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ACAP Small Grants Final Report – Winter Movements of Black-browed Albatross

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ACAP SMALL GRANTS FINAL REPORT – WINTER MOVEMENTS OF BLACK-BROWED ALBATROSS

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23/03/2026 - RACHAEL ORBEN & ALASTAIR BAYLIS

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1. SUMMARY

Understanding the winter (non-breeding) ecology of Black-browed albatrosses is critical for assessing population-level threats, yet winter movements remain poorly resolved in the Falkland Islands - the largest breeding population of the species. Between 2021 and 2023, and with support from the Agreement on the Conservation of Albatrosses and Petrels (ACAP) Small Grants Programme, we deployed 55 tracking devices (51 GPS loggers and four satellite transmitters) at two previously untracked colonies - Bird Island (West Falkland) and Grand Jason Island. Challenges with base-station–linked GPS tags necessitated a shift to satellite telemetry, delaying winter deployments and reducing sample size. However, to maximise the data collected during the project, GPS tracking was conducted during the breeding season, generating the first high-resolution movement data from both colonies and identifying previously unrecorded foraging areas. Satellite tracking in 2023 provided novel insights into winter movements, revealing Black-browed albatross from Bird Island (West Falkland) returned to the breeding site throughout the deployment period and providing insights into fishery interactions over winter. These findings support partial migration within the population and highlight the importance of conservation and management within the Falkland Islands Conservation Zone.

2. INTRODUCTION

As abundant upper-trophic-level predators, colonial breeding seabirds exert a significant influence on marine food webs and are widely regarded as sentinel species, providing integrative signals of ecosystem condition (Hazen *et al.* 2019). Understanding their spatial ecology is therefore central to ecosystem-based management. Albatrosses, in particular, face multiple threats at sea including fisheries-related mortality, climate driven ecosystem change, and pollution and are consequently among the most threatened avian groups globally. Advances in biologging and tracking technologies have been central to addressing these threats, transforming our capacity to quantify individual movement strategies, colony-level habitat use, and population connectivity. These approaches provide the empirical basis for identifying spatial overlap with anthropogenic pressures and support the development of adaptive, evidence-based marine conservation strategies (Maxwell *et al.* 2013, Baylis *et al.* 2019).

The Falkland Islands represent one of the world's most important breeding regions for colonial marine predators, both in terms of abundance and conservation significance (Auge *et al.* 2018, Baylis *et al.* 2021). Notably, the archipelago supports approximately 75% of the global population of the Black-browed Albatross (Agreement on the Conservation of Albatrosses and Petrels 2010), meaning that demographic fluctuations within the Falklands have disproportionate influence on the species' global conservation status. Despite this importance, tracking datasets remain spatially and temporally constrained, particularly for certain colonies, life-history stages (e.g. early chick rearing), and seasons.

A key knowledge gap for the Falklands Black-browed albatross population is movement ecology during the non-breeding period. Black-browed albatrosses nesting outside the Falkland Islands are characterised as long-distance migrants that disperse widely during austral winter (e.g. Phillips *et al.* 2008, Desprez *et al.* 2018). In the Falkland Islands, distributions are generally restricted to the Patagonian Shelf (Grémillet *et al.* 2000, Hedd *et al.*, Seabird Tracking Database #899). Due to the spatially constrained extent of the Patagonian Shelf, individual movements are not easily discernible using geolocation (GLS) data loggers - which offer a relatively inexpensive method for studying non-breeding distributions and behaviors (Phillips *et al.* 2004). However, Black-browed albatrosses in the Falkland Islands undergo substantial feather molt during chick-rearing (Catry *et al.* 2013). Hence, the retention of GPS and Argos PTT tags attached to feathers is likely to last 4-6 months over winter - sufficient to capture fine-scale localized movements. This, coupled with our observations of birds roosting on Bird Island, West Falklands, during mid-winter (Fig. 1), prompted the motivation for this project to provide the fine-scale winter tracking data needed to understand individual use of the Patagonian Shelf during the non-breeding period.

Here, we examine non-breeding movements of albatrosses in the Falkland Islands, with particular focus on the extent of migratory variability and winter colony attendance. Colony attendance during winter suggests partial rather than obligate migration, given that chicks fledge at the end of April. This pattern of seasonal colony visitation has important implications for understanding migratory strategies, carry-over effects between breeding and non-breeding periods, and exposure to at-sea threats during winter. By refining our understanding of partial migration and seasonal site fidelity, we aim to improve population-level assessments and strengthen the evidence base for year-round conservation management.

3. METHODS

3.1 Field Methods

Field work was located at Bird Island (West Falkland) and Grand Jason Island, which are large albatross colonies that have previously not been studied (Fig. 2). The most recent population census indicates Bird Island accounts for 2.5 % of the Falkland Islands breeding population (14,000 breeding pairs), while Grand Jason Island accounts for 19 % (105,000 breeding pairs) of the Falkland Islands breeding population (Fig. 2).

We initially deployed base-station GPS loggers designed to remotely download stored data when within line-of-sight (<150 m) of a fixed receiver (Pathtrack, UK). These devices were selected to maximise data retrieval efficiency while reducing the need for recapture. Because we were working at large, previously untracked colonies of Black-browed Albatross, we prioritised summer deployments to (i) obtain baseline breeding-season movement data for comparison with winter distributions and (ii) trial the remote download functionality under field conditions (Table 1). Summer deployment also ensured that tags could be physically recovered if remote data transfer proved unsuccessful.

