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Fine-scale overlap analyses of Gibson's and Southern Buller's Albatross with pelagic longline fishing effort

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ABSTRACT

Gibson’s Albatross (*Diomedea antipodensis gibsoni*) and Southern Buller’s Albatross (*Thalassarche bulleri bulleri*) are endemic to New Zealand and predominantly forage within the WCPFC Convention Area. Both taxa are highly susceptible to bycatch in commercial pelagic longline fisheries, and both are currently declining at their New Zealand colonies.

The distribution of these taxa and spatiotemporal overlap with pelagic longline fisheries are assessed, enabling the identification of high-risk areas. Specifically, 100 adult and juvenile Gibson’s Albatross were tracked during 2019 and 2022-25, and 48 adult Southern Buller's Albatross were tracked during 2024-25 using GPS-PTT satellite transmitters. Fishing effort, inferred from Automated Identification System (AIS) data by Global Fishing Watch, was then used to assess spatiotemporal overlap of tracked birds with pelagic longline fishing effort.

Of the albatrosses tracked in this study, 80% of Gibson’s Albatross and 75% of Southern Buller’s overlapped with pelagic longline fishing effort. This overlap occurred almost exclusively within the WCPFC Convention Area (97% of overlap events with Gibson’s Albatross, and 98% of overlap events with Southern Buller's Albatross). We found substantial overlap in the High Seas within the WCPFC Convention Area (79% and 15% respectively) as well as in Australia’s EEZ (16% and 35%). Additionally, for Southern Buller's Albatross, the New Zealand EEZ was also an area of high overlap (50%), but since the New Zealand pelagic longline fleet implements highly effective mitigation methods, overlap with this fleet represents a lower risk.

The overlap varied considerably among the latitudinal bands relevant to CMM 2018-03. Gibson’s Albatross, the more threatened and more steeply declining of the two taxa, exhibited considerable overlap with High Seas fishing effort between 25°S and 30°S (20% of bird hours within this area overlap with fishing vessels). As such, the information presented here can inform the review of CMM2018-03 by identifying where effective mitigation methods are needed.

1. INTRODUCTION

Albatrosses are a globally threatened group of seabirds, vulnerable to bycatch in commercial pelagic longline fisheries (hereafter 'pelagic longline fisheries') (Dias et al., 2019). The majority of the World's albatrosses (17/22 species; 77%) breed and/or forage within the Western and Central Pacific Fisheries Commission (WCPFC) Convention Area. Among these, the Gibson's Albatross (*Diomedea antipodensis gibsoni*) and the Southern Buller's Albatross (*Thalassarche bulleri bulleri*) are two taxa that are particularly vulnerable to bycatch in pelagic longline fisheries based on results of various fisheries risk and bycatch assessments (e.g., Anon. 2024, Edwards et al. 2023a,b, Abraham et al. 2019), including assessments specific to the WCPC Convention Area (i.e., Peatman et al. 2019). Although these assessments are subject to various limitations, most notably limited observer data (particularly Peatman et al. 2019), they consistently highlighted both taxa as being of high conservation concern, including the most recent work (Anon. 2024) that highlighted Gibson's Albatross as the most at-risk species.

The Gibson's Albatross breeds on the Auckland Islands (Maukahuka) and range throughout the Tasman Sea and along the continental shelf of southeastern Australia, the Great Australian Bight, and eastern Aotearoa New Zealand (Walker and Elliot, 2006; Rowley et al., 2024). The Southern Buller's Albatross breeds on the Snares (Tini Heke) and Solander Island (Hautere) (Sagar et al., 2024) and ranges along the eastern coast of New Zealand's South Island and across the Tasman Sea to Tasmania (Stahl and Sagar, 2000; Poupart et al., 2019).

