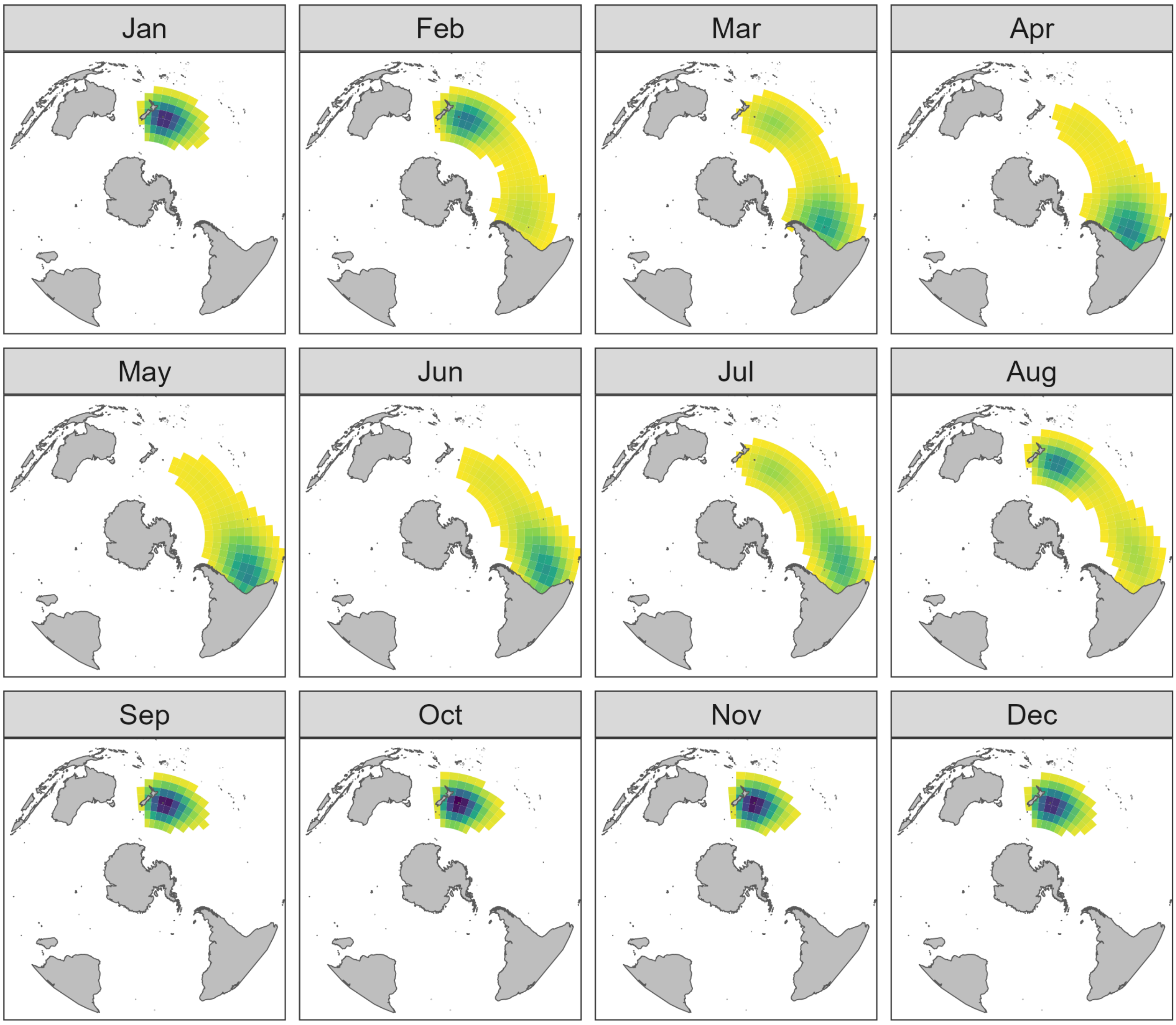

Figure 15: Relative density maps of adult Chatham Island albatross (DER) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 54: Input covariate probabilities for Chatham Island albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.10
Feb	1.00	0.05
Mar	1.00	0.05
Apr	1.00	0.05
May	1.00	0.00
Jun	1.00	0.00
Jul	1.00	0.20
Aug	1.00	0.40
Sep	1.00	0.50
Oct	1.00	0.50
Nov	1.00	0.40
Dec	1.00	0.30

Table 55: Prior distributions of demographic parameters for Chatham Island albatross.

Parameter	Distribution	Parameter *a*	Parameter *b*
Annual breeding pairs	log-normal	5294	0.010
Proportion of adults breeding	logit-normal	0.773	0.05
Age at first reproduction	log-normal	9.9	0.118
Current adult survival rate	logit-normal	0.925	0.03
Optimal adult survival rate	uniform	0.935	0.975

Table 56: Summary statistics for prior distributions of demographic parameters for Chatham Island albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	5 294	5 188-5 400	Pairs
Proportion of adults breeding	0.77	0.66-0.86	Proportion
Age at first reproduction	9.9	7.8-12.3	Years
Current adult survival rate	0.92	0.84-0.97	Proportion
Optimal adult survival rate	0.96	0.94-0.97	Proportion
Population size (adults)	13 835	12 342-16 052	Individuals

3.16. Grey-headed albatross (*Thalassarche chrysostoma*)

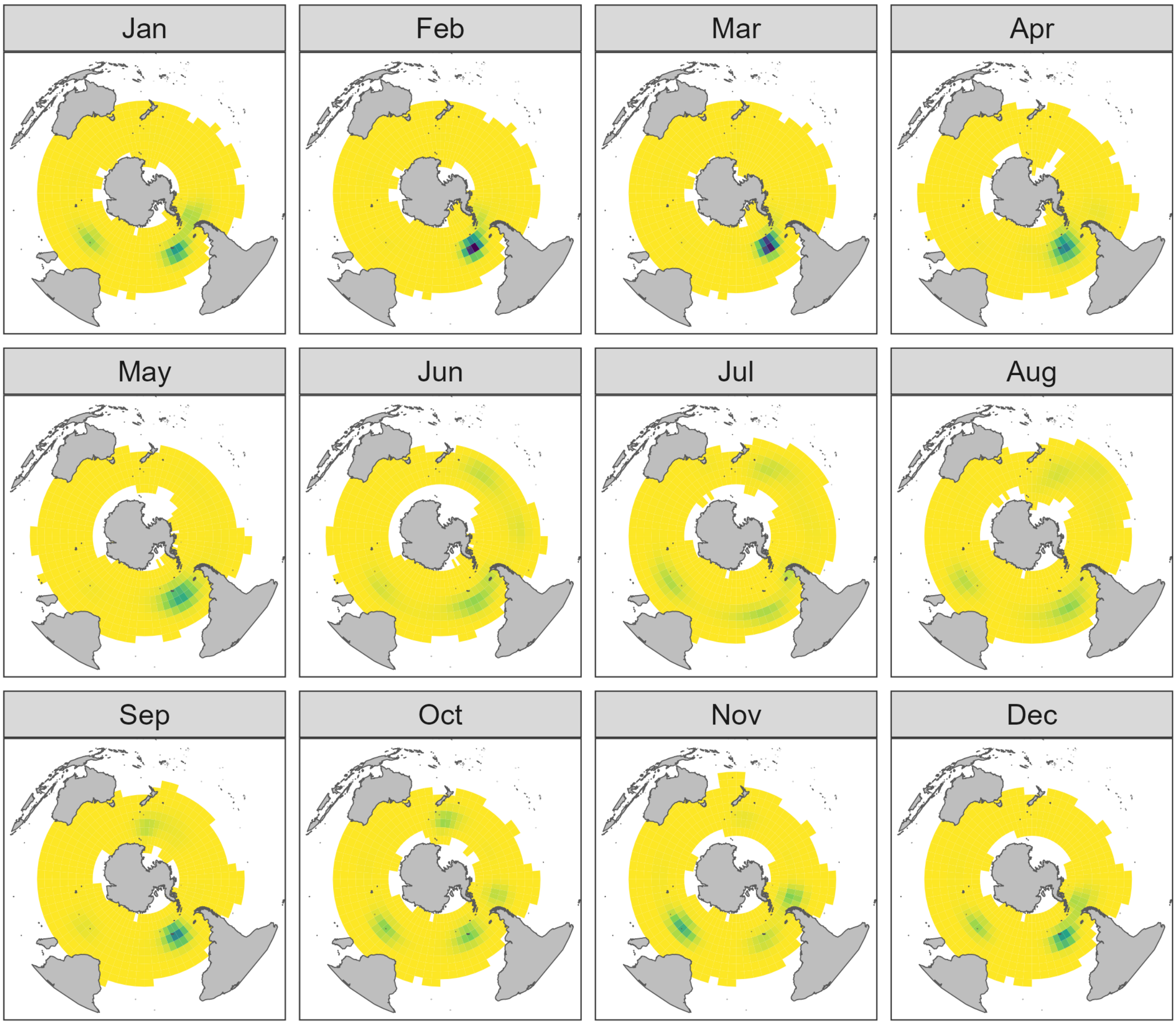

Figure 16: Relative density maps of adult Grey-headed albatross (DIC) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 57: Input covariate probabilities for Grey-headed albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.30
Feb	1.00	0.05
Mar	1.00	0.05
Apr	1.00	0.05
May	1.00	0.05
Jun	1.00	0.00
Jul	1.00	0.00
Aug	1.00	0.00
Sep	1.00	0.10
Oct	1.00	0.50
Nov	1.00	0.50
Dec	1.00	0.40

Table 58: Prior distributions of demographic parameters for Grey-headed albatross.

Parameter	Distribution	Parameter a	Parameter b
Annual breeding pairs	log-normal	6.3055×10^4	0.050
Proportion of adults breeding	beta	0.406	17.5
Age at first reproduction	log-normal	12.9	0.116
Current adult survival rate	beta	0.95	96.4
Optimal adult survival rate	uniform	0.95	0.98

Table 59: Summary statistics for prior distributions of demographic parameters for Grey-headed albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	63 034	57 057-69 504	Pairs
Proportion of adults breeding	0.41	0.19-0.63	Proportion
Age at first reproduction	12.9	10.2-16.1	Years
Current adult survival rate	0.95	0.90-0.98	Proportion
Optimal adult survival rate	0.96	0.95-0.98	Proportion
Population size (adults)	340 458	195 740-648 759	Individuals

3.17. Southern Buller's albatross (*Thalassarche bulleri bulleri*)

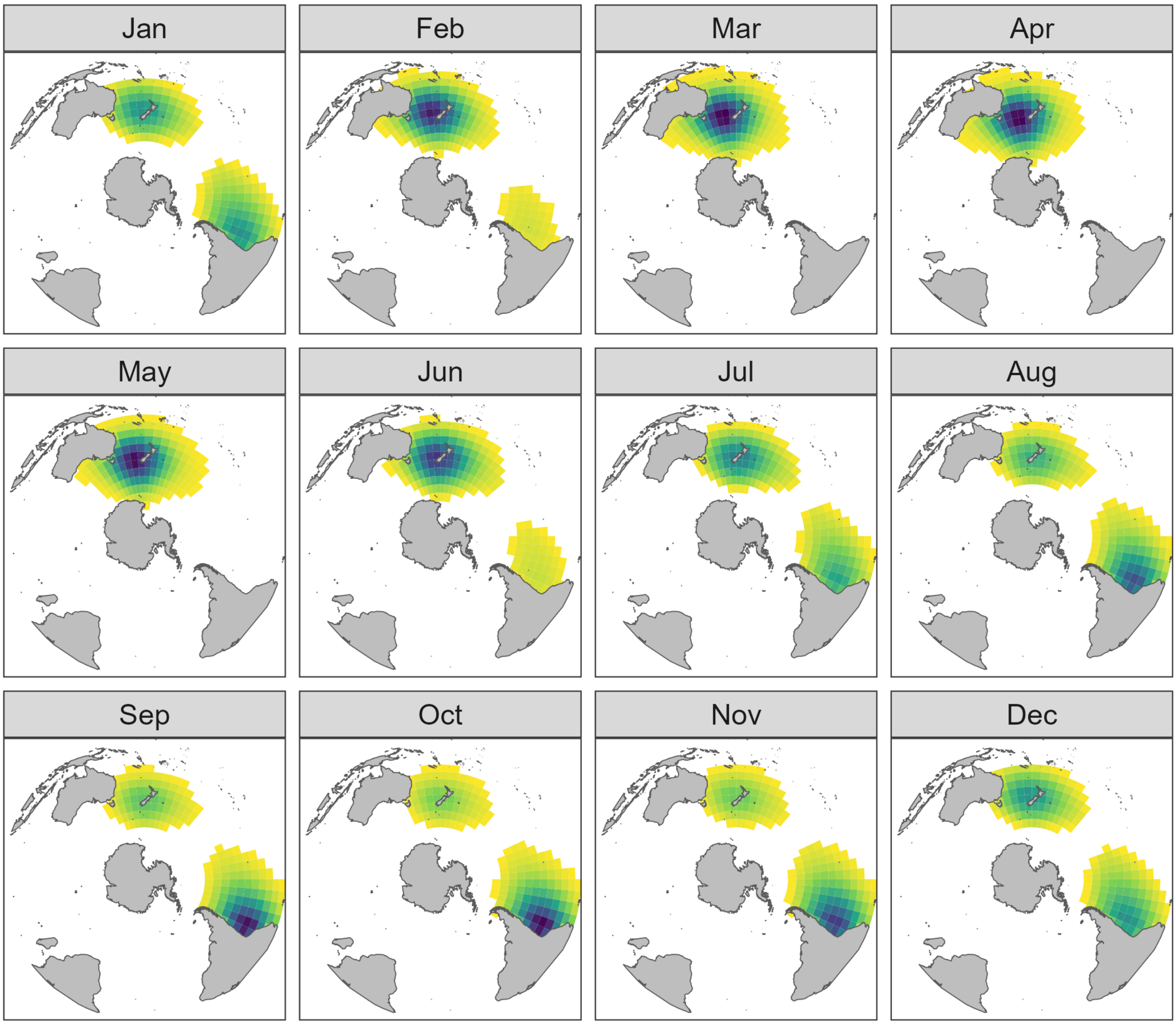

Figure 17: Relative density maps of adult Southern Buller's albatross (DSB) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 60: Input covariate probabilities for Southern Buller's albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.20
Feb	1.00	0.50
Mar	1.00	0.45
Apr	1.00	0.30
May	1.00	0.05
Jun	1.00	0.05
Jul	1.00	0.05
Aug	1.00	0.00
Sep	1.00	0.00
Oct	1.00	0.00
Nov	1.00	0.00
Dec	1.00	0.00

Table 61: Prior distributions of demographic parameters for Southern Buller's albatross.