Field trials demonstrated that base-station GPS units purchased in 2021, were unsuitable for winter deployment (please note that considerable improvements have been made to remote download GPS tags in recent years). Colony topography frequently obstructed line-of-sight transmission, and even where visual line-of-sight was unobstructed, data transfer success was inconsistent - potentially due to power limitations at the base station. These limitations would have substantially reduced data return during winter, when recapture was not an option. Despite these technical constraints, summer deployments yielded extensive high-resolution tracking data from globally significant, previously untracked colonies of Black-browed albatross. To ensure reliable data acquisition during the non-breeding season and to complete project objectives, we transitioned to satellite-transmitting devices, which provide reliable remote data access. This type of data logger is, however, more costly due to both the price of the individual instruments and the data transmission fees, which translated into a very small sample size.

All albatross were captured by hand and manually restrained following established ethical handling protocols. When capturing albatross during summer, we waited for pairs to swap and captured the outgoing bird once it was off the nest to minimize disturbance to the nest. In winter, we captured birds that were attending a nest. Birds in winter were generally more skittish, but still approachable. Devices were attached to body feathers on the center of the upper back using Tesa tape and a small bead of super glue. We used three different types of tags during the project. In addition to the base-station GPS tags (Pathtrack, UK), we also deployed archival CatLog GPS tags, which were programmed at 10 min intervals and sealed inside heat-shrink tubing (Perthold Engineering, USA). Finally, we used Telonics satellite tags for winter data collection (35 g TAV-2630, Telonics, USA). All birds were released at the point of capture. To recover tags from albatross in summer, we removed tags while the bird was on the nest and without restraining the bird. We did not recover tags during winter deployments – rather these fell off birds after several months of transmitting data.

3.2 Fisheries Association During Winter and Spring

Argos satellite tracking data was first processed to remove aberrant and duplicate locations. The resulting dataset had a mean interval of 61 +/- 146 min. The tracks were then regularized to hourly intervals using a correlated random walk within a state-space model framework using the R package ‘aniMotum’(Jonsen *et al.* 2023). Trips were determined using the R package ‘TrakR’, using distance to the colony (Bird Island), with a distance threshold of 20 km and a required minimum duration of 6 hrs (6 locations away from the colony) (Fleishman *et al.*, 2022).

Fisheries data was extracted from the Global Fishing Watch dataset using R package ‘gfwr’ (Sánchez-Tapia *et al.* 2026). To determine large-scale overlap, fishing effort in hours was calculated for each month and gridded into a 0.25 degree hexagon grid. Overlap was calculated as the percentage of hourly bird locations within grid cells with and without fishing effort and for both the long-line and trawler gear types. Additionally, the percentage of time within the Falkland Islands Conservation Zone was calculated for each month.

To understand movement behavior in relation to fishing activity, fishing data was extracted for each day at a higher spatial resolution of 0.01 degrees (Sánchez-Tapia *et al.* 2026). Each bird location was then associated with the sum of fishing effort within a 5 km radius using the R package 'terra'. Bird locations were also associated with bathymetry and sea surface temperature to characterise habitat features following Baylis *et al.* 2019. Bathymetry was extracted at 1-minute resolution from the ETOPO 2022 dataset using the R package 'marmap' and 0.01° daily sea surface temperature data was sourced from the Multi-scale Ultra-high Resolution (MUR) SST Analysis fv04.1 using the R package 'rerddap'. Finally, a movement persistence mixed-effect model containing fishing hours, bathymetry, and sea surface temperature and individual as a random effect was fit using the R package 'mpmm' (Jonsen *et al.* 2019). Movement persistence (γ_t) is a scaled variable from 0 to 1, where smaller values indicate more tortious movement, while larger values indicate more directional movements. For albatross, we expect that low movement persistence values should indicate foraging and searching activity, while higher movement persistence is associated with transit traveling behavior (Torres *et al.* 2017).

4 RESULTS AND DISCUSSION

With support from ACAP Small Grants, we deployed 55 tracking devices on Black-browed Albatross between 2021 and 2023, comprising 51 GPS loggers and four satellite transmitters. Fieldwork was conducted at two previously untracked breeding colonies: Bird Island and Grand Jason Island (Fig. 1). Both colonies are globally important in terms of breeding pair numbers, and their inclusion substantially expands the spatial representation of movement data within the Falklands archipelago. A summary of deployments is provided in Table 1. Satellite tags were deployed at Bird Island in early August. GPS tracking occurred during late incubation and early chick-brooding at both Bird Island and Grand Jason Island during early December.

4.1 Winter movements

The four individuals tracked from Bird Island in winter of 2023 undertook 57 trips with an average duration of 4.78 days (SD = 7.84) and a maximum distance of 1,183 km (Table 1). The satellite tags remained attached and transmitting for 92 +/- 22 days, with the longest deployment lasting until early December (115 days). Two tags stopped transmitting at 72 days suggesting battery life may have shortened deployment durations rather than the attachment. All four tracked birds conducted foraging trips over the Patagonian shelf, with the longest trip occurring during incubation (Fig. 3). The bird that was tracked the longest, 232326, showed evidence of colony residency between foraging trips in October and November that suggest this individual may have been nesting. The tracks for the remaining three individuals are more ambiguous and it is not clear if these birds were also breeding individuals (Fig. 4).

Importantly, these birds returned to the colony multiple times outside of the breeding period, demonstrating central place foraging behavior during the non-breeding season (Fig. 4). Their movements consisted of a mixture of long and short trips, indicating a strategy of alternating between extended foraging excursions and colony returns.