The population of Gibson's Albatross is limited to ~4,750 breeding pairs. From 2005 to 2020, the population has experienced a sustained annual decline of 5.7% with only limited signs of recovery in subsequent years (Francis et al., 2015; Elliott et al., 2020; Fischer et al, 2024, Elliott et al. 2025). Moreover, recent data suggests a potential renewed decline beginning around 2016 (Elliot et al., 2024). The population of Southern Buller's Albatross is estimated at ~12,400 breeding pairs, with 7,031 on the Snares and 5,373 on Solander Island (Frost et al 2024, Sagar et al. 2025). The population increased considerably from 1948 to 1990, however, since then, adult survival has decreased with marked annual variation in the breeding population, including a significant decline in the last few years (Francis and Sagar, 2012; Sagar et al., 2024, 2025).

Given the threat posed by pelagic longline fisheries to both taxa, a comprehensive understanding of their spatial and temporal distributions as well as their overlap with fishing effort is essential for identifying areas of elevated bycatch risk and to inform the development of targeted mitigation strategies. In response to this need, New Zealand has conducted a multi-year tracking study of Gibson's Albatross since 2019, and of Southern Buller's Albatross since 2024. Here, we collate these tracking data to determine the ranges of these taxa and quantify their spatiotemporal overlap with fisheries.

2. METHODS AND MATERIALS

2.1 Tracking devices

We fitted a total of 100 Gibson's Albatross and 48 Southern Buller's Albatross with GPS/PTT satellite transmitters to their back feathers using water-proof tape (Tesa® 4651). We deployed tracking devices on Gibson's Albatross from Adams Island in January 2019 (n = 12), early (n = 29) and late (n = 23) 2022, late 2023/early 2024 (n = 20), and late 2024 (n = 16) which provide 2 to >30 fixes per day depending on the transmitter type. A portion of these data have been reported on by Fischer et al. (2024), but here we include more deployments, and integrate more location data from prior deployment which has since been acquired. We deployed tracking devices on Southern Buller's Albatross from the Snares colony in April 2024 (n = 8) and January (n = 20) 2025, and from the Solander Island in March 2024 (n = 20). These devices provide location data for as long as they are attached to the birds (Gibson's Albatross mean = 188 days, range = 11-541 days; Southern Buller's Albatross from the Snares mean = 75 days, Solander mean = 95 days, overall mean = 80 days, range = 3-223 days). Full details of the fieldwork, technical details of transmitting devices, and attachment methods for Gibson's Albatross are reported by Rexer-Huber et al. (2020), Parker et al. (2022) and Walker et al. (2023), and for Southern Buller's Albatross by Sagar et al. (2024, 2025). As devices are always deployed on birds during the breeding period, there is a bias in quantity of tracking data during the breeding period. This means time spent and overlap occurring in the Pacific Ocean High Seas and near South America during non-breeding periods (for Southern Buller's Albatross) may be underrepresented.

2.2 Data

Following deployment, bird location data were compiled and pre-processed using a standardised procedure to ensure accuracy and consistency for subsequent analysis. The standardised pre-processing procedure included the following: 1) PTT-derived locations with an Argos quality of A, B and Z were discarded due to their low positional accuracy (Douglas et al., 2012), 2) Argos-generated error ellipse variable of >100km error radius were eliminated, and 3) a speed filter was applied removing flight speeds greater than 50 m/s as sustained flight at this speed was deemed unrealistic (Merkel et al., 2016; Bose & Debski, 2020).

After filtering, 107,254 location fixes were retained for Southern Buller's Albatross from the Snares Islands and 6,683 fixes from Solander Island, and 186,241 were retained from the Gibson's Albatross. The filtered data were then linearly interpolated at 1-hour intervals to standardise temporal resolution. Additionally, location points over land and within 5 km of the centre of the colony were excluded to focus on at-sea positions.

We quantified the relative occurrence of albatrosses within geopolitical jurisdictions as the proportion of bird hours spent in each jurisdiction. This metric was derived across all tracking data without grouping by individual bird identity, thereby avoiding disproportionate weighting of tracks with fewer location fixes, given the variation in tracking duration among individuals.