Parameter	Distribution	Parameter *a*	Parameter *b*
Annual breeding pairs	log-normal	1.3493×10^4	0.050
Proportion of adults breeding	beta	0.804	34.9
Age at first reproduction	log-normal	11.9	0.125
Current adult survival rate	beta	0.891	106
Optimal adult survival rate	uniform	0.93	0.97

Table 62: Summary statistics for prior distributions of demographic parameters for Southern Buller's albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	13 499	12 211-14 878	Pairs
Proportion of adults breeding	0.80	0.66-0.92	Proportion
Age at first reproduction	11.9	9.2-15.1	Years
Current adult survival rate	0.89	0.83-0.94	Proportion
Optimal adult survival rate	0.95	0.93-0.97	Proportion
Population size (adults)	33 852	28 455-41 829	Individuals

3.18. Northern Buller's albatross (*Thalassarche bulleri platei*)

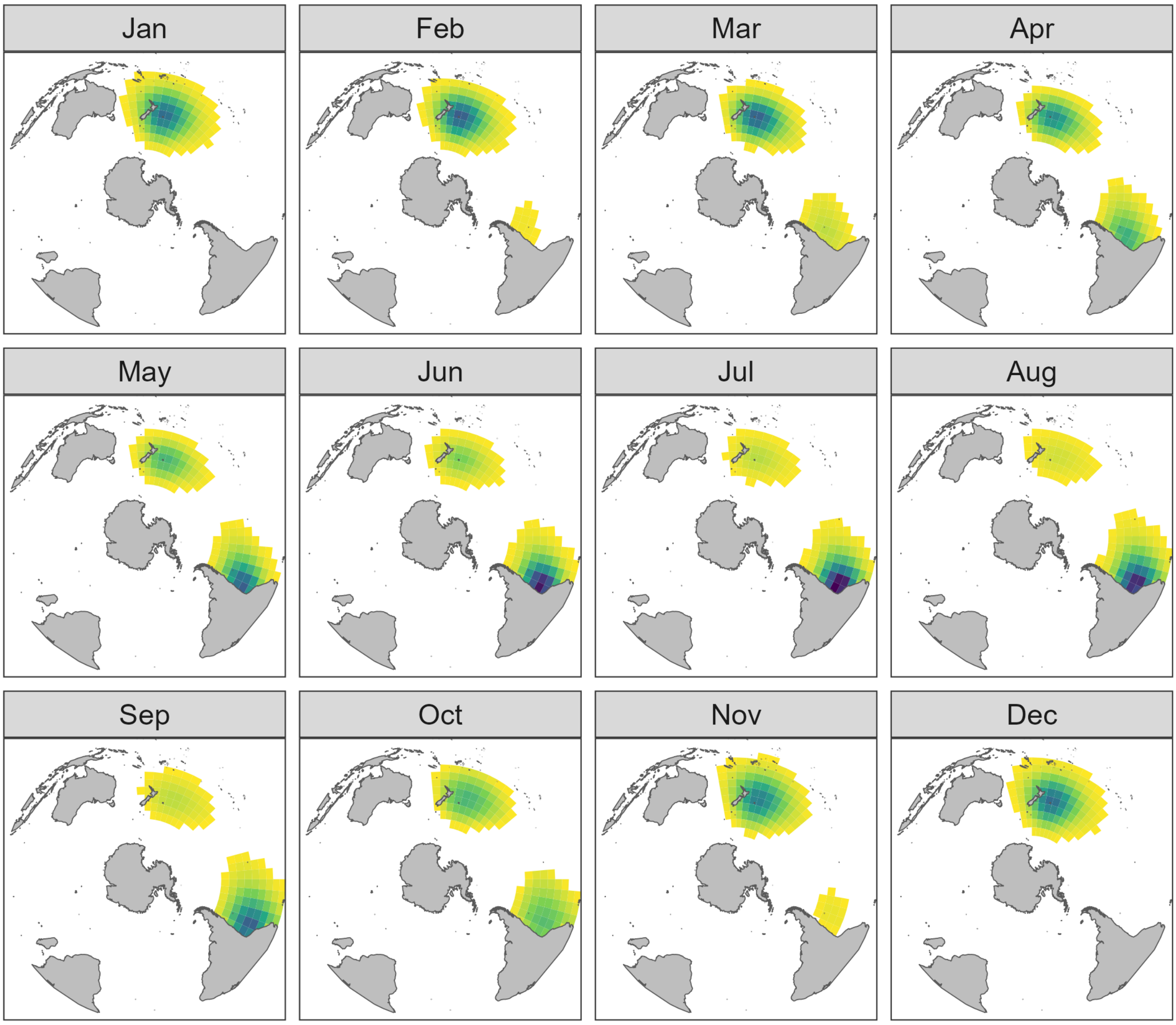

Figure 18: Relative density maps of adult Northern Buller's albatross (DNB) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 63: Input covariate probabilities for Northern Buller's albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.45
Feb	1.00	0.40
Mar	1.00	0.05
Apr	1.00	0.05
May	1.00	0.05
Jun	1.00	0.00
Jul	1.00	0.00
Aug	1.00	0.00
Sep	1.00	0.00
Oct	1.00	0.00
Nov	1.00	0.40
Dec	1.00	0.50

Table 64: Prior distributions of demographic parameters for Northern Buller's albatross.

Parameter	Distribution	Parameter a	Parameter b
Annual breeding pairs	log-normal	1.9354×10^4	0.050
Proportion of adults breeding	logit-normal	0.8	0.05
Age at first reproduction	log-normal	11.9	0.125
Current adult survival rate	logit-normal	0.925	0.025
Optimal adult survival rate	uniform	0.93	0.97

Table 65: Summary statistics for prior distributions of demographic parameters for Northern Buller's albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	19 362	17 529-21 341	Pairs
Proportion of adults breeding	0.80	0.69-0.88	Proportion
Age at first reproduction	11.9	9.3-15.1	Years
Current adult survival rate	0.92	0.86-0.96	Proportion
Optimal adult survival rate	0.95	0.93-0.97	Proportion
Population size (adults)	48 877	41 987-58 026	Individuals

3.19. Sooty albatross (*Phoebetria fusca*)

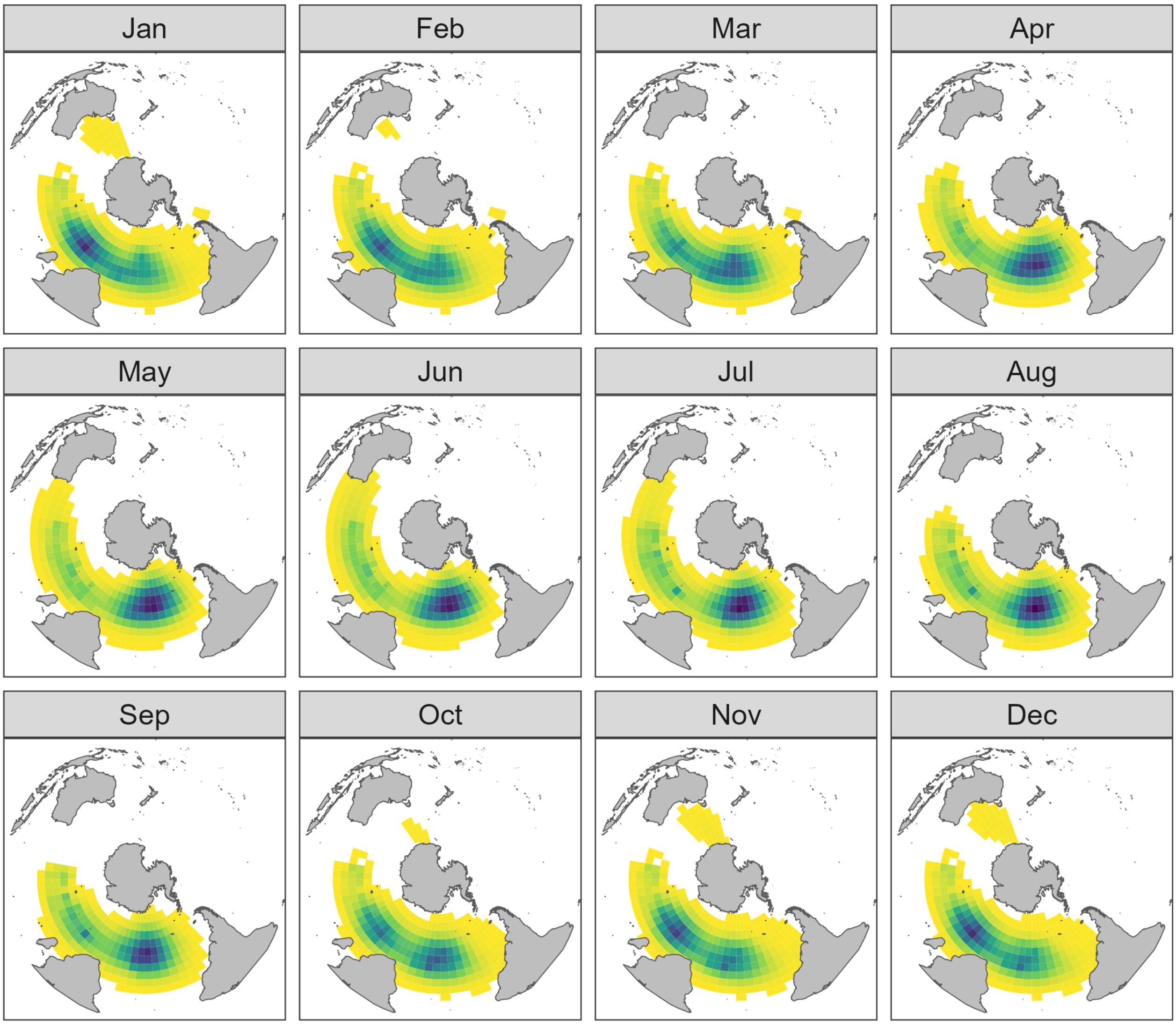

Figure 19: Relative density maps of adult Sooty albatross (PHU) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 66: Input covariate probabilities for Sooty albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.20
Feb	1.00	0.05
Mar	1.00	0.05
Apr	1.00	0.05
May	1.00	0.05
Jun	1.00	0.00
Jul	1.00	0.00
Aug	1.00	0.50
Sep	1.00	0.70
Oct	1.00	0.70
Nov	1.00	0.50
Dec	1.00	0.50

Table 67: Prior distributions of demographic parameters for Sooty albatross.

Parameter	Distribution	Parameter *a*	Parameter *b*
Annual breeding pairs	weibull	23.2	13660
Proportion of adults breeding	logit-normal	0.73	0.05
Age at first reproduction	log-normal	9.2	0.189
Current adult survival rate	logit-normal	0.92	0.025
Optimal adult survival rate	uniform	0.95	0.98

Table 68: Summary statistics for prior distributions of demographic parameters for Sooty albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	13 359	11 705-14 451	Pairs
Proportion of adults breeding	0.73	0.62-0.82	Proportion
Age at first reproduction	9.2	6.3-13.1	Years
Current adult survival rate	0.92	0.85-0.96	Proportion
Optimal adult survival rate	0.97	0.95-0.98	Proportion
Population size (adults)	36 871	30 880-44 041	Individuals

3.20. Light-mantled sooty albatross (*Phoebetria palpebrata*)

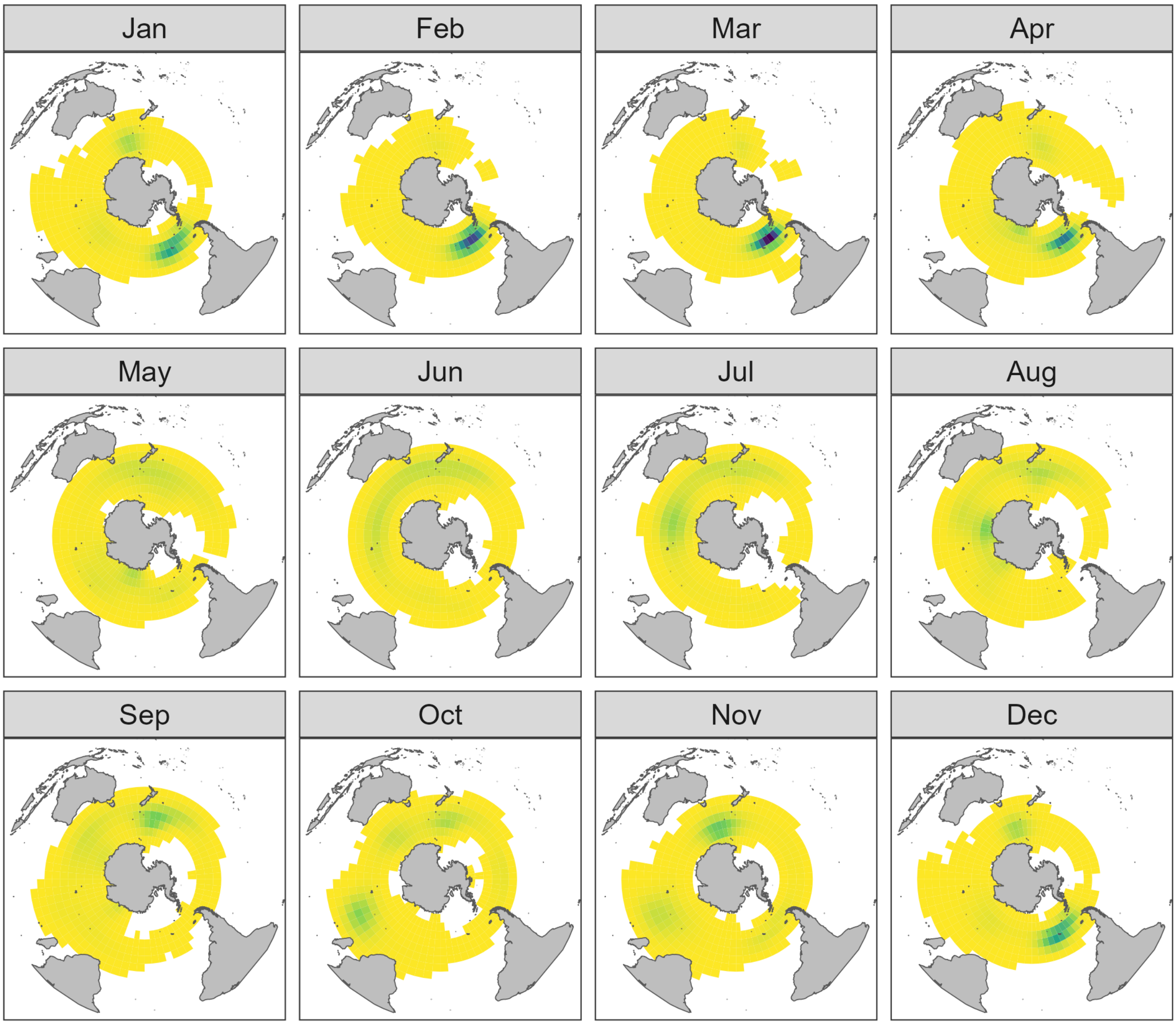

Figure 20: Relative density maps of adult Light-mantled sooty albatross (PHE) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 69: Input covariate probabilities for Light-mantled sooty albatross: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.40
Feb	1.00	0.10
Mar	1.00	0.05
Apr	1.00	0.05
May	1.00	0.05
Jun	1.00	0.05
Jul	1.00	0.00
Aug	1.00	0.00
Sep	1.00	0.10
Oct	1.00	0.50
Nov	1.00	0.50
Dec	1.00	0.40

Table 70: Prior distributions of demographic parameters for Light-mantled sooty albatross.