Historical data from Saunders Island in 1999/2000 show that male and female adults undertook very long winter trips, averaging 167 and 180 days respectively, with maximum distances reaching 1,463 km (males) and 2,247 km (females) (Huin 2007). Similarly, birds from New Island in 1996/1997 appeared to return to the colony in September (Grémillet *et al.* 2000). Fledgling albatrosses from Steeple Jason in 2007 also exhibited long-range movements, averaging 96 days and reaching up to 2,508 km (Huin 2007). It could be that individuals tagged on Bird Island returned from an extended winter foraging trip early, and subsequently alternated between colony attendance and local and regional foraging trips. This strategy is not unlike that observed in the Shy Albatross, another albatross species whose foraging areas are also generally restricted to shelf habitats (Hedd & Gales 2005, Alderman *et al.* 2010, Mason *et al.* 2023). However, in July 2018 and 2019, we observed individual birds consistently attending nests at Bird Island, implying at least some birds do not undertake prolonged pelagic migrations during winter, but instead remain regionally resident.

From a conservation perspective, winter central place foraging behavior means that local management within the Falkland Islands is relevant year-round. For example, albatrosses may spend a significant portion of the non-breeding season within waters overlapping with Falkland Islands fisheries or protected areas. Hence, national measures that reduce bycatch or support ecosystem-based fishery management likely have positive impacts on survival and foraging success during the winter, not just the breeding season.

Recognizing winter central place foraging behavior also highlights opportunities for further research. With the improved reliability and cost-effectiveness of base-station linked GPS tags, there is an opportunity for a larger tracking effort to understand colony, individual, and demographic variation in winter movement strategies and the environmental or ecological drivers influencing movement. In addition, we were not able to deploy satellite tags earlier in winter due to logistical constraints. As a result, April – July remains a key data gap, and targeted data collection during this period is needed to capture the full extent of winter movements. Without a clear baseline encompassing both breeding and non-breeding behaviour, it will be difficult to detect shifts in movement patterns, habitat use, and foraging strategies, and interpret any future changes in the status of the Falkland Islands Black-browed albatross population. Strengthening this baseline will help attribute ecological change, improve long-term monitoring, and support adaptive management in a rapidly changing marine environment.

4.1 Fisheries Overlap

Quantifying interactions between wide-ranging marine predators and fisheries operating across jurisdictional boundaries is central to bycatch mitigation and ecosystem-based management. The widespread adoption of Automatic Identification Systems (AIS) by commercial vessels, combined with global data aggregation platforms such as Global Fishing Watch, enables fine-scale spatial and temporal characterisation of fishing effort (e.g. Kroodsma *et al.* 2018). These datasets make it possible to quantify animal–vessel co-occurrence across entire ocean basins, including the Patagonian Shelf (e.g. Orben *et al.* 2021).

We first conducted an exploratory spatial comparison between tracking data and fishing effort (expressed as fishing hours) derived from Global Fishing Watch (Fig. 5). Overlap was quantified at a course monthly resolution to identify regions of spatial co-occurrence. As anticipated, Black-browed Albatrosses showed extensive spatial overlap with fisheries, both within and beyond the Falkland Islands Conservation Zone (Table 2). Overlap was more pronounced with trawl fisheries than with long-line vessels (Fig 5). This finding is consistent with the species' known susceptibility to bycatch and underscores the importance of continued non-area based mitigation measures implemented under Agreement on the Conservation of Albatrosses and Petrels framework.

Our movement persistence model offers a preliminary understanding of how movements are associated with fishing vessel effort. All covariates, sea surface temperature, bathymetry, and fishing effort, were significant and retained in the final model (Fig. 6). Adding more covariates to the model such as bathymetric slope, primary productivity, eddy kinetic energy and wind may offer more behavioral insights into the conditions that promote foraging and searching behavior in this species. Our results indicate that there was variation in the response to fishing vessels among our tracked birds, but regardless there is a general tendency to adopt more tortuous moment paths in the vicinity of activity fishing vessels.

4.2 REGIONAL CONNECTIVITY IN THE CONTEXT OF AVIAN INFLUENZA

Briefly, Black-browed albatross foraging tracks demonstrate strong ecological connectivity between the Falkland Islands and the South American mainland (Fig. 8). Movements across the Patagonian Shelf highlight the potential for cross-border ecological processes, including pathogen transmission. Recent work (Riaz *et al.* 2024) indicates that transit times between the Falkland Islands and South America for Falklands-breeding albatrosses, Magellanic penguins, and fur seals ranged from 0.2 to 70 days, with 84% of tracked individuals completing the crossing within four days - approximately the estimated infectious period for highly pathogenic avian influenza (HPAI) (Fig. 9). This temporal overlap between host movement and HPAI infectious period provides plausible mechanistic pathways for pathogen introduction from South America to the Falkland Islands. While colony-level differences in Black-browed albatross space use are evident (Fig. 7), including indications that birds from Beauchêne Island may spend proportionally more time in pelagic waters, all colonies exhibited some degree of connectivity with South America. Moreover, core foraging areas overlapped among colonies, implying potential inter-colony mixing at sea. Together, these patterns suggest that neither geographic separation nor foraging segregation are sufficient to separate Falkland Islands Black-browed albatross breeding colonies from epidemiological pathways in South America, reinforcing the role of regional-scale connectivity in shaping disease outbreak dynamics.

4.3 FUTURE RECOMMENDATIONS

Winter movements of Black-browed albatrosses in the Falkland Islands remain a key data gap. Addressing this limitation is important for developing a more complete understanding of year-round spatial ecology, particularly given that wintering behaviour may differ substantially from the breeding season and influence exposure to environmental variability and anthropogenic threats.