The jurisdictions considered in this analysis included the Exclusive Economic Zones (EEZs) of Australia, New Zealand, Chile, and Peru, as well as two Regional Fisheries Management Organisations (RFMOs): WCPFC and the Inter-American Tropical Tuna Commission (IATTC). Due to spatial overlap between EEZs and RFMOs, bird occurrence was assessed using two approaches, 1) EEZs and High Seas areas under RFMO jurisdiction (excluding EEZs), and 2) RFMOs inclusive of EEZs. Additionally, because WCPFC and IATTC jurisdictions overlap in certain regions, we accounted for this by assigning overlapping locations to WCPFC in the first approach, and by introducing a distinct 'Both' category in the second approach. We calculated the distribution across latitudes as the proportion of bird hours spend in 5° latitudinal bands. For each latitudinal band the proportion in each RFMO was also calculated. To aid visualisations and to examine core ranges, we created a kernel density utilisation distribution (UD) using the *stat_density2d* function from *ggplot2* (Wickham, 2016; R Core Team, 2025).

2.3 Point-based fishing effort overlap estimation

To quantify spatiotemporal overlap of fishing effort for each bird location, we identified pelagic longline vessels within a 100 km radius of albatross locations using AIS fishing vessel locations from Global Fishing Watch (GFW; (Kroodsma et al., 2018) at an hourly resolution following the protocols in Rowley et al. 2024). We defined an overlap event as a bird location (equating to one bird hour) where overlap has occurred (at least one fishing vessel is within 100 km of the bird location within that hour). This means a bird following a fishing vessel would be classified as multiple overlap events if this took place over >1 bird hours. We define fishing effort as the number of vessel hours spent in overlap with a bird location (e.g. if 2 vessels were within 100km of a bird for the entire bird hour, the fishing effort of that overlap event would be 2). We calculated the proportion of overlap events for each geopolitical jurisdiction. Geopolitical jurisdictions were defined with the same two approaches as were taken for bird distribution (Section 2.2).

To ensure that our analyses assisted the ongoing review of the CMM 2018-03, we calculated the proportion of overlap events out of the total bird hours spent in each latitudinal band, equating to the probability of overlap in each latitudinal band. We also calculated the extent of fishing effort associated with these overlap events for each latitudinal band (i.e., the number of vessel hours per bird hour for each overlap event).

2. RESULTS

2.1 At-sea distribution

Distributions across jurisdictions

The at-sea distribution of Gibson's and Southern Buller's Albatross ranged differently across various geopolitical jurisdictions (Figure 1; Figure 2; Supplementary material 1). Gibson's and Southern Buller's Albatross distribution largely remained within the Convention Area of WCPFC, with 94% and 87% occurrence respectively (Figure 2). This occurrence was still substantial when considering only the High Seas jurisdictions of WCPFC (37% and 16%). Both taxa heavily utilised the central Tasman Sea, though Gibson's Albatross consistently covered a greater area and also ranged further north into the Coral Sea (Figure 1). Southern Buller's Albatross spent more time within Australia's EEZ (30%) particularly around the Tasmanian Shelf. Though with a lower occupancy of Australia's EEZ (18%), Gibson's Albatross ranged both further west (to the Great Australian Bight) and further north (to Lord Howe Island) within Australia's EEZ. Both taxa had considerable occurrence within New Zealand's EEZ (43% and 43%). The core distribution of Gibson's Albatross in New Zealand encompassed both North and South Islands, while Southern Buller's Albatross generally remained around the South Island. Southern Buller's Albatross ranged across the Pacific Ocean to Chile (7%) and Peru (<1%). Most birds that were tracked during this cross-Pacific journey were likely failed breeders as they left before chicks begin to fledge in September.