Parameter	Distribution	Parameter *a*	Parameter *b*
Annual breeding pairs	log-normal	2.0927×10^4	0.100
Proportion of adults breeding	beta	0.73	15.8
Age at first reproduction	log-normal	9.2	0.189
Current adult survival rate	beta	0.93	1.03×10^4
Optimal adult survival rate	uniform	0.95	0.98

Table 71: Summary statistics for prior distributions of demographic parameters for Light-mantled sooty albatross.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	20 905	17 136-25 231	Pairs
Proportion of adults breeding	0.73	0.49-0.91	Proportion
Age at first reproduction	9.2	6.3-13.1	Years
Current adult survival rate	0.93	0.92-0.93	Proportion
Optimal adult survival rate	0.97	0.95-0.98	Proportion
Population size (adults)	58 790	42 233-88 017	Individuals

3.21. Grey petrel (*Procellaria cinerea*)

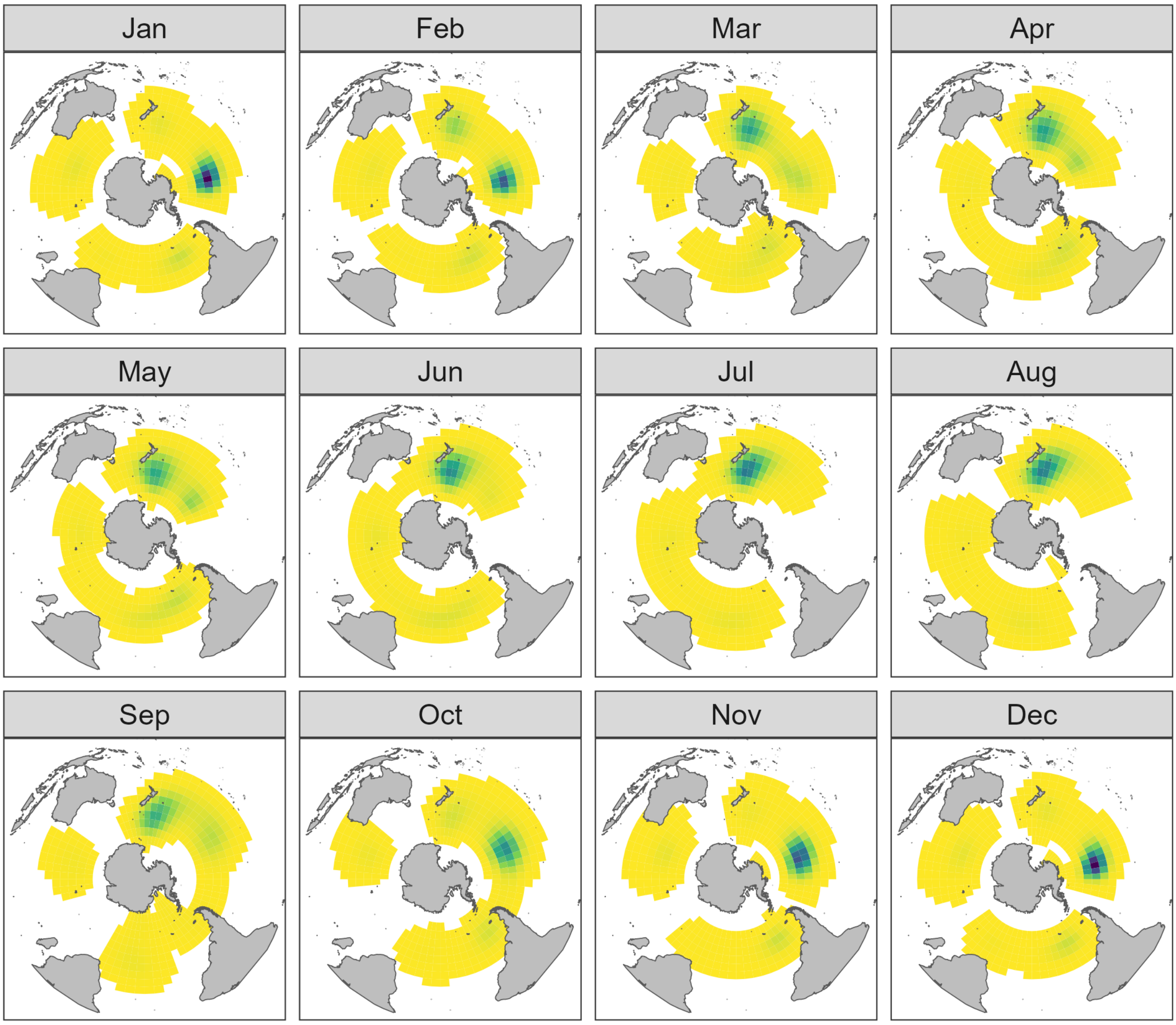

Figure 21: Relative density maps of adult Grey petrel (PCI) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 72: Input covariate probabilities for Grey petrel: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.00
Feb	1.00	0.50
Mar	1.00	0.50
Apr	1.00	0.50
May	1.00	0.40
Jun	1.00	0.30
Jul	1.00	0.05
Aug	1.00	0.05
Sep	1.00	0.05
Oct	1.00	0.05
Nov	1.00	0.05
Dec	1.00	0.00

Table 73: Prior distributions of demographic parameters for Grey petrel.

Parameter	Distribution	Parameter a	Parameter b
Annual breeding pairs	log-normal	1.05617×10^5	0.150
Proportion of adults breeding	logit-normal	0.9	0.05
Age at first reproduction	log-normal	6.94	0.142
Current adult survival rate	logit-normal	0.897	0.025
Optimal adult survival rate	uniform	0.92	0.95

Table 74: Summary statistics for prior distributions of demographic parameters for Grey petrel.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	105 660	77 870-140 105	Pairs
Proportion of adults breeding	0.89	0.75-0.96	Proportion
Age at first reproduction	6.9	5.2-9.0	Years
Current adult survival rate	0.89	0.84-0.94	Proportion
Optimal adult survival rate	0.94	0.92-0.95	Proportion
Population size (adults)	238 644	172 197-326 322	Individuals

3.22. Black petrel (*Procellaria parkinsoni*)

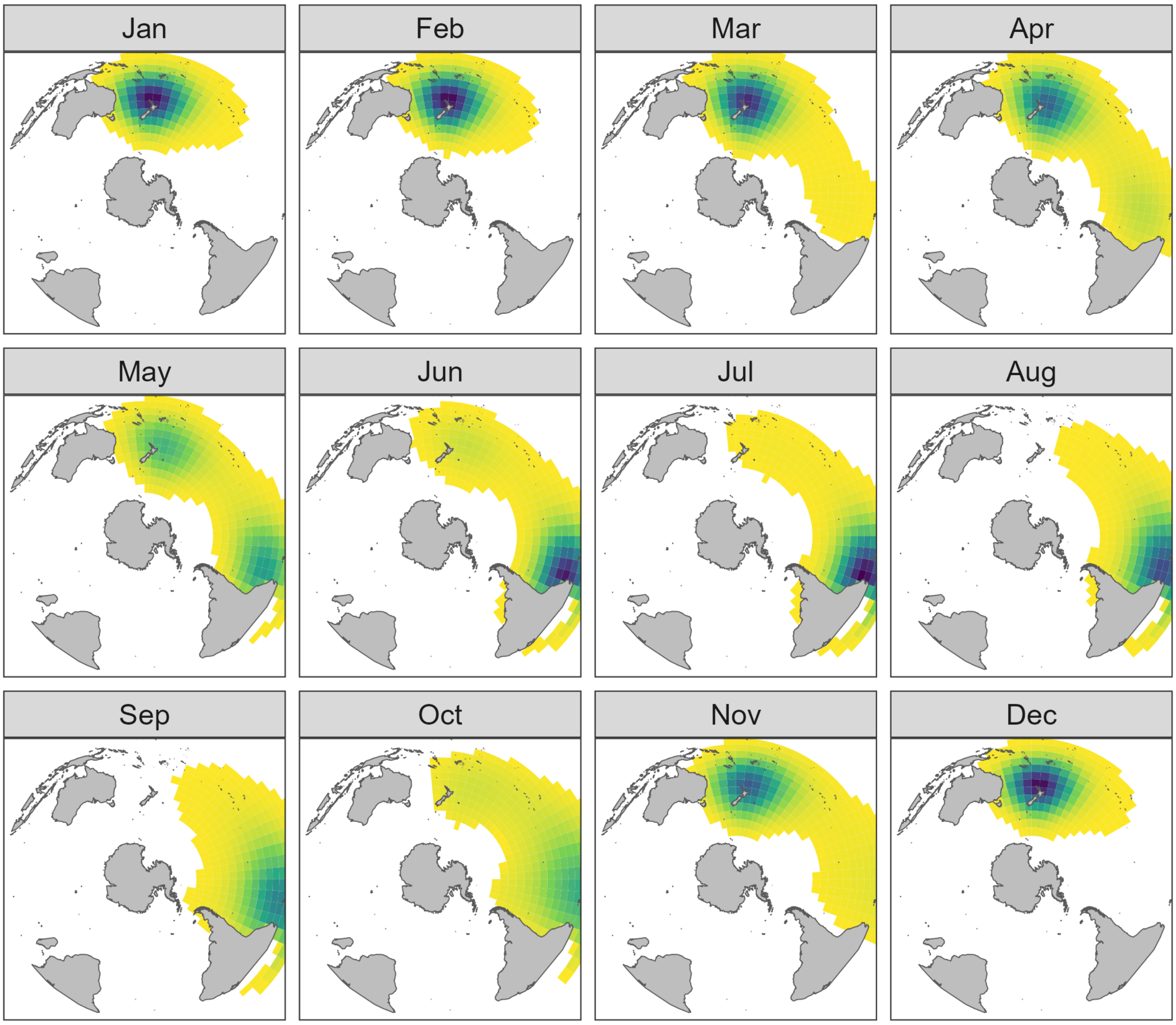

Figure 22: Relative density maps of adult Black petrel (PRK) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 75: Input covariate probabilities for Black petrel: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.50
Feb	1.00	0.40
Mar	1.00	0.05
Apr	1.00	0.05
May	1.00	0.05
Jun	0.80	0.05
Jul	0.80	0.00
Aug	0.80	0.00
Sep	0.80	0.00
Oct	0.80	0.05
Nov	1.00	0.30
Dec	1.00	0.50

Table 76: Prior distributions of demographic parameters for Black petrel.

Parameter	Distribution	Parameter *a*	Parameter *b*
Annual breeding pairs	log-normal	5456	0.057
Proportion of adults breeding	beta	0.61	143
Age at first reproduction	log-normal	7.4	0.031
Current adult survival rate	beta	0.864	2150
Optimal adult survival rate	uniform	0.92	0.95

Table 77: Summary statistics for prior distributions of demographic parameters for Black petrel.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	5 458	4 873-6 083	Pairs
Proportion of adults breeding	0.61	0.53-0.69	Proportion
Age at first reproduction	7.4	7.0-7.9	Years
Current adult survival rate	0.86	0.85-0.88	Proportion
Optimal adult survival rate	0.93	0.92-0.95	Proportion
Population size (adults)	17 981	15 118-21 433	Individuals

3.23. Westland petrel (*Procellaria westlandica*)

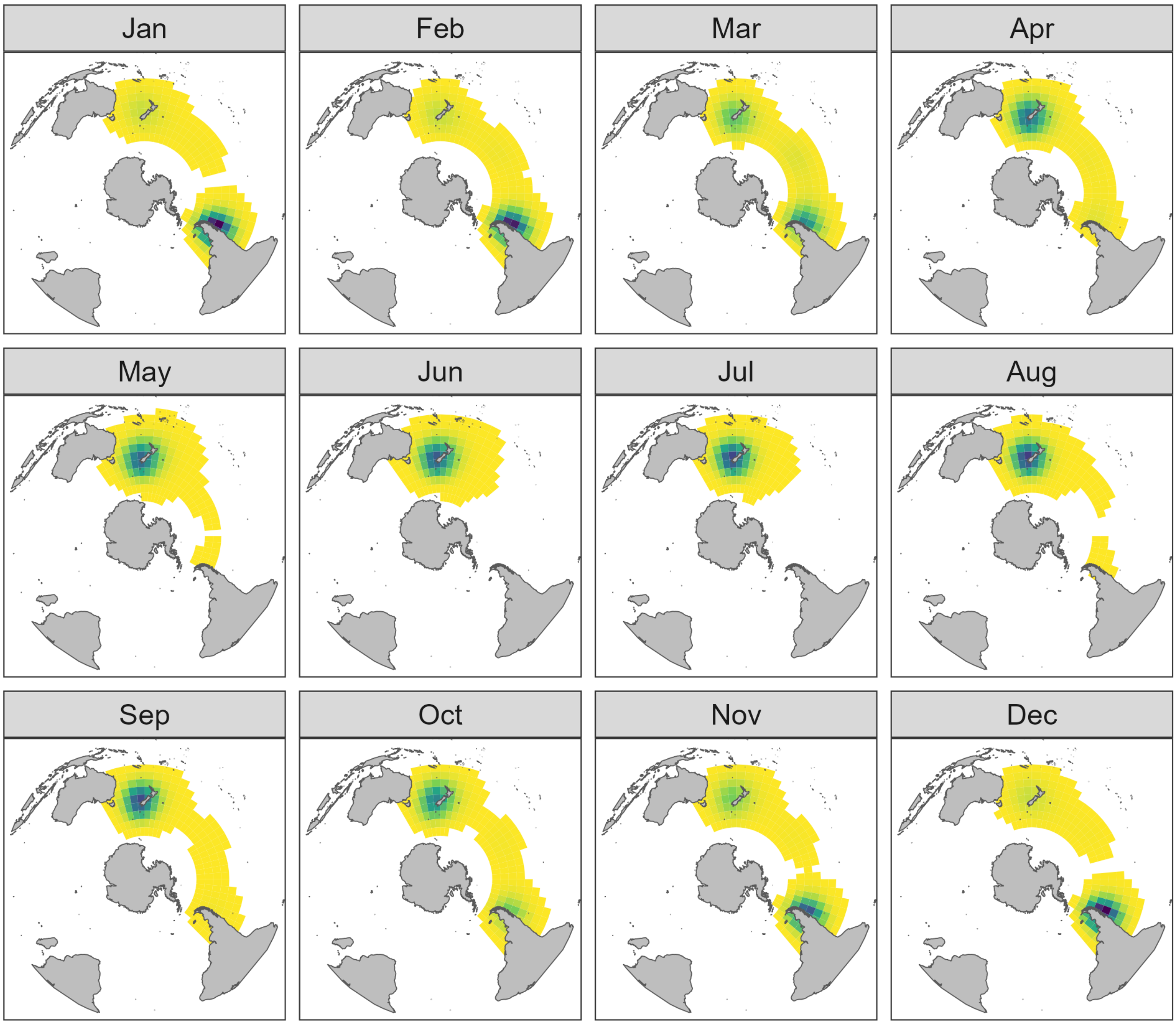

Figure 23: Relative density maps of adult Westland petrel (PCW) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 78: Input covariate probabilities for Westland petrel: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.00
Feb	1.00	0.15
Mar	1.00	0.30
Apr	1.00	0.40
May	1.00	0.50
Jun	1.00	0.50
Jul	1.00	0.45
Aug	1.00	0.40
Sep	1.00	0.05
Oct	1.00	0.05
Nov	1.00	0.05
Dec	1.00	0.00

Table 79: Prior distributions of demographic parameters for Westland petrel.