With the increasing reliability and cost-effectiveness of base-station-linked GPS tags, there is now a opportunity to implement larger-scale tracking efforts. Such studies would enable robust assessment of variation in winter movement strategies across colonies, individuals, and demographic groups (e.g. age or breeding status), and improve our capacity to identify critical habitats and periods of elevated risk

Acknowledgements

We are extremely grateful to the many colleagues who assisted with the fieldwork. In addition to funding from the ACAP Small Grants Scheme, field work was supported by a Shackleton Scholarship Fund grant. All seabird handling was conducted under permits issued by the Falkland Islands Government. Albatross handling and tagging procedures were also approved by the Oregon State University Animal Care and Use Committee under protocol 2019-0002.

Table 1: Summary of ACAP supported deployments from three Falkland Islands field seasons, including summer 2021 and 2022 and winter 2023. Also included is a summary of older winter tracking data from Huin (2007). The seasons are split in 2023 on September 22, with trips assigned to the season based on start date. **The four individuals included in the 2023 tracking effort.*

Season	Colony	Year	Individuals	Trips	Average duration (days)	Duration (sd)	Max distance (km)
Summer	Bird	2021/22	24	63	2.9	2.7	589.9
Summer	Grand Jason	2022/23	27	31	4.8	3.1	930.9
Winter/Spring	Bird	2023	4	56	4.78	7.84	1183
Winter	Bird	2023	4*	23	6.06	8.62	1054
Spring	Bird	2023	4*	33	3.9	7.25	1183
			55	**150**			
Winter	Saunders (female)	1999/2000	12	-	180	-	2247
Winter	Saunders (male)	1999/2000	19	-	167	-	1463
Winter (Fledgling)	Steeple Jason	2007	3	-	96	-	2508
			34				

Table 2: *Monthly overlap between black-browed albatrosses tracked from Bird Island with PTT tags in 2023, with monthly fishing effort from Global Fishing Watch. Time within the Falklands Zone is total time irrespective of fishing effort. The category of long-liners includes those classed as drifting-longlines and set-longlines. Percentages are calculated from the pooled points irrespective of individual.*

Month	Time within FCZ (%)	Time associated with fishing effort (%)	Time associated with trawlers (%)	Time associated with long-liners (%)
August	57.7	65	65.4	0.047
September	83.0	50	49.54	0
October	57.4	39	34.19	0
November	28.4	42	40.94	0.15

Fig 1: *A photo taken at Bird Island on July 20, 2018 of a portion of the subcolony visible from the landing bay. Nine albatrosses are in this photo. The inset shows one of these birds. Photo: R. Orben.*

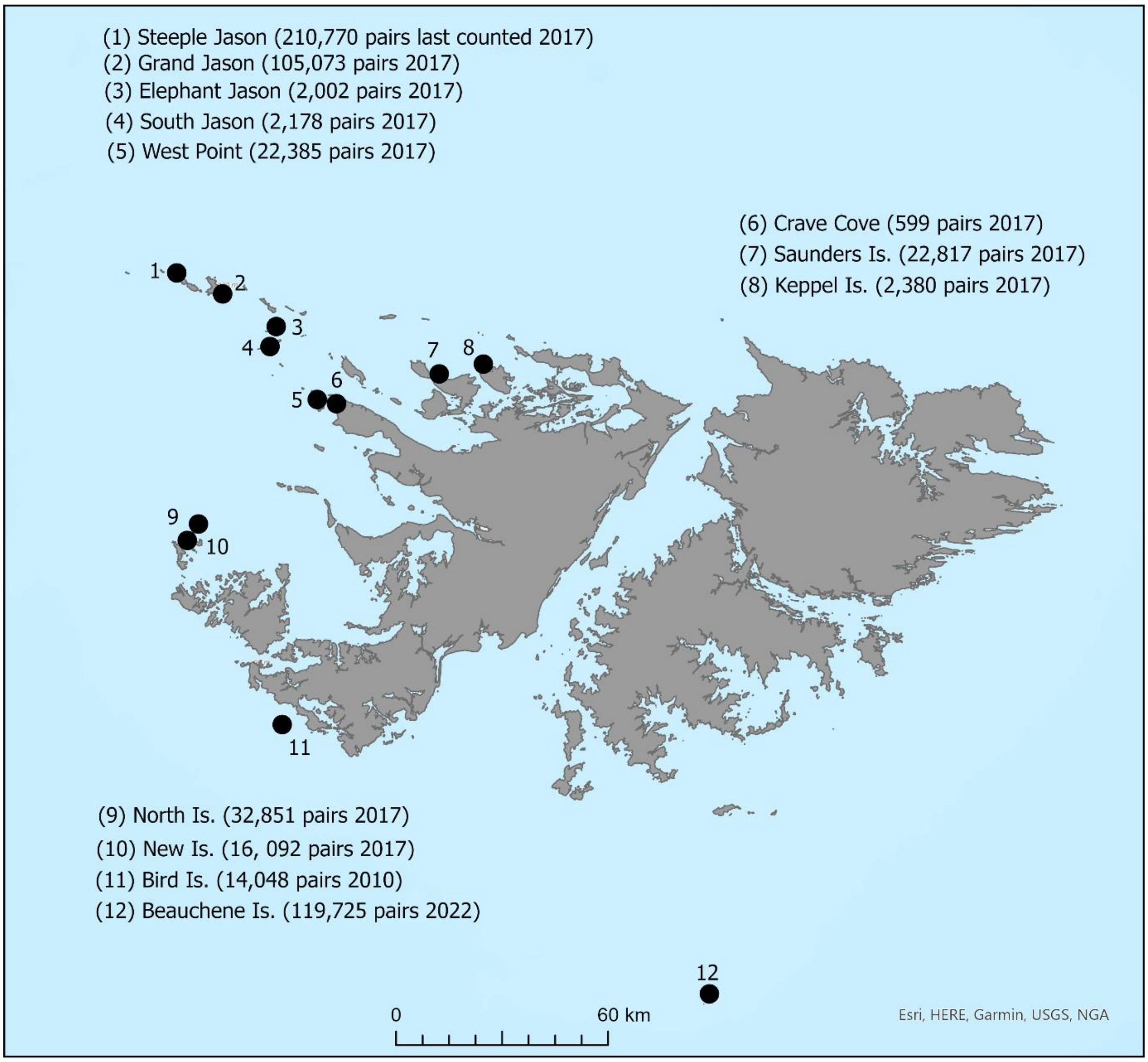


***Fig 2**: Breeding colonies of Black-browed albatross in the Falkland Islands, including most recent population census data from 2017 & 2022 (Crofts 2020; SAERI unpublished data). Also shown, the location of study colonies, Bird Island (11) and Grand Jason Island (2).*