Distributions across latitudes

Gibson's and Southern Buller's Albatross exhibited wide latitudinal ranges (Figure 1), with Gibson's Albatrosses ranging from 22°S to 63°S (overall mean = 41°S) compared to 17°S to 54°S (overall mean = 43°S) for Southern Buller's. The core latitudinal distribution of Southern Buller's was between 35°S and 45°S (96% occurrence), while Gibson's consistently utilised a wider latitudinal range from 30°S to 50°S (99%) (Figure 2; Supplementary material 2). At their extremes, both taxa demonstrated similarly extensive latitudinal ranges, with some individual Gibson's Albatross ranging from 23°S to 63°S, and Southern Buller's Albatross ranging from 16°S to 53°S. However, the non-breeding range of Southern Buller's Albatross is fundamentally different from Gibson's Albatross and extends further north targeting the Northern Humboldt Current upwelling system. When restricting the dataset to locations west of 176°E (i.e., excluding areas east if the Chatham Islands to approximate the breeding range), Southern Buller's Albatross occupied a narrower latitudinal range of 34°S to 53°S. Consequently, Gibson's Albatross exhibited a wider latitudinal range than Southern Buller's Albatross during the breeding period.

2.2 Spatiotemporal overlap with fisheries

Most tracked individuals from both Gibson's and Southern Buller's Albatross populations overlapped with pelagic longline fisheries. In total, 80 of 100 Gibson's Albatross (80%) and 36 of 48 Southern Buller's Albatross (75%) overlapped with pelagic longline fisheries. Gibson's and Southern Buller's Albatross overlapped with pelagic longline vessels primarily within the Convention Area of WCPFC (97% and 98% overlap events respectively) (Figure 1; Figure 2; Supplementary material 2).

Overlap across jurisdictions

Overlap of tracked Gibson's Albatross with pelagic longline vessels occurred primarily in the High Seas of WCPFC (79% of overlap events) and within Australia's EEZ (17%) (Figure 2; Supplementary material 1). Most High Seas overlap occurred in the Tasman Sea, further north in the Coral Sea, and northeast of New Zealand. Overlap in Australia's EEZ occurred along the East Coast, the eastern coast of Tasmania, the South Coast adjacent to the Bass Strait, and in the Great Australian Bight (Figure 1). For Southern Buller's Albatross, overlap primarily occurred within New Zealand's EEZ (50% of overlap events), Australia's EEZ (35% of overlap events) and the mid-Tasman High Seas (15% of overlap) (Figure 2; Supplementary material 1). The majority of overlap in New Zealand's EEZ occurred on the East and West Coast of the South Island (Figure 1). Overlap in Australia occurred around Tasmania and along the adjacent coasts of Australia.

Overlap across latitudes

Gibson's Albatross between 25°S and 30°S were associated with the highest probability of overlap with pelagic longline fishing effort, with overlap events occurring in 20% of bird hours in this area (Figure 2; Supplementary material 2). This area also corresponded to the highest fishing effort, averaging 1.95 vessel-hours per overlap event. The region between 20°S and 25°S also showed relatively high overlap (17% of bird-hours), though it accounted for <0.001% of total bird hours. For Southern Buller's, 35°S to 40°S and 40°S to 45°S had the highest probability of overlap, with overlap events occurring in 26% and 69% of bird hours spent at these latitudes (Figure 2; Supplementary material 2). Overlap events at these latitudes were also associated with the greatest fishing effort with 1.69 and 1.28 vessels hours per bird hour respectively.