Parameter	Distribution	Parameter *a*	Parameter *b*
Annual breeding pairs	log-normal	6223	0.061
Proportion of adults breeding	beta	0.48	45.4
Age at first reproduction	log-normal	6.95	0.16
Current adult survival rate	beta	0.954	190
Optimal adult survival rate	uniform	0.93	0.96

Table 80: Summary statistics for prior distributions of demographic parameters for Westland petrel.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	6 225	5 514-6 987	Pairs
Proportion of adults breeding	0.48	0.34-0.63	Proportion
Age at first reproduction	7.0	5.0-9.4	Years
Current adult survival rate	0.95	0.92-0.98	Proportion
Optimal adult survival rate	0.95	0.93-0.96	Proportion
Population size (adults)	26 630	19 309-37 730	Individuals

3.24. White-chinned petrel (*Procellaria aequinoctialis*)

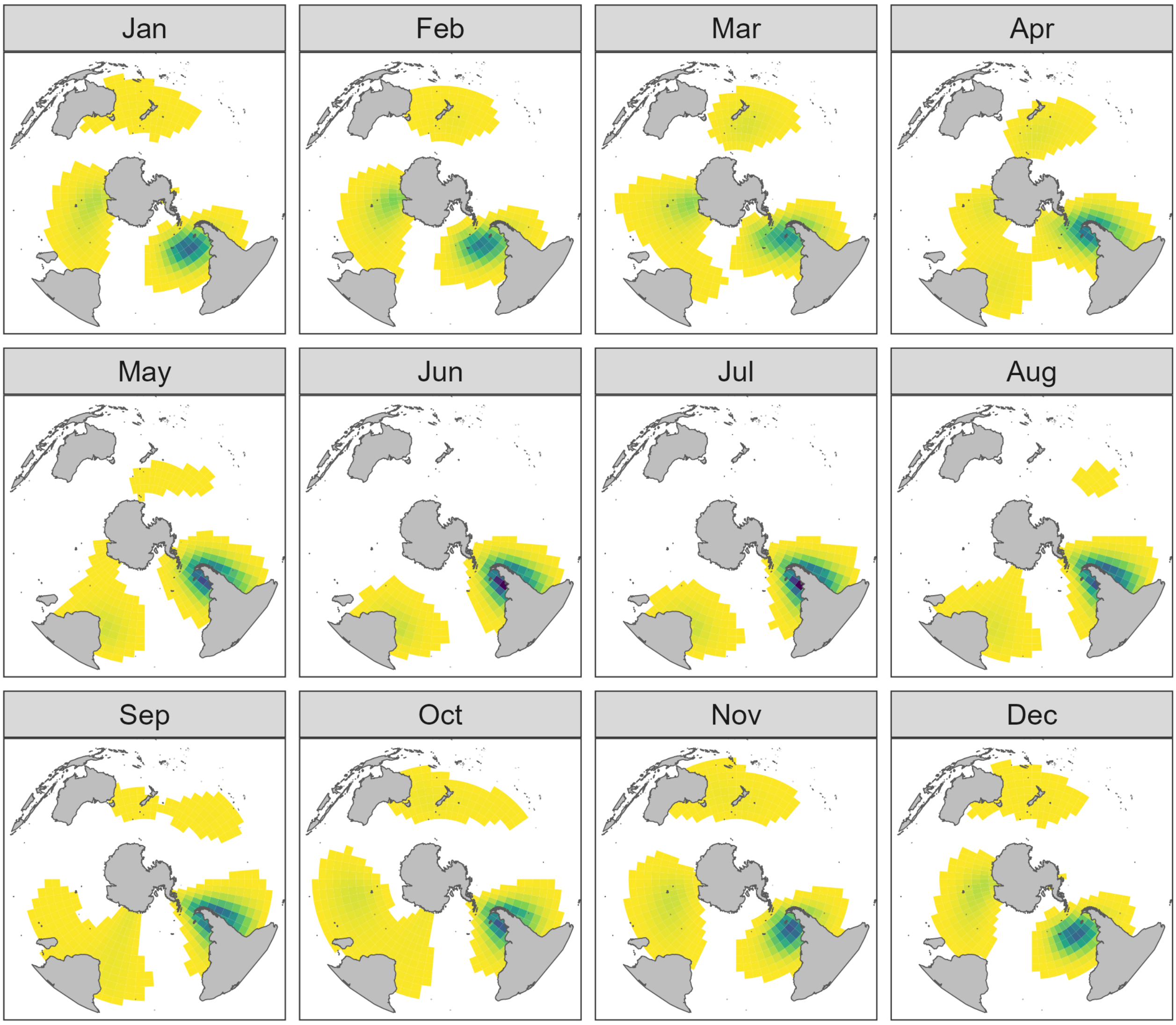

Figure 24: Relative density maps of adult White-chinned petrel (PRO) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 81: Input covariate probabilities for White-chinned petrel: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.40
Feb	1.00	0.30
Mar	1.00	0.05
Apr	1.00	0.05
May	1.00	0.00
Jun	1.00	0.00
Jul	1.00	0.00
Aug	1.00	0.00
Sep	1.00	0.30
Oct	1.00	0.40
Nov	1.00	0.50
Dec	1.00	0.50

Table 82: Prior distributions of demographic parameters for White-chinned petrel.

Parameter	Distribution	Parameter a	Parameter b
Annual breeding pairs	log-normal	1.3173×10^6	0.100
Proportion of adults breeding	logit-normal	0.75	0.05
Age at first reproduction	log-normal	6.59	0.178
Current adult survival rate	logit-normal	0.874	0.02
Optimal adult survival rate	uniform	0.92	0.95

Table 83: Summary statistics for prior distributions of demographic parameters for White-chinned petrel.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	1 316 786	1 074 335-1 593 474	Pairs
Proportion of adults breeding	0.75	0.64-0.83	Proportion
Age at first reproduction	6.6	4.6-9.2	Years
Current adult survival rate	0.87	0.83-0.91	Proportion
Optimal adult survival rate	0.93	0.92-0.95	Proportion
Population size (adults)	3 543 560	2 799 132-4 491 550	Individuals

3.25. Spectacled petrel (*Procellaria conspicillata*)

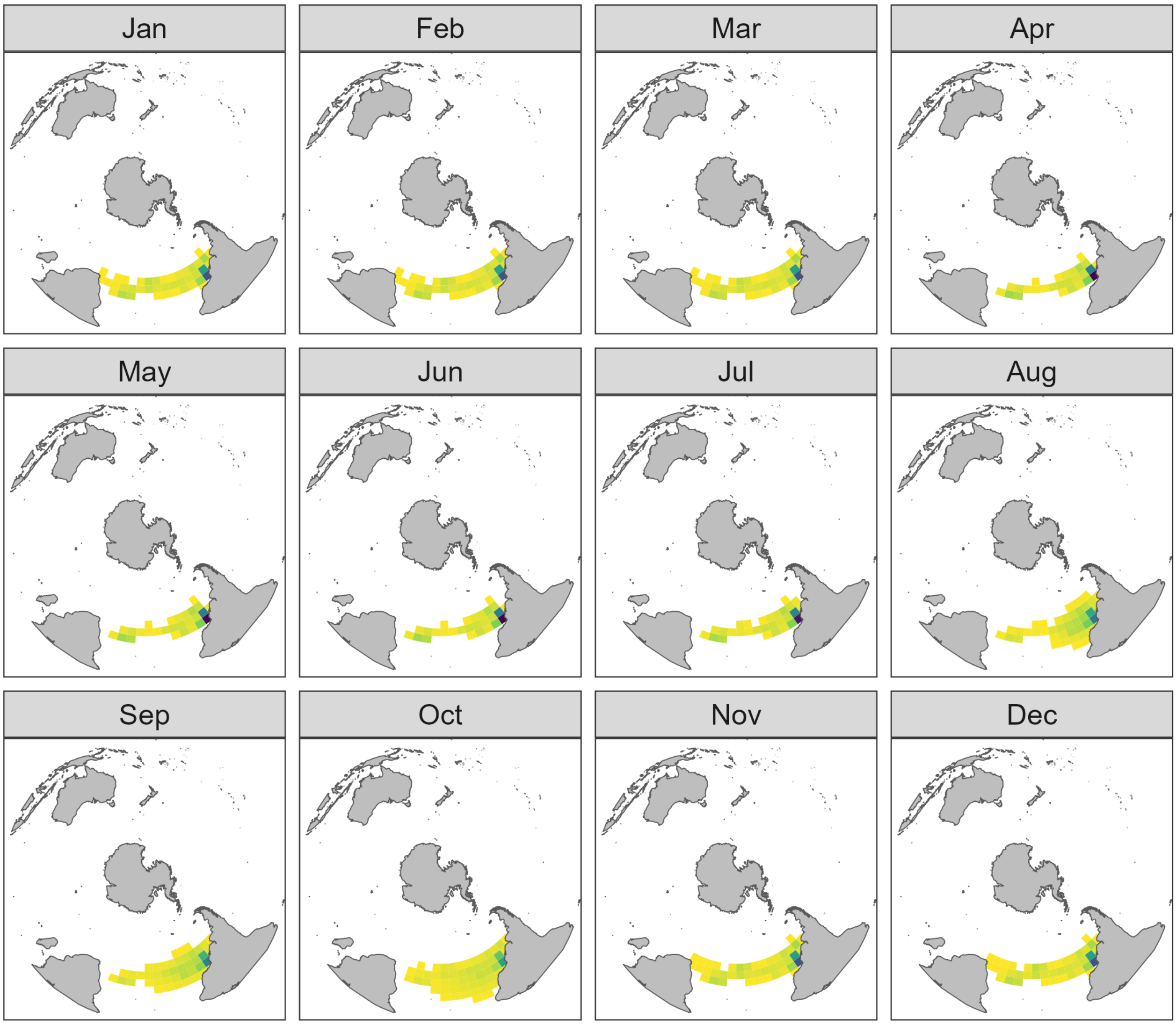

Figure 25: Relative density maps of adult Spectacled petrel (PCN) by month (proportion of individuals per square kilometre) (Edwards et al. 2023).

Table 84: Input covariate probabilities for Spectacled petrel: probabilities of being in the southern hemisphere (P_s^{SH}), and of a breeding adult being on nest (P_s^{nest}).

Month	Probability in SH	Probability on nest
Jan	1.00	0.10
Feb	1.00	0.05
Mar	1.00	0.05
Apr	1.00	0.00
May	1.00	0.00
Jun	1.00	0.00
Jul	1.00	0.00
Aug	1.00	0.00
Sep	1.00	0.50
Oct	1.00	0.50
Nov	1.00	0.40
Dec	1.00	0.30

Table 85: Prior distributions of demographic parameters for Spectacled petrel.

Parameter	Distribution	Parameter a	Parameter b
Annual breeding pairs	log-normal	4.2×10^4	0.096
Proportion of adults breeding	logit-normal	0.797	0.05
Age at first reproduction	log-normal	6.59	0.178
Current adult survival rate	logit-normal	0.874	0.025
Optimal adult survival rate	uniform	0.92	0.95

Table 86: Summary statistics for prior distributions of demographic parameters for Spectacled petrel.

Parameter	Mean	95% CI	Unit
Annual breeding pairs	41 988	34 447-50 333	Pairs
Proportion of adults breeding	0.79	0.68-0.88	Proportion
Age at first reproduction	6.6	4.6-9.1	Years
Current adult survival rate	0.87	0.82-0.92	Proportion
Optimal adult survival rate	0.94	0.92-0.95	Proportion
Population size (adults)	106 495	84 283-133 438	Individuals

4. Sources for prior distributions for demographic parameters

Table 87: Sources of species' values of annual breeding pairs (N_s^{BP}).

Species	Source(s)
Gibson's Albatross	Baker & Jensz (2014), Elliott et al. (2024)
Antipodean Albatross	Parker et al. (2023), Rexer-Huber et al. (2024)
Wandering Albatross	ACAP (2024), Mackley et al. (2024), Ryan et al. (2009), Weimerskirch et al. (2018)
Tristan Albatross	Carneiro et al. (2020), Oppel et al. (2022)
Amsterdam Albatross	Heerah et al. (2019), Weimerskirch et al. (2018)
Southern Royal Albatross	Mischler & Wickes (2023), Mischler et al. (2024)
Northern Royal Albatross	Frost et al. (2023), Richard et al. (2015)
Atlantic Yellow-nosed Albatross	Birdlife International (2024), Cuthbert et al. (2014), Ryan et al. (2011)
Indian Yellow-nosed Albatross	Ryan et al. (2009), Weimerskirch et al. (2018)
Black-browed Albatross	ACAP (2010, 2024), Brothers & Ledingham (2008), Cleeland et al. (2021), Mackley et al. (2024), Robertson et al. (2014, 2017), Weimerskirch et al. (2018), Wolfaardt (2013)
Campbell Albatross	Mischler et al. (2024)
Shy Albatross	NRE Tas unpub. data
White-capped Albatross	Baker et al. (2023), Walker et al. (2020), Fischer et al. unpub
Salvin's Albatross	Baker & Jensz (2019), Sagar et al. (2014)
Chatham Albatross	Bell et al. (2017)
Grey-headed Albatross	ACAP (2024), Mackley et al. (2024), Mischler et al. (2024), Robertson et al. (2007, 2017), Ryan et al. (2009), Stevens et al. (2024), Weimerskirch et al. (2018), NRE Tas unpub. data
Southern Buller's Albatross	Frost et al. (2024), Thompson & Sagar (2020)
Northern Buller's Albatross	Bell et al. (2017, 2018), Bell (2023)
Sooty Albatross	ACAP (2010), Cuthbert et al. (2014), Ryan et al. (2009), Schoombie et al. (2017), Weimerskirch et al. (2018)
Light-mantled Sooty Albatross	ACAP (2010), Cleeland et al. (2021), Schoombie et al. (2016), Weimerskirch et al. (2018)
Southern Giant Petrel	ACAP (2010, 2024), Marin (2018), Poncet et al. (2020), Ryan et al. (2009)
Northern Giant Petrel	ACAP (2010, 2024), Frost (2021), Parker et al. (2020), Patterson et al. (2008), Poncet et al. (2020), Rexer-Huber et al. (2020a), Ryan et al. (2009), Walker & Elliott (2022)
Grey Petrel	ACAP (2024), Barbraud et al. (2009), Bird et al. (2022), Carneiro et al. (2020), Parker et al. (2017), Thompson (2019)
Black Petrel	Bell et al. (2016, 2022)
Westland Petrel	Waugh et al. (2020)
White-chinned Petrel	ACAP (2024), Barbraud et al. (2009), Carneiro et al. (2020), Rexer-Huber et al. (2017), Rexer-Huber (2017), Rexer-Huber et al. (2020b, 2023), Ryan et al. (2012)
Spectacled Petrel	Ryan et al. (2019)

Table 88: Sources of species' values of adult annual probability of breeding (P_s^B).