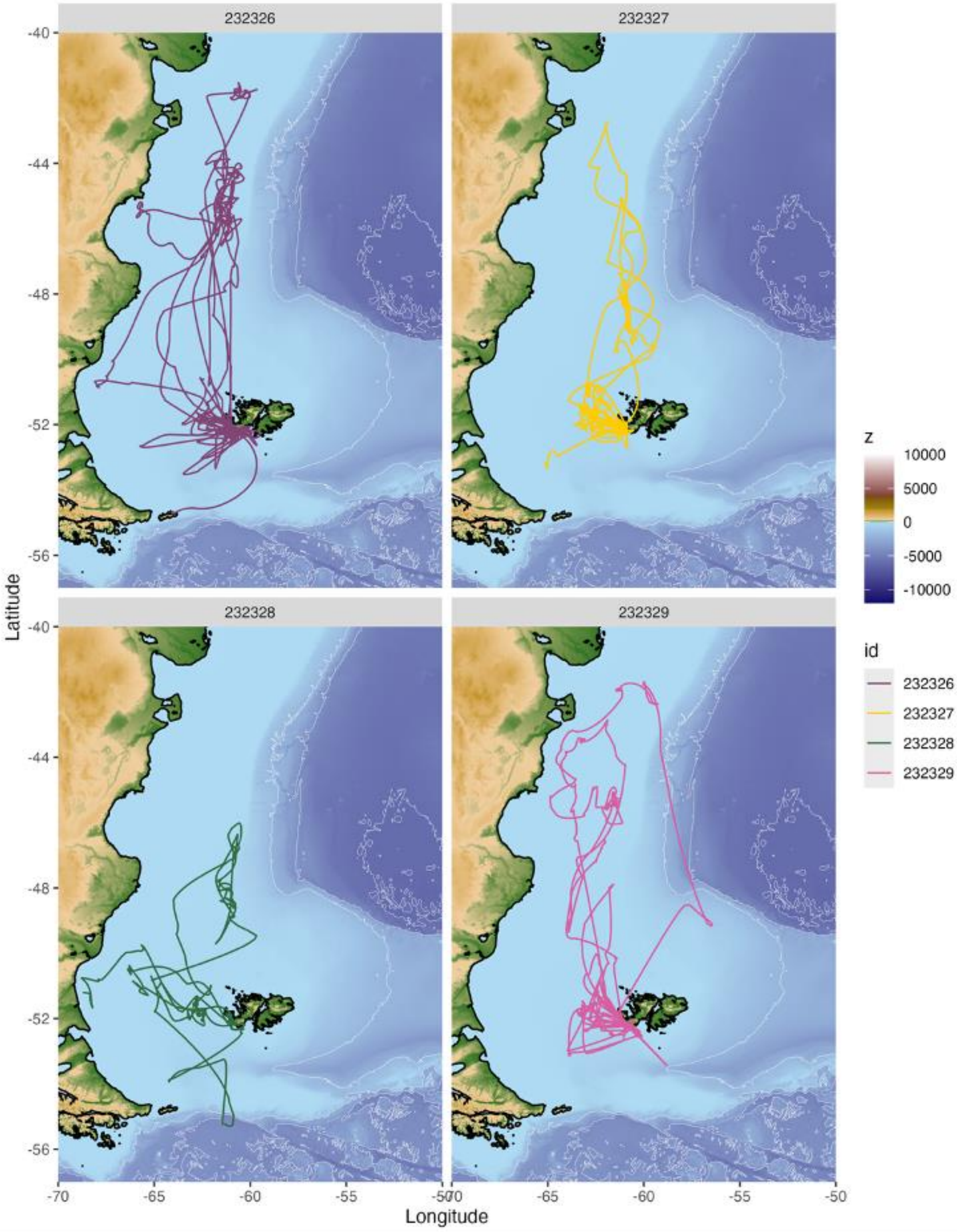


Fig 3: *Foraging tracks of black-browed albatrosses tracked from Bird Island, Falkland Islands from August through November of 2023.*