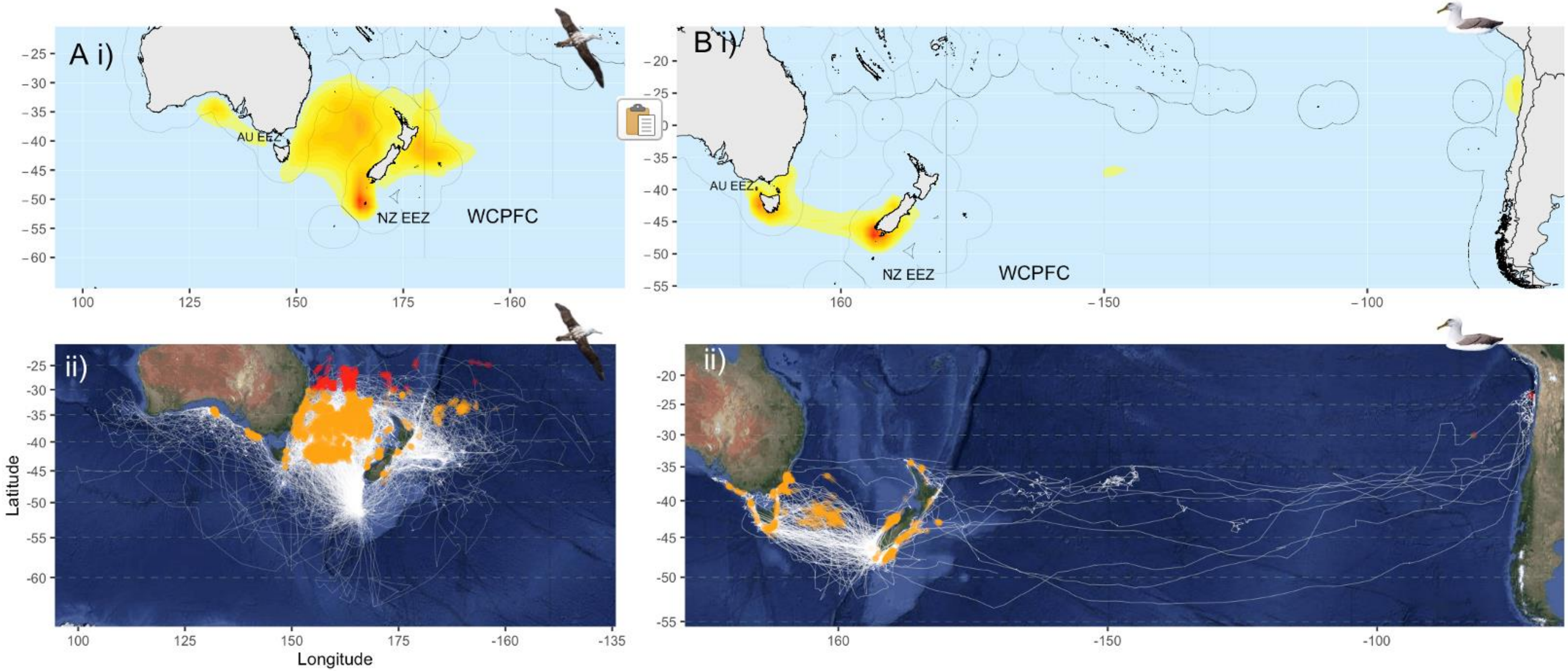

Figure 1. Utilisation distributions (UD) and overlap with commercial pelagic longline fisheries for **A)** Gibson's Albatross and **B)** Southern Buller's Albatross. UDs illustrate where the spend most of their time for **A i)** Gibson's Albatross and **B i)** Southern Buller's Albatross with boundaries of geopolitical areas shown in grey, comprising EEZs of Australia, New Zealand, Peru, and Chile, and Convention Areas WCPFC and IATTC. Tracks of **A ii)** Gibson's and **A ii)** Southern Buller's Albatross with orange points indicating overlap south of 30°S and red points indicating overlap north of 30°S.