Species	Source(s)
Gibson's Albatross	Elliott et al. (2024), JF unpub.
Antipodean Albatross	Rexer-Huber et al. (2024), JF unpub.
Wandering Albatross	Carneiro et al. (2020), Cleeland et al. (2021), Pardo et al. (2017)
Tristan Albatross	Carneiro et al. (2020), Oppel et al. (2022)
Amsterdam Albatross	Carneiro et al. (2020)
Southern Royal Albatross	
Northern Royal Albatross	Carneiro et al. (2020)
Atlantic Yellow-nosed Albatross	Bratt (2023)
Indian Yellow-nosed Albatross	
Black-browed Albatross	Carneiro et al. (2020), Cleeland et al. (2021), Pardo et al. (2017), Ventura et al. (2023)
Campbell Albatross	Frost (2020), Rexer-Huber et al. (2020a), DT & PS unpub.
Shy Albatross	Thomson et al. (2015)
White-capped Albatross	Carneiro et al. (2020), Francis (2012)
Salvin's Albatross	Sagar et al. (2011)
Chatham Albatross	Carneiro et al. (2020)
Grey-headed Albatross	Carneiro et al. (2020), Cleeland et al. (2021), Pardo et al. (2017), Waugh et al. (1999)
Southern Buller's Albatross	Fu & Sagar (2016)
Northern Buller's Albatross	Carneiro et al. (2020)
Sooty Albatross	
Light-mantled Sooty Albatross	Cleeland et al. (2020)
Southern Giant Petrel	Carneiro et al. (2020), Hunter (1984)
Northern Giant Petrel	Carneiro et al. (2020), Hunter (1984)
Grey Petrel	Carneiro et al. (2020), Chastel (1995), JB unpub., SO unpub.
Black Petrel	Zhang et al. (2020), EB unpub.
Westland Petrel	Waugh et al. (2020)
White-chinned Petrel	Carneiro et al. (2020), Dasnon et al. (2022)
Spectacled Petrel	

Table 89: Sources of species' values of current age at first breeding (A_s^{curr}).

Species	Source(s)
Gibson's Albatross	Francis et al. (2015)
Antipodean Albatross	Richard (2021)
Wandering Albatross	Fay et al. (2015), Nel et al. (2003), Weimerskirch et al. (1997), Weimerskirch (2018)
Tristan Albatross	Oppel et al. (2022), SO unpub.
Amsterdam Albatross	Carneiro et al. (2020)
Southern Royal Albatross	
Northern Royal Albatross	Richard et al. (2015)
Atlantic Yellow-nosed Albatross	Bratt (2023), SO unpub.
Indian Yellow-nosed Albatross	Bratt (2023)
Black-browed Albatross	Pardo et al. (2017), Ventura et al. (2023)
Campbell Albatross	Waugh et al. (1999)
Shy Albatross	Thomson et al. (2015)
White-capped Albatross	Carneiro et al. (2020)
Salvin's Albatross	Carneiro et al. (2020)
Chatham Albatross	Robertson et al. (2003)
Grey-headed Albatross	Pardo et al. (2017), Waugh et al. (1999)
Southern Buller's Albatross	Fu & Sagar (2016)
Northern Buller's Albatross	
Sooty Albatross	Carneiro et al. (2020)
Light-mantled Sooty Albatross	Carneiro et al. (2020)
Southern Giant Petrel	ACAP (2010), Carneiro et al. (2020), Hunter (1984), SO unpub.
Northern Giant Petrel	ACAP (2010), Carneiro et al. (2020), Hunter (1984), Voisin (1988)
Grey Petrel	Carneiro et al. (2020)
Black Petrel	Zhang et al. (2020)
Westland Petrel	Waugh et al. (2015)
White-chinned Petrel	Barbraud et al. (2008), Dasnon et al. (2022)
Spectacled Petrel	

Table 90: Sources of species' values of current annual survival probability (S_s^{curr}).

Species	Source(s)
Gibson's Albatross	Walker et al. (2023)
Antipodean Albatross	Parker et al. (2023), Richard (2021)
Wandering Albatross	Barbraud & Weimerskirch (2012), Carneiro et al. (2020), Cleeland et al. (2021), Pardo et al. (2017)
Tristan Albatross	Oppel et al. (2022)
Amsterdam Albatross	Carneiro et al. (2020)
Southern Royal Albatross	
Northern Royal Albatross	Richard et al. (2015)
Atlantic Yellow-nosed Albatross	Bratt (2023)
Indian Yellow-nosed Albatross	Carneiro et al. (2020)
Black-browed Albatross	Carneiro et al. (2020), Cleeland et al. (2021), Pardo et al. (2017), Ventura et al. (2023)
Campbell Albatross	Waugh et al. (1999)
Shy Albatross	Alderman et al. (2011), Thomson et al. (2015)
White-capped Albatross	Elliott et al. (2023), Parker et al. (2022)
Salvin's Albatross	Sagar et al. (2014)
Chatham Albatross	Carneiro et al. (2020)
Grey-headed Albatross	Carneiro et al. (2020), Cleeland et al. (2021), Pardo et al. (2017), Waugh et al. (1999)
Southern Buller's Albatross	Thompson & Sagar (2023)
Northern Buller's Albatross	
Sooty Albatross	SO unpub.
Light-mantled Sooty Albatross	Cleeland et al. (2021)
Southern Giant Petrel	Carneiro et al. (2020), SO unpub.
Northern Giant Petrel	Carneiro et al. (2020)
Grey Petrel	
Black Petrel	Zhang et al. (2020)
Westland Petrel	Waugh et al. (2015)
White-chinned Petrel	Barbraud et al. (2008), Carneiro et al. (2020), Dasnon et al. (2022), Thompson (2019)
Spectacled Petrel	

5. Review of biological inputs in 2024

An expert review of biological inputs to CCSBT's 2024 collaborative seabird risk assessment was undertaken last year. This included collation of the latest information on key demographic variables for the taxa covered by the risk assessment, a preliminary review of the density maps, and recommended biological inputs to the risk assessment model. The review was coordinated by Johannes Fischer (Department of Conservation), and described more fully in Edwards et al. (in prep.). This Section provides a summary of the colony-specific demographic information collated during the review. This Section also summaries other ouputs of the review process, including recommended prior distributions for relevant demographic variables. The tables also include updated information for breeding pairs (Gibson's, Antipodean, wandering, Southern Royal, black-browed, Campbell, shy, white-capped, Salvin's, grey-headed and southern Buller's albatrosses) and probability of breeding (Gibson's and Antipodean albatrosses) provided for the 2025 risk assessment.

Table 91: Suggested updates to prior distributions of number of breeding pairs (N_s^{BP}). Reported 95% CIs are provided in parentheses where available. Percentages of breeding pairs (% column) from each colony were used to calculate weighted averages for demographic parameters where applicable.

Species	Island(s)	Breeding pairs	%	Time period	References	Suggested prior distribution	Feedback provided
Gibson's Albatross	Disappointment	244	6	2014	Baker & Jensz (2014), Elliott et al. (2024)		
	Adams	4,181	94	2024	Elliott et al. (2024)		
	Total	4,425				Log-norm (4425, 0.05)	GE, KRH
Antipodean Albatross	Moutere Mahue / Antipodes	3,383	100	2024	Parker et al. (2023), Rexer-Huber et al. (2024)	Log-norm (3383, 0.05)	GE, KRH
Wandering Albatross	S. Georgia (Islas Georgias del Sur)	1,278	12	2024	Mackley et al. (2024)		
	Prince Edward	1,600	16	2008	Ryan et al. (2009), ACAP (2024)		
	Marion	2,668	26	2023	ACAP (2024)		
	Crozet	2,324	23	2017	Weimerskirch et al. (2018)		
	Kerguelen	2,252	22	2017	Weimerskirch et al. (2018)		
	Macquarie	8 (3-15)	< 1	2023	ACAP (2024)		
	Total	10,130		2008-24		Log-norm (10130, 0.05)	AM, JM, MC, MW, PR, RP, SH, TC
Tristan Albatross	Gough	1,650 (1,106-1,921)	100	2004-21	Carneiro et al. (2020), Oppel et al. (2022)	Fit log-norm that most closely mirrors reported mean and 95% CIs	BC, PR, RW, SO
Amsterdam Albatross	Amsterdam	60	100	2021	Weimerskirch et al. (2018), Heerah et al. (2019)	Log-norm (60, 0.100)	MW
Southern Royal Albatross	Enderby	47	1	2022	Mischler & Wickes (2023)		
	Motu Ihupuku / Campbell	5,767	99	2024	Mischler et al. (2024)		
	Total	5,814		2022-2024		Log-norm (5814, 0.05)	KRH, PM

Table 91: Suggested updates to prior distributions of number of breeding pairs (N_s^{BP}). Reported 95% CIs are provided in parentheses where available. Percentages of breeding pairs (% column) from each colony were used to calculate weighted averages for demographic parameters where applicable. *(continued)*

Species	Island(s)	Breeding pairs	%	Time period	References	Suggested prior distribution	Feedback provided
Northern Royal Albatross	Taiaroa Head	33 (28-38)	1	2018-23	Richard et al. (2015)		
	Chatham Islands	4,228 (3,301-5,156)	99	2016-21	Frost et al. (2023)		
	Total	4,261 (3,329-5,194)		2012-21		Fit log-norm that most closely mirrors reported mean and 95% CIs	PF, MW
Atlantic Yellow-nosed Albatross	Tristan da Cunha	15,250	57	2015	Birdlife International (2024)		
	Inaccessible	2,000	7	-			
	Nightingale	4,000	15	2007	Birdlife International (2024)		
	Gough	5,300 (4,600-6,000)	20	2011	Cuthbert et al. (2014)		
	Middle & Stoltenhoff	250	1	2009-10	Ryan et al. (2011)		
	Total	26,800		2001-15		Log-norm (26,800, 0.100)	AC, BC, MW, SC, SO
Indian Yellow-nosed Albatross	Prince Edward	7,000	21	2008	Ryan et al. (2009)		
	Crozet	4,212	12	2014	Weimerskirch et al. (2018),		
	Kerguelen	23	< 1	2016	Weimerskirch et al. (2018)		
	Amsterdam	22,753	67	2015	Weimerskirch et al. (2018)		
	Total	33,988		2008-16		Log-norm (33,988, 0.100)	AM, MW
Black-browed Albatross	Falklands (Islas Malvinas)	474,219	71	2011	Wolfaardt (2013), ACAP (2024)		
	S. Georgia (Islas Georgias del Sur)	55,119	8	2024	Mackley et al. (2024)		

Table 91: Suggested updates to prior distributions of number of breeding pairs (N_s^{BP}). Reported 95% CIs are provided in parentheses where available. Percentages of breeding pairs (% column) from each colony were used to calculate weighted averages for demographic parameters where applicable. ***(continued)***

Species	Island(s)	Breeding pairs	%	Time period	References	Suggested prior distribution	Feedback provided
	Islas Diego de Almagro	15,594	2	2002	ACAP (2010)		
	Islotes Evangelistas	4,818	<1	2014	Robertson et al. (2017)		
	Islas Diego Ramirez	61,749	9	2003-15	Robertson et al. (2017), ACAP (2024)		
	Islas Ildefonso	54,284	8	2014	Robertson et al. (2017)		
	Islote Albatross	104	<1	2012	Robertson et al. (2014)		
	Islote Leonard	545	<1	2014	Robertson et al. (2017)		
	Crozet	710	<1	1982-2016	Weimerskirch et al. (2018)		
	Kerguelen	2,880	<1	2014-18	Weimerskirch et al. (2018), ACAP (2024)		
	Heard	600	<1	2001	ACAP (2010)		
	Macquarie, Bishop & Clerk	192	<1	1993-2014	Brothers & Ledingham (2008), Cleeland et al. (2021), ACAP (2024)		
	New Zealand Subantarctic	146	<1	1995-96	ACAP (2024)		
	Total	670,960		1982-2024		Log-norm (670960, 0.05)	AC, GT, JM, MW, TC
Campbell Albatross	Motu Ihupuku / Campbell	14,129	100	2024	Mischler et al. (2024)	Log-norm (14129, 0.05)	DT, GT, PS
Shy Albatross	Albatross Island	5,585 (4,905-5,961)	36	2017-22	NRE Tas unpub. data		
	Pedra Branca	90	<1	2017-22	NRE Tas unpub. data		
	Mewstone	9,660	63	2022	NRE Tas unpub. data		
	Total	15,335		2017-22		Log-norm (15,335, 0.100)	JM, SH
White-capped Albatross	Maukahuka / Auckland	85,820 (66,385-106,530)	100	2015-16	Walker et al. (2020), Baker et al. (2023), Fischer et al. unpub	Log-norm that approximates the updated CIs provided	BB, GT, KRH
Salvin's Albatross	Western Chain	1,213	2	2014	Sagar et al. (2014)		

Table 91: Suggested updates to prior distributions of number of breeding pairs (N_s^{BP}). Reported 95% CIs are provided in parentheses where available. Percentages of breeding pairs (% column) from each colony were used to calculate weighted averages for demographic parameters where applicable. *(continued)*

Species	Island(s)	Breeding pairs	%	Time period	References	Suggested prior distribution	Feedback provided
	Hauriri / Bounties	34,029	98	2024	Baker & Jensz (2019)		
	Total	35,242		2014-24		Log-norm (35242, 0.05)	BB, DT, KRH, PS
Chatham Albatross	Tarakoikoia / Pyramid	5,294 (5,194-5,407)	100	2017	Bell et al. (2017)	Fit log-norm that most closely mirrors reported mean and 95% CIs	GT, MW
Grey-headed Albatross	S. Georgia (Islas Georgias del Sur)	18,475	29	2024	Mackley et al. (2024)		
	Islas Diego Ramirez	18,358	29	2003-14	Robertson et al. (2007, 2017)		
	Prince Edward	1,506	2	2008	Ryan et al. (2009)		
	Marion	8,180	13	2021	Stevens et al. (2024)		
	Crozet	6,319	10	1982-2016	Weimerskirch et al. (2018), ACAP (2024)		
	Kerguelen	6,445	10	2014	Weimerskirch et al. (2018)		
	Macquarie	100	< 1	2022	NRE Tas unpub. data		
	Campbell	3,672	6	2024	Mischler et al. (2024)		
	Total	63,055		1982-2024		Log-norm (63055, 0.05)	GT, JM, MW, SH, TC
Southern Buller's Albatross	Hautere / Solander	4,793 (4,213-5,373)	36	2024	Frost et al. (2024)		
	Tini Heke / Snares	8,700	61	2020	Thompson & Sagar (2020)		
	Total	14,320		2016-20		Log-norm (13493, 0.05)	PS, SW
Northern Buller's Albatross	Motuhara / Forty-fours	16,081	83	2016-22	Bell et al. (2017), Bell (2023)		
	Rangitatahi / Sisters	3,273	17	2017	Bell et al. (2018)		