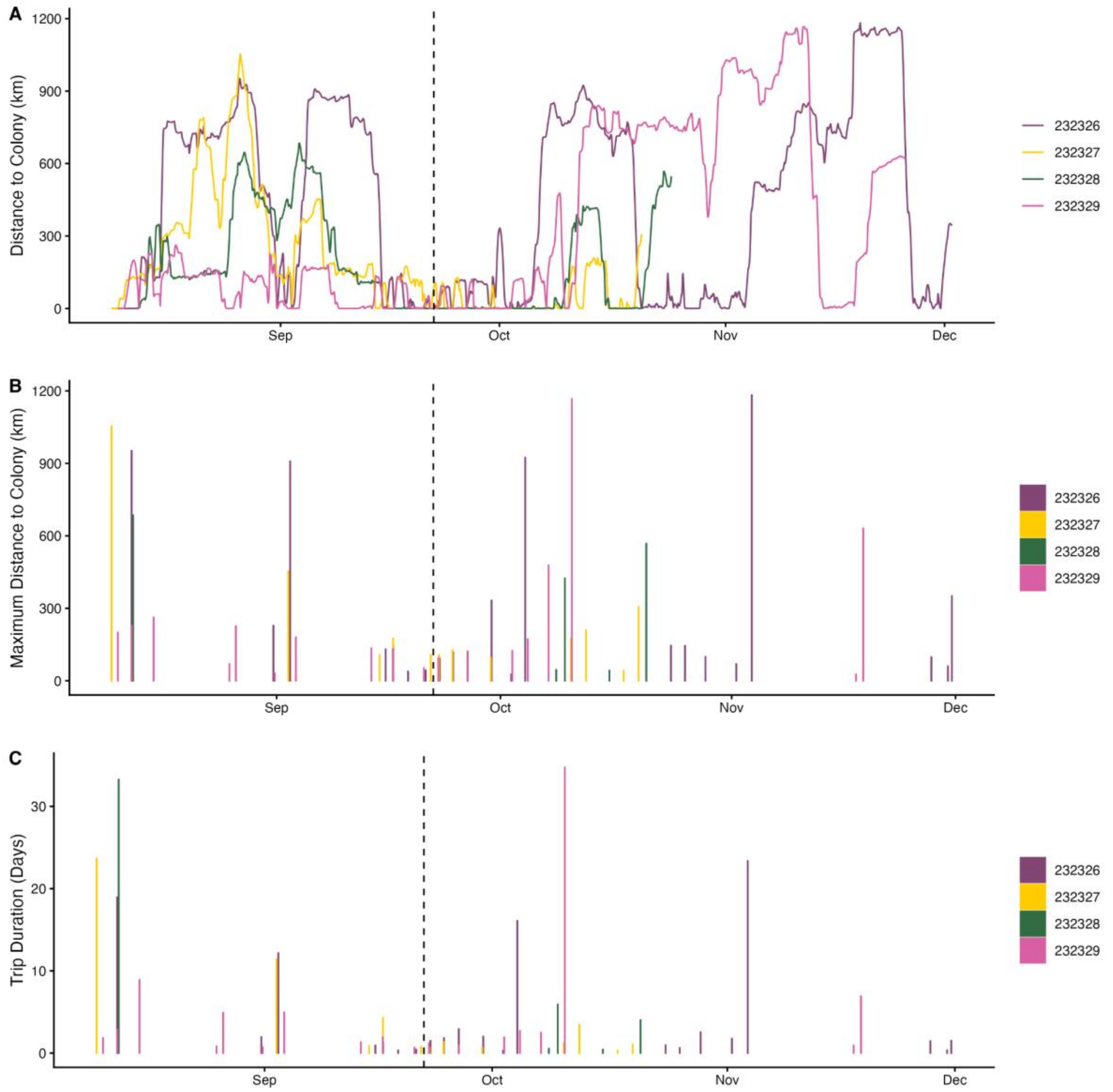
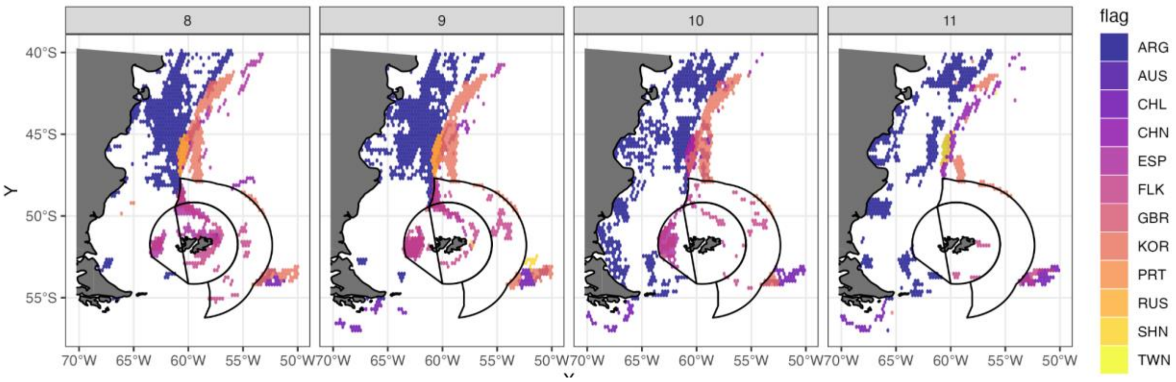


Fig 4: Foraging trip metrics *for the black-browed albatrosses deployed with PTTs in 2023 from Bird Island showing the mix of long-distance and short trips made by these four individuals. A) Distance to colony over time, B) Maximum distance to the colony labeled at the beginning of each trip, C. Trip duration.*

A.



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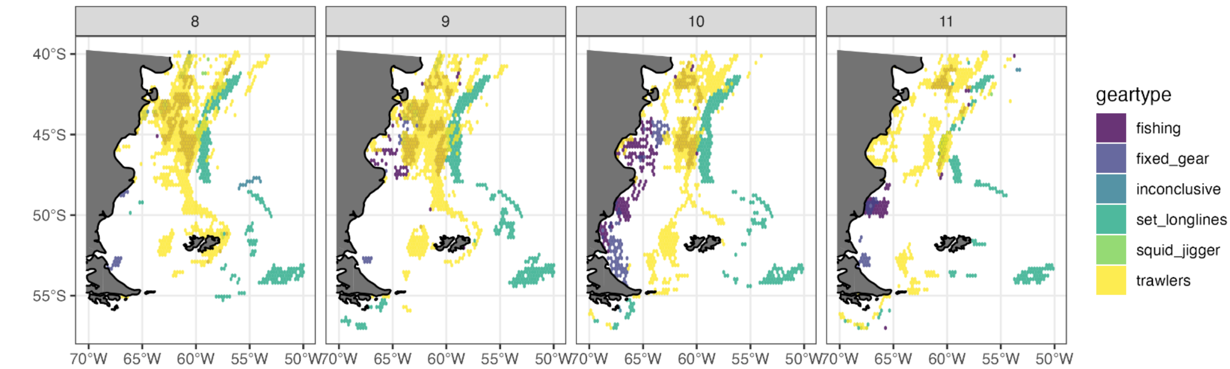