Table 91: Suggested updates to prior distributions of number of breeding pairs (N_s^{BP}). Reported 95% CIs are provided in parentheses where available. Percentages of breeding pairs (% column) from each colony were used to calculate weighted averages for demographic parameters where applicable. ***(continued)***

Species	Island(s)	Breeding pairs	%	Time period	References	Suggested prior distribution	Feedback provided
	Total	19,354		2016-22		Log-norm (19,354, 0.05)	-
Sooty Albatross	Gough	3,750 (2,500-5,000)	28	2011	Cuthbert et al. (2014)		
	Inaccessible	500	4	2000	ACAP (2010)		
	Nightingale	150 (100-200)	1	1974	ACAP (2010)		
	Stoltenhoff	37 (25-50)	< 1	1974	ACAP (2010)		
	Tristan	2,675	20	-	Schoombie et al. (2017)		
	Prince Edward	1,500	11	2008	Ryan et al. (2009), Schoombie et al. (2017)		
	Marion	2,000	15	2019	Ryan et al. (2009), Schoombie et al. (2017)		
	Crozet	2,144 (2,144-2,224)	16	1976-2017	ACAP (2010), Weimerskirch et al. (2018)		
	Amsterdam	394	3	2012	Weimerskirch et al. (2018)		
	Total	13,150 (11,738-14,563)		1976-2019		Log-norm (13,150, 0.100) or beta (85,7)*13,150	BC, MW, RP, RW, SO, SS
Light-mantled Sooty Albatross	S. Georgia (Islas Georgias del Sur)	5,000	24	1983	ACAP (2010)		
	Prince Edward	150	1	2002	ACAP (2010)		
	Marion	268 (184-352)	< 1	2012-14	ACAP (2010), Schoombie et al. (2016)		
	Crozet	2,159	10	1984-2017	ACAP (2010), Weimerskirch et al. (2018)		
	Kerguelen	4,000 (3,000-5,000)	19	1987	ACAP (2010)		
	Heard	350 (200-500)	2	1954	ACAP (2010)		
	Macquarie	2,150 (1,850-2,450)	10	2014	Cleeland et al. (2021)		

Table 91: Suggested updates to prior distributions of number of breeding pairs (N_s^{BP}). Reported 95% CIs are provided in parentheses where available. Percentages of breeding pairs (% column) from each colony were used to calculate weighted averages for demographic parameters where applicable. *(continued)*

Species	Island(s)	Breeding pairs	%	Time period	References	Suggested prior distribution	Feedback provided
	Maukahuka / Auckland	5,000	24	1972	ACAP (2010)		
	Motu Ihupuku / Campbell	1,600	8	1995	ACAP (2010)		
	Moutere Mahue / Antipodes	250	1	1995	ACAP (2010)		
	Total	20,927 (19,393-22,461)		1983-2017		Log-norm (20,927, 0.100)	BB, GT, JM, MW, RW, SH, SS, TC
Southern Giant Petrel	Falklands (Islas Malvinas)	19,529	36	2005	ACAP (2010)		
	S. Georgia (Islas Georgias del Sur)	8,803	16	2005-07	Poncet et al. (2020)		
	South Orkney	3,350	6	2006	ACAP (2010)		
	South Shetland	5,400	10	2005-07	ACAP (2010)		
	Islas Sandwich del Sur / South Sandwich	1,882	3	2011	ACAP (2024)		
	Antarctic Peninsula	1,190	2	2005	ACAP (2010)		
	Antarctic Continent	300	<1	2001	ACAP (2010)		
	South America	2,831	5	2004-05	ACAP (2010)		
	Islas Diego Ramirez & Noir	1,847	3	1984-2014	Marin (2018)		
	Gough	348	<1	2002	ACAP (2024)		
	Prince Edwards	2,156	4	2006-08	Ryan et al. (2009)		
	Crozet	1,141	2	1976-2008	ACAP (2010)		
	Heard	3,500	6	2004	ACAP (2010)		
	Macquarie	2,125	4	2007	ACAP (2010)		
	Total	54,402		1984-2022		Log-norm (54,402, 0.100)	BC, BW, MW, RP, RW, JM, SO
Northern Giant Petrel	S. Georgia (Islas Georgias del Sur)	15,398	67	2005-07	Poncet et al. (2020)		

Table 91: Suggested updates to prior distributions of number of breeding pairs (N_s^{BP}). Reported 95% CIs are provided in parentheses where available. Percentages of breeding pairs (% column) from each colony were used to calculate weighted averages for demographic parameters where applicable. *(continued)*

Species	Island(s)	Breeding pairs	%	Time period	References	Suggested prior distribution	Feedback provided
	Prince Edward & Marion	713	3	-	Ryan et al. (2009), ACAP (2024)		
	Crozet	1,238 (1,213-1,263)	5	1976-2007	ACAP (2010)		
	Kerguelen	1,400	6	1995	Patterson et al. (2008)		
	Macquarie	1,487	7	2013-14	ACAP (2024)		
	Maukahuka / Aucklands	340 (210-390)	2	2015	Parker et al. (2020)		
	Motu Ihupuku / Campbell	150 (134-173)	1	2019	Rexer-Huber et al. (2020a)		
	Moutere Mahue / Antipodes	300 (295-304)	1	2020-21	Walker & Elliott (2022)		
	Rēkohu / Wharekauri / Chathams	2,050 (1,799-2,251)	9	2020	Frost (2021)		
	Total	23,051 (22,649-23,379)		1976-2021		Log-norm (23,051, 0.100)	GT, JM, KRH, MW, RP
Grey Petrel	Gough	17,500 (10,000-25,000)	17	2001	Carneiro et al. (2020), ACAP (2024)		
	Prince Edward & Marion	5,000	5	-	Carneiro et al. (2020)		
	Crozet	5,500 (2,000-9,000)	5	1984			
	Kerguelen	3,400 (1,900-5,600)	3	2004-2006	Barbraud et al. (2009)		
	Amsterdam	7 (5-10)	< 1	1980			
	Macquarie	252 (227-302)	< 1	2017-2018	Bird et al. (2022)		
	Motu Ihupuku / Campbell	98 (83-109)	< 1	2015	Parker et al. (2017)		
	Moutere Mahue / Antipodes	73,860 (40,076-107,644)	70	2008-10	Thompson (2019)		
	Total	105,617 (59,291-152,665)		1984-2018		Log-norm (105,617, 0.150)	BC, BD, EB, JB, JM, KRH, MW, PR, SO, SS
Black Petrel	Hauturu-o-Toi / Little Barrier	620	11	2015	Bell et al. (2016)		

Table 91: Suggested updates to prior distributions of number of breeding pairs (N_s^{BP}). Reported 95% CIs are provided in parentheses where available. Percentages of breeding pairs (% column) from each colony were used to calculate weighted averages for demographic parameters where applicable. *(continued)*

Species	Island(s)	Breeding pairs	%	Time period	References	Suggested prior distribution	Feedback provided
	Aotea / Great Barrier	4,836 (4,270-5,493)	89	2018-21	Bell et al. (2022)		
	Total	5,456 (4,890-6,112)		2015-19		Fit log-norm that most closely mirrors reported mean and 95% CIs	EB, GT, RP
Westland Petrel	Punakaiki	6,223 (5,478-6,967)	100	2019-20	Waugh et al. (2020)	Fit log-norm that most closely mirrors reported mean and 95% CIs	BB, GT, KS, SW
White-chinned Petrel	S. Georgia (Islas Georgias del Sur)	773,150	59	2007	Carneiro et al. (2020)		
	Prince Edward	12,000 (9,000-15,000)	1	2008	Ryan et al. (2012)		
	Marion	24,000 (20,000-28,000)	2	2009	Ryan et al. (2012)		
	Crozet	44,428 (34,614-54,241)	3	1984-2004	ACAP (2024)		
	Kerguelen	234,000 (186,000-297,000)	18	2004-06	Barbraud et al. (2009)		
	Disappointment	153,000 (119,700-195,700)	12	2015	Rexer-Huber et al. (2017)		
	Adams	28,300 (10,400-44,800)	2	2013-17	Rexer-Huber et al. (2020b)		
	Motu Ihupuku / Campbell	22,000	2	2014-15	Rexer-Huber (2017)		
	Moutere Mahue / Antipodes	26,400 (22,200-31,600)	2	2022-23	Rexer-Huber et al. (2023)		
	Total	1,317,278 (1,197,064-1,461,491)		2004-23		Log-norm (1,317,278, 0.100)	KRH, MW, TC
Spectacled Petrel	Inaccessible	42,000 (34,000-50,000)	100	2018	Ryan et al. (2019)	Fit log-norm that most closely mirrors reported mean and 95% CIs	BC, PR, RW, SO

Table 92: Suggested updates to prior distributions of breeding probability (P_s^B). Reported 95% CIs are provided in parentheses, where available.

Species	Island(s)	Breeding probability	Time period	References	Suggested prior distribution	Feedback provided
Gibson's Albatross	Adams	0.595 (0.527-0.674)	2014-24	Elliott et al. (2024), JF unpub.	Fit beta dist that most closely mirrors reported mean and 95% CIs	GE, KRH
Antipodean Albatross	Moutere Mahue / Antipodes	0.450 (0.363-0.565)	2014-24	Rexer-Huber et al. (2024), JF unpub.	Fit beta dist that most closely mirrors reported mean and 95% CIs	GE, KRH
Wandering Albatross	S. Georgia (Islas Georgias del Sur)	0.356	1980-2019	Pardo et al. (2017), Carneiro et al. (2020),		
	Kerguelen	0.566	-	Carneiro et al. (2020),		
	Macquarie	0.738 (0.738-0.814)	1995-2014	Cleeland et al. (2021)		
	Weighted mean	0.494			Logit-norm (0.494, 0.05)	AM, JM, MC, MW, PR, RP, SH, TC
Tristan Albatross	Gough	0.349 (0.227-0.484)	2004-21	Carneiro et al. (2020), Oppel et al. (2022)	Fit beta dist (perhaps, 35, 70) that most closely mirrors reported mean and 95% CIs	BC, PR, RW, SO
Amsterdam Albatross	Amsterdam	0.600	-	Carneiro et al. (2020)	Logit-norm (0.600, 0.05)	MW
Southern Royal Albatross	-	–	-		Fit beta dist that most closely mirrors a mean of 0.582 (Northern Royal Albatross) and 95% CIs of 0.300-0.700	KRH, PM
Northern Royal Albatross	Rēkohu / Wharekauri / Chathams	0.582	-	Carneiro et al. (2020)		
Atlantic Yellow-nosed Albatross	Gough	0.596 (0.579-0.609)	1985-2020	Bratt (2023)	Norm (0.596, 0.005)	AC, BC, MW, SC, SO

Table 92: Suggested updates to prior distributions of breeding probability (P_s^B). Reported 95% CIs are provided in parentheses, where available. *(continued)*

Species	Island(s)	Breeding probability	Time period	References	Suggested prior distribution	Feedback provided
Indian Yellow-nosed Albatross	-	–	-		Use Atlantic yellow-nosed albatross mean estimate to inform prior. Logit-norm (0.596, 0.05)	AM, MW
Black-browed Albatross	Falklands (Islas Malvinas)	0.880 (0.870-0.890)	2003-21	Ventura et al. (2023)		
	S. Georgia (Islas Georgias del Sur)	0.586 (0.228-0.980)	1980-2019	Pardo et al. (2017), Carneiro et al. (2020)		
	Macquarie	0.748 (0.725-0.772)	1995-2014	Cleeland et al. (2021)		
	Weighted mean	0.844 (0.792-0.901)			Fit beta dist that most closely mirrors reported weighted mean and 95% CIs?	AC, GT, JM, MW, TC
Campbell Albatross	Motu Ihupuku / Campbell	0.820	2017	Frost (2020), Rexer-Huber et al. (2020a), DT & PS unpub.	Logit-norm (0.900, 0.05). High prior distribution retained due to comments received on high (unpublished) breeding probability.	DT, GT, PS
Shy Albatross	Albatross	0.950	2000-10	Thomson et al. (2015)	Return rates interpreted as breeding probability, so prior distribution adjusted to accommodate for this. Logit-norm (0.747, 0.05)	JM, SH
White-capped Albatross	Maukahuka / Auckland (Southwest Cape)	0.680 (0.580-0.810)	2005-10	Francis (2012), Carneiro et al. (2020)	Fit beta dist that most closely mirrors reported mean and 95% CIs	BB, GT, KRH

Table 92: Suggested updates to prior distributions of breeding probability (P_s^B). Reported 95% CIs are provided in parentheses, where available. *(continued)*

Species	Island(s)	Breeding probability	Time period	References	Suggested prior distribution	Feedback provided
Salvin's Albatross	Western Chain	0.865	1995, 2008-10	Sagar et al. (2011)	Fit beta dist that most closely mirrors reported mean and 95% CIs of 0.650-0.900	BB, DT, KRH, PS
Chatham Albatross	Tarakoikoia / Pyramid	0.773	-	Carneiro et al. (2020)	Logit-norm (0.773, 0.05)	GT, MW
Grey-headed Albatross	S. Georgia (Islas Georgias del Sur) Macquarie Campbell Weighted mean	0.368 (0.154-0.673) 0.951 (0.935-0.967) 0.601 0.406 (0.227-0.662)	1980-2019 1995-2014 1945-96	Pardo et al. (2017), Carneiro et al. (2020) Cleeland et al. (2021) Waugh et al. (1999)	Fit beta dist that most closely mirrors reported weighted mean and 95% CIs	GT, JM, MW, SH, TC
Southern Buller's Albatross	Tini Heke / Snares	0.826	1994-2014	Fu & Sagar (2016)	Fit beta dist that most closely mirrors reported mean and 95% CIs of 0.650-0.900	PS, SW
Northern Buller's Albatross	Rēkohu / Wharekauri / Chathams	0.800	-	Carneiro et al. (2020)	Logit-norm (0.800, 0.05)	-
Sooty Albatross	-	–	-		Use distribution for light-mantled Sooty-albatross estimates	BC, MW, RP, RW, SO, SS
Light-mantled Sooty Albatross	Macquarie	0.730 (0.514-0.946)	2004-15	Cleeland et al. (2020)	Fit beta dist that most closely mirrors reported mean and 95% CIs	BB, GT, JM, MW, RW, SH, SS, TC
Southern Giant Petrel	S. Georgia (Islas Georgias del Sur)	0.730	1978-81	Hunter (1984), Carneiro et al. (2020)	Logit-norm (0.730, 0.05)	BC, BW, MW, RP, RW, JM, SO

Table 92: Suggested updates to prior distributions of breeding probability (P_s^B). Reported 95% CIs are provided in parentheses, where available. *(continued)*