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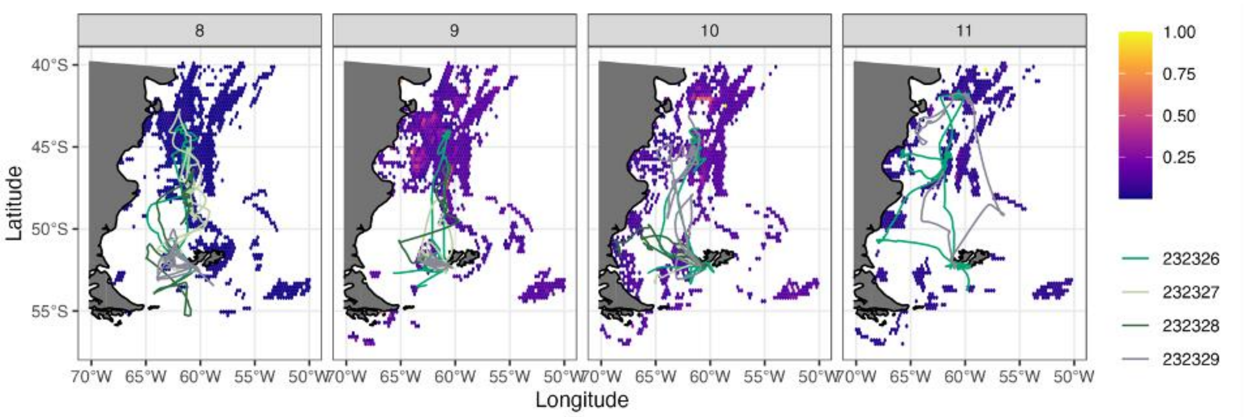

Fig 5: *Exploring overlap of Black-browed albatrosses with commercial fisheries using monthly data from Global Fishing Watch from August to November. A. Fishing effort coloured by flag nation. B. Fishing effort coloured by gear type with the Falkland Islands Conservation Zone in black. C. Fishing hour effort normalized within each month along with the black-browed albatross PTT tracks.*

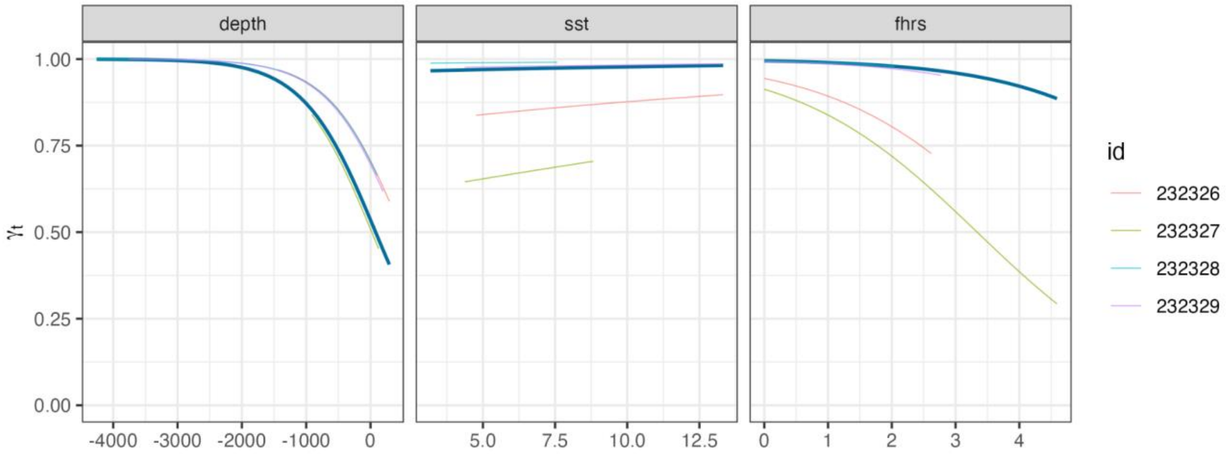

Fig 6: *Relationship of movement persistence (γt) to environmental covariates including depth, sea surface temperature and fishing effort (daily, 0.01 degree). Individual bird responses are shown with thin lines, while the overall model is shown by a thicker line in dark blue.*