Species	Island(s)	Breeding probability	Time period	References	Suggested prior distribution	Feedback provided
Northern Giant Petrel	S. Georgia (Islas Georgias del Sur)	0.730	1978-81	Hunter (1984), Carneiro et al. (2020)	Logit-norm (0.730, 0.05)	GT, JM, KRH, MW, RP
Grey Petrel	Kerguelen & Crozet	0.900	-	Chastel (1995), Carneiro et al. (2020), JB unpub., SO unpub.	Logit-norm (0.900, 0.05). High prior distribution retained due to comments received on high (unpublished) breeding probability.	BC, BD, EB, JB, JM, KRH, MW, PR, SO, SS
Black Petrel	Aotea / Great Barrier	0.610 (0.540-0.700)	1996-2017	Zhang et al. (2020), EB unpub.	Fit beta dist that most closely mirrors reported mean and 95% CIs	EB, GT, RP
Westland Petrel	Punakaiki	0.480 (0.337-0.623)	2007-19	Waugh et al. (2020)	Fit beta dist that most closely mirrors reported mean and 95% CIs	BB, GT, KS, SW
White-chinned Petrel	-	0.750	-	Carneiro et al. (2020), Dasnon et al. (2022)	Logit-norm (0.750, 0.05)	KRH, MW, TC
Spectacled Petrel	-	–	-		Logit-norm (0.797, 0.05). Mean *Procellaria* estimate used to inform prior in absence of data.	BC, PR, RW, SO

Table 93: Proportion of adults on nests (conditional on breeding probability, i.e., only applicable to breeding birds) as influenced by the breeding phenology. Darker colours represent a higher proportion on nests. CS = courtship period, IN = incubation period, CR = chick-rearing period, while the chick is being guarded, PG = post-guard chick-rearing period, NB = non-breeding period.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	References	Feedback provided
Gibson's Albatross	0.5 IN	0.5 IN	0.5 IN	0.4 CR	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.22 CS	ACAP (2010)	GE, KRH
Antipodean Albatross	0.4 IN	0.5 IN	0.45 IN	0.45 CR	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.2 CS	ACAP (2010)	GE, KRH
Wandering Albatross	0.5 IN	0.5 IN	0.4 IN	0.2 CR	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.4 CS/IN	Berrow & Croxall (2001), ACAP (2010), Jones et al. (2017)	AM, JM, MC, MW, PR, RP, SH, TC
Tristan Albatross	0.6 IN	0.5 IN	0.5 IN	0.5 IN	0.3 CR	0.3 CR	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.4 CS	ACAP (2010)	BC, PR, RW, SO
Amsterdam Albatross	0.05 PG	0.4 CS/IN	0.5 IN	0.5 IN	0.4 CR	0.3 CR	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.05 PG	ACAP (2010)	MW
Southern Royal Albatross	0.5 IN	0.5 IN	0.4 IN/CR	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0 NB	0.4 CS	0.5 IN	ACAP (2010)	KRH, PM
Northern Royal Albatross	0.5 IN	0.4 IN	0.3 IN/CR	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0 NB	0.4 CS	0.5 IN	0.5 IN	ACAP (2010)	PF, MW
Atlantic Yellow-nosed Albatross	0.3 PG	0.2 PG	0.1 PG	0.05 PG	0 NB	0 NB	0 NB	0.5 CS	0.6 IN	0.5 IN	0.5 IN	0.5 CR	ACAP (2010)	AC, BC, MW, SC, SO
Indian Yellow-nosed Albatross	0.2 CR	0.1 PG	0.05 PG	0.05 PG	0 NB	0 NB	0 NB	0.1 CS	0.5 CS/IN	0.5 IN	0.4 IN	0.4 IN	ACAP (2010)	AM, MW
Black-browed Albatross	0.2 CR	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0 NB	0 NB	0 NB	0.4 CS	0.5 IN	0.5 IN	0.4 IN/CR	ACAP (2010)	AC, GT, JM, MW, TC
Campbell Albatross	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0 NB	0 NB	0 NB	0.2 CS	0.5 IN	0.5 IN	0.4 IN	0.3 IN/CR	ACAP (2010)	DT, GT, PS
Shy Albatross	0.1 CR	0.05 PG	0.05 PG	0.05 PG	0.05 NB	0.05 NB	0.1 NB/CS	0.1 CS	0.5 IN	0.5 IN	0.4 IN	0.4 IN/CR	ACAP (2010), Hedd & Gales (2005)	JM, SH
White-capped Albatross	0.4 CR	0.1 CR/PG	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0 NB	0 NB	0.25 CS	0.5 IN	0.5 IN	ACAP (2010), Walker et al. (2020)	BB, GT, KRH
Salvin's Albatross	0.05 PG	0.05 PG	0.05 PG	0 NB	0 NB	0 NB	0.1 CS	0.3 CS/IN	0.5 IN	0.5 IN	0.4 IN/C	0.1 C	ACAP (2010), Rexer-Huber et al. (2021)	BB, DT, KRH, PS

Table 93: Proportion of adults on nests (conditional on breeding probability, i.e., only applicable to breeding birds) as influenced by the breeding phenology. Darker colours represent a higher proportion on nests. CS = courtship period, IN = incubation period, CR = chick-rearing period, while the chick is being guarded, PG = post-guard chick-rearing period, NB = non-breeding period. *(continued)*

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	References	Feedback provided
Chatham Albatross	0.1 PG	0.05 PG	0.05 PG	0.05 PG	0 NB	0 NB	0.2 CS	0.4 CS/IN	0.5 IN	0.5 IN	0.4 IN/CR	0.3 CR	ACAP (2010)	GT, MW
Grey-headed Albatross	0.3 CR	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0 NB	0 NB	0 NB	0.1 CS	0.5 IN	0.5 IN	0.4 IN	ACAP (2010)	GT, JM, MW, SH, TC
Southern Buller's Albatross	0.2 NB/CS	0.5 IN	0.45 IN	0.3 IN/CR	0.05 PG	0.05 PG	0.05 PG	0 NB	0 NB	0 NB	0 NB	0 NB	ACAP (2010), Fischer et al. (2023)	PS, SW
Northern Buller's Albatross	0.45 IN	0.4 IN/CR	0.05 PG	0.05 PG	0.05 PG	0 NB	0 NB	0 NB	0 NB	0 NB	0.4 CS/IN	0.5 IN	ACAP (2010), Fischer et al. (2023)	
Sooty Albatross	0.2 CR	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0 NB	0 NB	0.5 CS	0.7 IN	0.7 IN	0.5 IN	0.5 IN/CR	ACAP (2010)	BC, MW, RP, RW, SO, SS
Light-mantled Sooty Albatross	0.4 IN/CR	0.1 PG	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0 NB	0 NB	0.1 CS	0.5 CS/IN	0.5 IN	0.4 IN	ACAP (2010)	BB, GT, JM, MW, RW, SH, SS, TC
Southern Giant Petrel	0.3 CR	0.25 CR/PG	0.25 PG	0.25 PG	0.1 PG	0.1 NB	0.1 NB	0.1 NB	0.25 CS/IN	0.5 IN	0.5 IN	0.5 IN/CR	ACAP (2010), Otovic et al. (2018), Ryan & Oppel (2022)	BC, BW, MW, RP, RW, JM, SO
Northern Giant Petrel	0.1 PG	0.05 PG	0.05 PG	0.05 PG	0.05 NB	0.05 NB	0.1 NB/CS	0.5 IN	0.5 IN	0.5 IN	0.4 IN/CR	0.2 CR	ACAP (2010)	GT, JM, KRH, MW, RP
Grey Petrel	0 NB	0.5 CS	0.5 IN	0.5 IN	0.4 IN/CR	0.3 CR	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0 NB	ACAP (2010), Dilley et al. (2019)	BC, BD, EB, JB, JM, KRH, MW, PR, SO, SS
Black Petrel	0.5 IN	0.4 IN/CR	0.05 PG	0.05 PG	0.05 PG	0.05 PG	0 NB	0 NB	0 NB	0.05 CS	0.3 CS/IN	0.5 IN	ACAP (2010)	EB, GT, RP
Westland Petrel	0 NB	0.15 CS	0.3 CS	0.4 CS/IN	0.5 IN	0.5 IN	0.45 CR	0.4 CR	0.05 PG	0.05 PG	0.05 PG	0 NB	ACAP (2010)	BB, GT, KS, SW
White-chinned Petrel	0.4 CR	0.3 CR/PG	0.05 PG	0.05 PG	0 NB	0 NB	0 NB	0 NB	0.3 CS	0.4 CS/IN	0.5 IN	0.5 IN	ACAP (2010)	KRH, MW, TC
Spectacled Petrel	0.1 PG	0.05 PG	0.05 PG	0 NB	0 NB	0 NB	0 NB	0 NB	0.5 CS	0.5 IN	0.4 IN	0.3 CR	ACAP (2010), Ryan et al. (2006), Hernandez et al. (2019)	BC, PR, RW, SO

Table 94: Suggested updates to prior distributions of current age at first breeding (A_s^{curr}). Age at first breeding provides reported modes and ranges.

Species	Island(s)	Age at first breeding	Time period	References	Suggested prior distribution	Feedback provided
Gibson's Albatross	Adams	12 (8-18)	1991-2011	Francis et al. (2015)	Gamma prior mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	GE, KRH
Antipodean Albatross	Moutere Mahue / Antipodes	14 (7-21)	1994-2021	Richard (2021)	Gamma prior mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	GE, KRH
Wandering Albatross	S. Georgia (Islas Georgias del Sur), Marion, Crozet, Kerguelen	10 (6-20)	1965-2018	Nel et al. (2003), Weimerskirch et al. (1997), Fay et al. (2015), Weimerskirch (2018)	Gamma prior mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	AM, JM, MC, MW, PR, RP, SH, TC
Tristan Albatross	Gough	8 (4-25)	2004-2021	Oppel et al. (2022), SO unpub.	Gamma prior (perhaps (10, 1)) mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	BC, PR, RW, SO
Amsterdam Albatross	Amsterdam	10 (6-15)	-	Carneiro et al. (2020)	Range informed by Wandering Albatross. Gamma prior mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	MW
Southern Royal Albatross	-	9 (6-18)	-		Use distribution for northern royal albatross	KRH, PM
Northern Royal Albatross	Taiaroa Head	9 (6-18)	1989-2012	Richard et al. (2015)	Gamma prior mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	PF, MW
Atlantic Yellow-nosed Albatross	Gough	9 (7-15)	1985-2020	Bratt (2023), SO unpub.	Gamma prior (perhaps (8, 0.9)) mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	AC, BC, MW, SC, SO

Table 94: Suggested updates to prior distributions of current age at first breeding (A_s^{curr}). Age at first breeding provides reported modes and ranges. *(continued)*

Species	Island(s)	Age at first breeding	Time period	References	Suggested prior distribution	Feedback provided
Indian Yellow-nosed Albatross	-	9 (7-15)	-	Bratt (2023)	Gamma prior mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	AM, MW
Black-browed Albatross	S. Georgia (Islas Georgias del Sur), Falklands (Islas Malvinas)	10 (6-15)	1980-2021	Pardo et al. (2017), Ventura et al. (2023)	Gamma prior mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	AC, GT, JM, MW, TC
Campbell Albatross	Motu Ihupuku / Campbell	9 (6-13)	1942-1996	Waugh et al. (1999)	Gamma prior mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	DT, GT, PS
Shy Albatross		8 (5-16)	1981-2011	Thomson et al. (2015)	Gamma prior mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	JM, SH
White-capped Albatross	-	9 (7-16)	-	Carneiro et al. (2020)	Informed by estimates for shy albatross. Gamma prior mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	BB, GT, KRH
Salvin's Albatross	-	10 (6-15)	-	Carneiro et al. (2020)	Gamma prior mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	BB, DT, KRH, PS
Chatham Albatross	Tarakoikoia / Pyramid	8 (6-16)	-	Robertson et al. (2003)	Range based on *Thalassarche* mean range. Gamma prior mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	GT, MW

Table 94: Suggested updates to prior distributions of current age at first breeding (A_s^{curr}). Age at first breeding provides reported modes and ranges. *(continued)*

Species	Island(s)	Age at first breeding	Time period	References	Suggested prior distribution	Feedback provided
Grey-headed Albatross	S. Georgia (Islas Georgias del Sur), Motu Ihupuku / Campbell	13 (6-20)	1980-2012	Waugh et al. (1999), Pardo et al. (2017)		
Southern Buller's Albatross	Tini Heke / Snares	12 (6-15)	1994-2014	Fu & Sagar (2016)	Gamma prior mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	PS, SW
Northern Buller's Albatross	-	12 (6-15)	-		Use distribution for southern Buller's albatross	-
Sooty Albatross	-	9 (6-16)	-	Carneiro et al. (2020)	Gamma prior (perhaps (9, 0.9)) mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	BC, MW, RP, RW, SO, SS
Light-mantled Sooty Albatross	-	9 (9-16)	-	Carneiro et al. (2020)	Gamma prior mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	BB, GT, JM, MW, RW, SH, SS, TC
Southern Giant Petrel	Gough	8 (6-11)	2010-23	Hunter (1984), ACAP (2010), Carneiro et al. (2020), SO unpub.	Gamma prior (perhaps (12, 1.5)) mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	BC, BW, MW, RP, RW, JM, SO
Northern Giant Petrel	-	9 (5-12)	-	Hunter (1984), Voisin (1988), ACAP (2010), Carneiro et al. (2020)	Gamma prior mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	GT, JM, KRH, MW, RP
Grey Petrel	-	7 (4-11)	-	Carneiro et al. (2020)	Range based on *Procellaria* mean range. Gamma prior mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	BC, BD, EB, JB, JM, KRH, MW, PR, SO, SS

Table 94: Suggested updates to prior distributions of current age at first breeding (A_s^{curr}). Age at first breeding provides reported modes and ranges. *(continued)*

Species	Island(s)	Age at first breeding	Time period	References	Suggested prior distribution	Feedback provided
Black Petrel	Aotea / Great Barrier	8 (4-12)	1996-2017	Zhang et al. (2020)	Gamma prior mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	EB, GT, RP
Westland Petrel	Punakaiki	8 (4-12)	1977-2012	Waugh et al. (2015)	Gamma prior mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	BB, GT, KS, SW
White-chinned Petrel	Crozet	7 (4-10)	1986-2017	Barbraud et al. (2008), Dasnon et al. (2022)	Gamma prior mirroring the reported mode and range (treated as an absolute range, not 95% CIs)	KRH, MW, TC
Spectacled Petrel	-	7 (4-10)	-		Use distribution for white-chinned petrel	BC, PR, RW, SO

Table 95: Suggested updates to prior distributions of current adult survival (S_s^{curr}). Reported 95% CIs are provided in parentheses, where available.