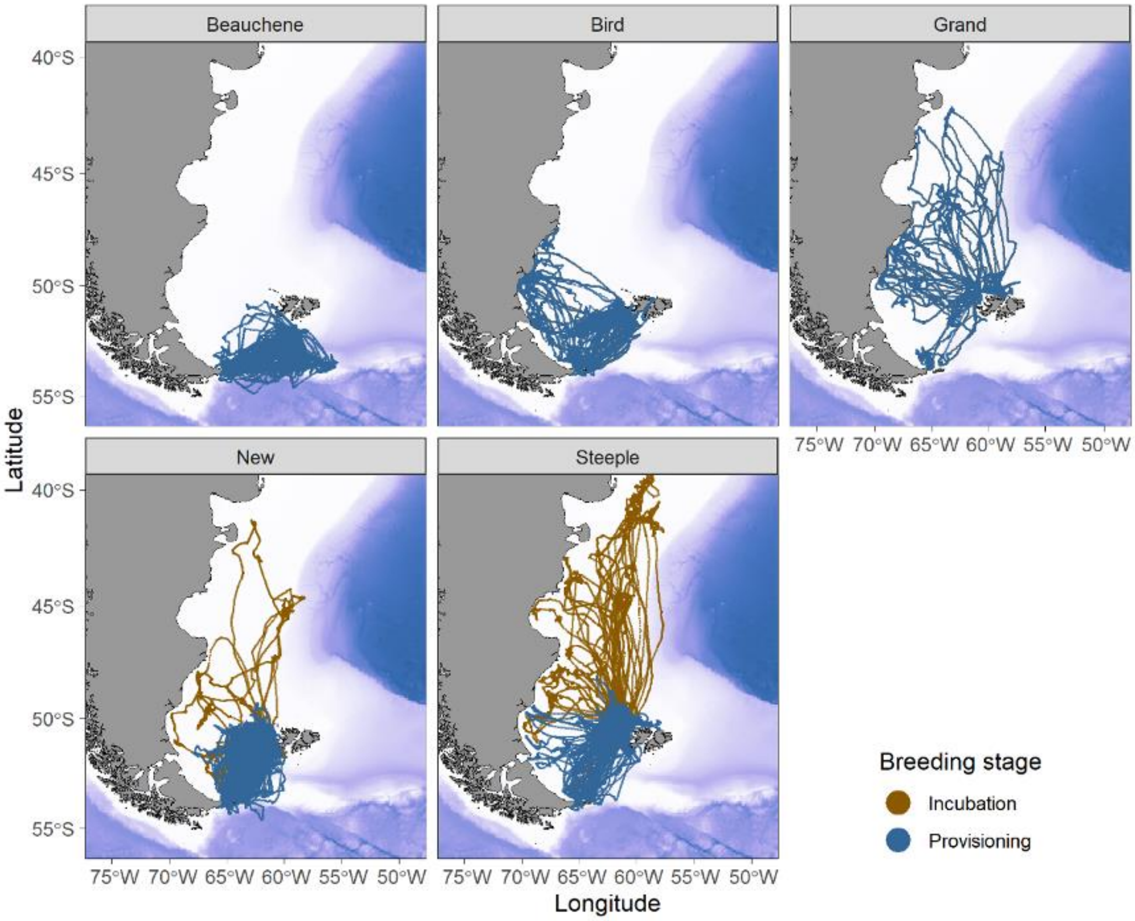

Fig 7: *Foraging areas of Black-browed albatross during incubation and provisioning (early chick rearing). Each panel represents a different breeding colony, and highlights spatial differences in foraging areas. Incubation trips are not distinguished for Bird Island or Grand Jason. While some colony differences in foraging areas are evident, all colonies interact with mainland South America. See also Fig 4. Source:* Riaz *et al.* 2024*.*

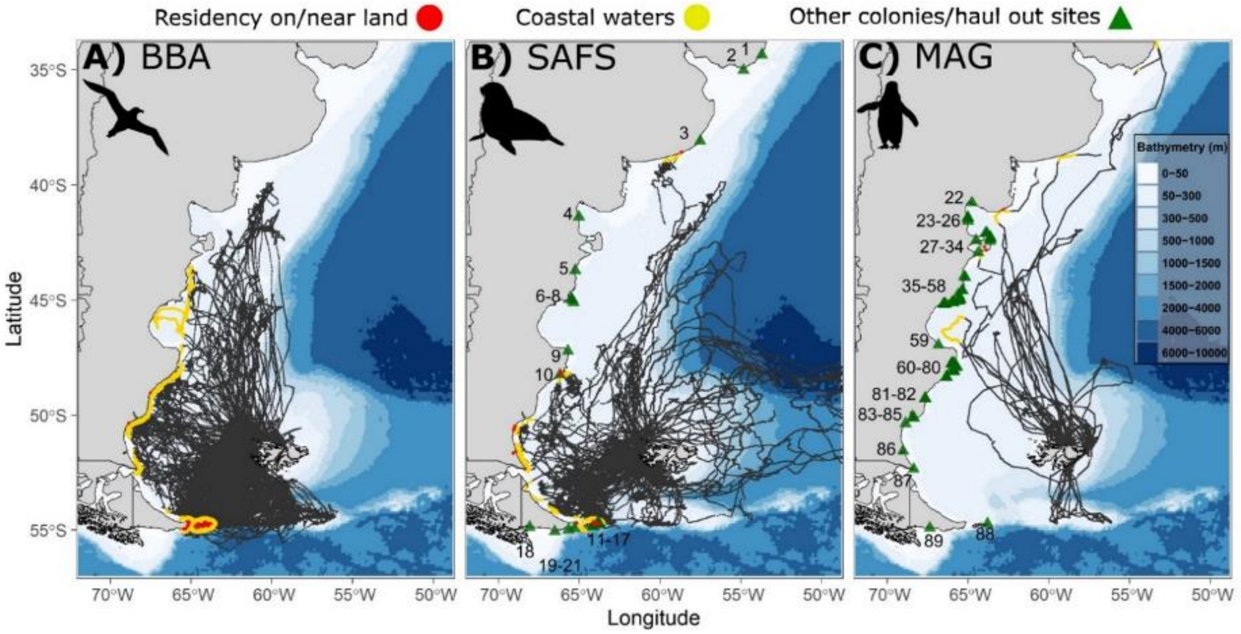

Fig. 8: *Foraging trips of Black-browed albatross, South American fur seals, Magellanic penguins, and connectivity with South America. Yellow points indicate location estimates nearshore, while red points illustrate residency on/near land. Source: Riaz et al. (2024).*

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