Species	Island(s)	Adult survival	Time period	References	Suggested prior distribution	Feedback provided
Gibson's Albatross	Adams	0.912 (0.837-0.987)	2008-21	Walker et al. (2023)	Fit beta dist that most closely mirrors reported mean and 95% CIs	GE, KRH
Antipodean Albatross	Moutere Mahue / Antipodes	0.907 (0.855-0.952)	2005-21	Richard (2021), Parker et al. (2023)	Fit beta dist that most closely mirrors reported mean and 95% CIs	GE, KRH
Wandering Albatross	S. Georgia (Islas Georgias del Sur)	0.879 (0.850-0.908)	1980-2019	Pardo et al. (2017)		
	Crozet	0.939 (0.888-0.989)	1966-2006	Barbraud & Weimerskirch (2012), Carneiro et al. (2020)		
	Macquarie	0.939 (0.912-0.966)	1995-2014	Cleeland et al. (2021)		
	Weighted mean	0.918 (0.875-0.962)	1966-2019		Fit beta dist that most closely mirrors reported weighted mean and 95% CIs	AM, JM, MC, MW, PR, RP, SH, TC
Tristan Albatross	Gough	0.948 (0.936-0.961)	2004-2021	Oppel et al. (2022)	Fit beta dist perhaps ((99, 5)) that most closely mirrors reported mean and 95% CIs	BC, PR, RW, SO
Amsterdam Albatross	Amsterdam	0.971		Carneiro et al. (2020)	Logit-norm (0.971, 0.01)	MW
Southern Royal Albatross		–			Mean estimate for northern royal albatross used to inform prior. Fit a beta dist with a mean of 0.950 and 95% CI's ranging 0.87-0.96 to mirror uncertainty and recent declines	KRH, PM
Northern Royal Albatross	Taiaroa Head	0.950 (0.941-0.959)	1989-2012	Richard et al. (2015)	Fit beta dist that most closely mirrors reported mean and 95% CIs	PF, MW

Table 95: Suggested updates to prior distributions of current adult survival (S_s^{curr}). Reported 95% CIs are provided in parentheses, where available. *(continued)*

Species	Island(s)	Adult survival	Time period	References	Suggested prior distribution	Feedback provided
Atlantic Yellow-nosed Albatross	Gough	0.923 (0.908-0.935)	1985-2020	Bratt (2023)	Fit beta dist that most closely mirrors reported mean and 95% CIs	AC, BC, MW, SC, SO
Indian Yellow-nosed Albatross	Amsterdam	0.902		Carneiro et al. (2020)	Logit-norm (0.902, 0.02)	AM, MW
Black-browed Albatross	Falklands (Islas Malvinas)	0.933 (0.892-0.974)	2003-21	Ventura et al. (2023)		
	S. Georgia (Islas Georgias del Sur)	0.924 (0.879-0.969)	1980-2019	Pardo et al. (2017), Carneiro et al. (2020)		
	Macquarie	0.914 (0.900-0.928)	1995-2014	Cleeland et al. (2021)		
	Weighted mean	0.931 (0.889-0.973)			Fit beta dist that most closely mirrors reported weighted mean and 95% CIs	AC, GT, JM, MW, TC
Campbell Albatross	Motu Ihupuku / Campbell	0.945	1945-96	Waugh et al. (1999)	Logit-norm (0.945, 0.007)	DT, GT, PS
Shy Albatross	Albatross	0.961 (0.952-0.970)	1981-2010	Alderman et al. (2011), Thomson et al. (2015)	Fit beta dist that most closely mirrors reported mean and 95% CIs	JM, SH
White-capped Albatross	Disappointment	0.920 (0.900-0.930)	2015-23	Parker et al. (2022), Elliott et al. (2023)	Due to differing estimates, a prior with a wider uncertainty range than the reported range is used here. Logit-norm (0.920, 0.01)	BB, GT, KRH
Salvin's Albatross	Western Chain	0.951 (0.754-0.992)	1995, 2008-10	Sagar et al. (2014)	Fit beta dist that most closely mirrors reported mean and 95% CIs	BB, DT, KRH, PS

Table 95: Suggested updates to prior distributions of current adult survival (S_s^{curr}). Reported 95% CIs are provided in parentheses, where available. *(continued)*

Species	Island(s)	Adult survival	Time period	References	Suggested prior distribution	Feedback provided
Chatham Albatross	Tarakoikoia / Pyramid	0.887		Carneiro et al. (2020)	Literature conflates adult and juvenile survival rates, so average *Thalassarche* estimate used here instead. Logit-norm (0.925, 0.03)	GT, MW
Grey-headed Albatross	S. Georgia (Islas Georgias del Sur)	0.952 (0.890-0.990)	1980-2019	Pardo et al. (2017), Carneiro et al. (2020)		
	Macquarie	0.933 (0.925-0.941)	1995-2014	Cleeland et al. (2021)		
	Campbell	0.941	1945-96	Waugh et al. (1999)		
	Weighted mean	0.950 (0.898-0.982)			Fit beta dist that most closely mirrors reported weighted mean and 95% CIs	GT, JM, MW, SH, TC
Southern Buller's Albatross	Tini Heke / Snares	0.891 (0.830-0.950)	2017-23	Thompson & Sagar (2023)	Fit beta dist that most closely mirrors reported mean and 95% CIs	PS, SW
Northern Buller's Albatross	Rēkohu / Wharekauri / Chathams	–			Average *Thalassarche* estimate used in the absence of a direct estimate. Logit-norm (0.925, 0.025)	-
Sooty Albatross		0.895 (0.831-0.941)		SO unpub.	The unpublished analysis likely an underestimate, so the mean for light-mantled Sooty Albatross used, with additional uncertainty. Logit-norm (0.920, 0.025)	BC, MW, RP, RW, SO, SS

Table 95: Suggested updates to prior distributions of current adult survival (S_s^{curr}). Reported 95% CIs are provided in parentheses, where available. *(continued)*

Species	Island(s)	Adult survival	Time period	References	Suggested prior distribution	Feedback provided
Light-mantled Sooty Albatross	Macquarie	0.924 (0.924-0.928)	1995-2014	Cleeland et al. (2021)	Fit beta dist that most closely mirrors reported mean and 95% CIs	BB, GT, JM, MW, RW, SH, SS, TC
Southern Giant Petrel	S. Georgia (Islas Georgias del Sur)	0.920		Carneiro et al. (2020)		
	Gough	0.928 (0.899-0.950)		SO unpub.		
	Prince Edwards	0.890		Carneiro et al. (2020)		
	Weighted mean	0.917			Norm (0.915, 0.100)	BC, BW, MW, RP, RW, JM, SO
Northern Giant Petrel	S. Georgia (Islas Georgias del Sur)	0.910		Carneiro et al. (2020)		
	Prince Edwards	0.890		Carneiro et al. (2020)		
	Weighted mean	0.909			Logit-norm (0.909, 0.025)	GT, JM, KRH, MW, RP
Grey Petrel		–			Average *Procellaria* estimate used in the absence of a direct estimate. Logit-norm (0.897, 0.025)	BC, BD, EB, JB, JM, KRH, MW, PR, SO, SS
Black Petrel	Aotea / Great Barrier	0.864 (0.864-0.879)	1996-2017	Zhang et al. (2020)	Fit beta dist that most closely mirrors reported mean and 95% CIs	EB, GT, RP
Westland Petrel	Punakaiki	0.954 (0.918-0.975)	1977-2012	Waugh et al. (2015)	Fit beta dist that most closely mirrors reported mean and 95% CIs	BB, GT, KS, SW
White-chinned Petrel	S. Georgia (Islas Georgias del Sur)	0.875		Carneiro et al. (2020)		
	Crozet	0.877	1986-2017	Barbraud et al. (2008), Dasnon et al. (2022)		
	Antipodes	0.825 (0.720-0.895)	2006-10	Thompson (2019)		

Table 95: Suggested updates to prior distributions of current adult survival (S_s^{curr}). Reported 95% CIs are provided in parentheses, where available. *(continued)*

Species	Island(s)	Adult survival	Time period	References	Suggested prior distribution	Feedback provided
	Weighted mean	0.874			Logit-norm (0.874, 0.02)	KRH, MW, TC
Spectacled Petrel		–			Use white-chinned petrel distribution with increased variance in absence of direct estimate	BC, PR, RW, SO

Table 96: A preliminary review of the seabird distribution maps from Devine et al. (In press).

Species	Comments	Coverage of tracking data	References	Feedback provided
Gibson's Albatross	Additional tracking to that which was used in the modelling of this distribution are now available. Future work should prioritise a revision of this distribution map and tracking of Disappointment Island population (8%).	Additional data required		GE, KRH
Antipodean Albatross		-		GE, KRH
Wandering Albatross	Additional tracking to that which was used in the modelling of this distribution are now available. Current distribution is heavily weighted towards Atlantic and S. Georgia which represent 11% of the world population. Future work should prioritise a revision of this distribution map, additional tracking work, and weighting available tracking data by population size, tracking duration, and timing.	Additional data required	Carneiro et al. (2020)	AM, JM, MC, MW, PR, RP, SH, TC
Tristan Albatross		-		BC, PR, RW, SO
Amsterdam Albatross	Future work should prioritise a revision of this distribution map to consider spatial differences between age classes.	-	Delord et al. (2022)	MW
Southern Royal Albatross	Additional tracking to that which was used in the modelling of this distribution will be available in 2025. Future work should prioritise a revision of this distribution map to take into account the additional tracking.	Additional data required		KRH, PM
Northern Royal Albatross	Additional tracking is required for this species before a revision of the distribution map is undertaken.	-		PF, MW
Atlantic Yellow-nosed Albatross	Additional tracking is potentially required for this species. If additional tracking is not undertaken, future work revising this distribution map should utilise additional data sources to take into account known foraging areas such as the Benguela Upwelling zone.	Additional data required	ACAP (2010)	AC, BC, MW, SC, SO

Table 96: A preliminary review of the seabird distribution maps from Devine et al. (In press). *(continued)*

Species	Comments	Coverage of tracking data	References	Feedback provided
Indian Yellow-nosed Albatross		-		AM, MW
Black-browed Albatross	Additional tracking is potentially required for this species in the Falkland Islands. Current distribution is heavily weighted towards areas such as the Australian Bight. Future work should prioritise a revision of this distribution map, and additional tracking.	Additional data required		AC, GT, JM, MW, TC
Campbell Albatross	Additional tracking to that which was used in the modelling of this distribution are now available. Known foraging areas in Western Australia and Chile are currently absent from the distribution, potentially due to the short duration of tracking studies on the species to date.	Additional data required	Thompson et al. (2021)	DT, GT, PS
Shy Albatross	Additional tracking to that which was used in the modelling of this distribution are now available. Known foraging areas in the Indian Ocean to the east coast of South Africa are currently absent from the distribution. Future work should prioritise a revision of this distribution map to ensure that tracking is representative of the total population, as tracks from Mewstone Island (63% of the world population) are currently not utilised.	Additional data required	Alderman et al. (2011), Thomson et al. (2015), Mason et al. (2018, 2023)	JM, SH
White-capped Albatross		-		BB, GT, KRH
Salvin's Albatross		-		BB, DT, KRH, PS
Chatham Albatross		-		GT, MW

Table 96: A preliminary review of the seabird distribution maps from Devine et al. (In press). ***(continued)***

Species	Comments	Coverage of tracking data	References	Feedback provided
Grey-headed Albatross	Additional tracking is required for this species before a revision of the distribution map is undertaken. Known foraging areas in the Indian Ocean are currently absent from the distribution, potentially due to tracking data from colonies in the Indian Ocean not being available.	Missing colonies in the Indian Ocean (Crozet 8%, Kerguelen, 8%) and additional data required.		GT, JM, MW, SH, TC
Southern Buller's Albatross	Additional tracking to that which was used in the modelling of this distribution are now available. Future work should prioritise a revision of this distribution map.	Additional data required	Fischer et al. (2023)	PS, SW
Northern Buller's Albatross	The distribution is a direct copy of Southern Buller's Albatross. However, the two taxa are temporally separated, and a short-term fix would be to offset the current maps following the phenological separation of the two species. See Fischer et al. (2023) for more details. Additional tracking to that which was used in the modelling of this distribution are now available. Future work should prioritise a revision of this distribution map.	Additional data required	Fischer et al. (2023)	-
Sooty Albatross	Additional tracking is required for this species before a revision of the distribution map is undertaken. There is also a potentially a track included erroneously in this distribution from the light-mantled sooty albatross. Future work should prioritise a revision of this distribution map.	Additional data required		BC, MW, RP, RW, SO, SS
Light-mantled Sooty Albatross	Additional tracking to that which was used in the modelling of this distribution will be available in 2025 for Pacific colonies. Additional tracking is required for this species before a revision of the distribution map is undertaken given the lack of tracks from several major colonies in the Pacific and the Atlantic, representing $>50\%$ of the world population.	Missing colonies in the Pacific (Maukahuka/Auckland Islands, 24%, Motu Ihupuku/Campbell 8%, and S. Georgia (Islas Georgia del Sur), 24%)		BB, GT, JM, MW, RW, SH, SS, TC
Southern Giant Petrel	Additional tracking is required for this species before a revision of the distribution map is undertaken given the lack of tracks from the Falklands (36% of the world population), South Shetland (10%), South Orkney Islands (Islas Sandwich del Sur) (3%), Antarctica (3%), Diego Ramirez (3%), Prince Edwards (4%), Crozet (2%), Heard (6%), and Macquarie (4%).	Additional data required. Tracking data represents less than 30% of the world population.		BC, BW, MW, RP, RW, JM, SO

Table 96: A preliminary review of the seabird distribution maps from Devine et al. (In press). *(continued)*

Species	Comments	Coverage of tracking data	References	Feedback provided
Northern Giant Petrel	Additional tracking is required for this species before a revision of the distribution map is undertaken given the lack of tracks from the Pacific (Macquarie, Maukahuka/Auckland Islands, Motu Ihupuku/Campbell, Moutere Mahue/Antipodes, and Rēkohu/Wharekauri/Chatham Islands).	Additional data required. Missing colonies in the Pacific representing > 20%.		GT, JM, KRH, MW, RP
Grey Petrel	Additional tracking to that which was used in the modelling of this distribution are now available. Tracking is required for a fully representative distribution given the lack of tracks from major colonies (Prince Edwards & Marion, 5%, Crozet, 5%, and Kerguelen, 3%). There is also the potential that tracks have been erroneously weighted as it is stated that the New Zealand population represent 6.9% of the world population, whereas the true proportion is 70%.	Additional data required. Indian Ocean populations (13%) not being represented and inaccurate population multipliers.	Thompson (2019)	BC, BD, EB, JB, JM, KRH, MW, PR, SO, SS
Black Petrel	Future work should prioritise a revision of this distribution map as this species should no longer be present in New Zealand waters in July-September. Additional grooming of GLS positions also required as maps suggest and the presence of this species in the Caribbean.	-		EB, GT, RP
Westland Petrel	Additional tracking to that which was used in the modelling of this distribution are now available. Future work should prioritise a revision of this distribution map to include these new data and ensure that the species is not shown to be present in New Zealand waters in January-March.	Additional data required	Simister et al. (2023)	BB, GT, KS, SW
White-chinned Petrel	Additional tracking to that which was used in the modelling of this distribution are now available. Known foraging areas such as the Benguela Upwelling zone not present in the current distibution.	-		KRH, MW, TC
Spectacled Petrel	Additional tracking is required for this species before a revision of the distribution map is undertaken.	-		BC, PR, RW, SO

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