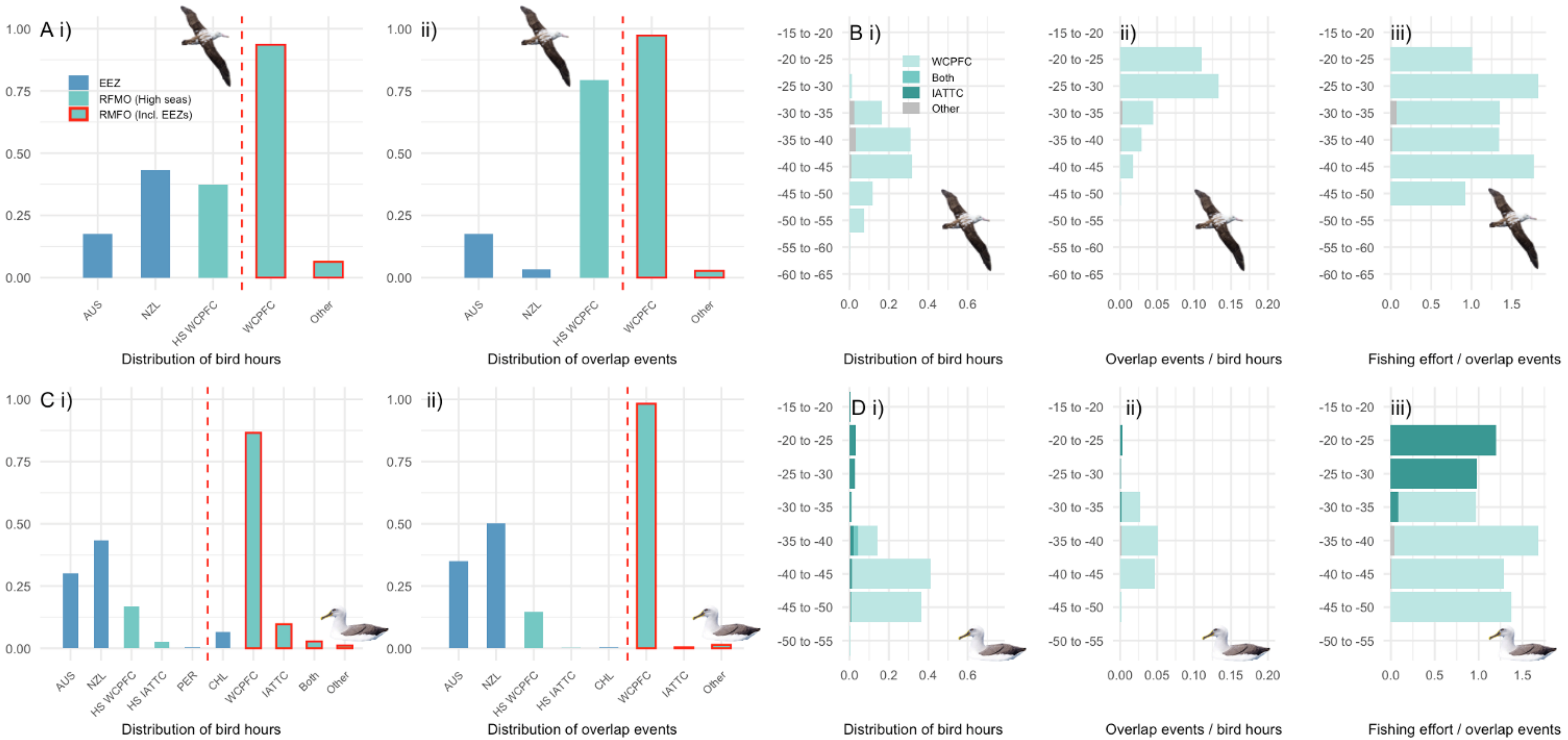

Figure 2. Distribution and overlap with commercial pelagic longline vessels for **A)** Gibson's and **B)** Southern Buller's Albatross. The distribution of bird hours for **A i)** Gibson's and **C i)** Southern Buller's Albatross and the distribution of overlap events for **A ii)** Gibson's and **C ii)** Southern Buller's Albatross across EEZs of Australia, New Zealand, Peru, and Chile and High Seas areas (prefixed in figure with HS for High Seas) within the Convention Areas of WCPFC and IATTC, shown left of red dotted lines, and the distribution of bird hours across entire EEZ-inclusive RFMO Convention Areas shown to the right of red dotted line and outlined in red. The distribution of bird hours for **B i)** Gibson's and **D i)** Southern Buller's Albatross across 5° latitudinal bands, coloured by RFMO. The proportion of overlap events out of the total bird hours in each latitudinal band for **B ii)** Gibson's and **D ii)** Southern Buller's Albatross, and the average fishing effort per overlap (vessels hours per bird hour in an overlap event) in each latitudinal band for **B iii)** Gibson's and **D iii)** Southern Buller's Albatross.

3. DISCUSSION

Bycatch in pelagic longline vessels poses a significant threat to Gibson's Albatross and Southern Buller's Albatross populations as demonstrated by multiple bycatch and risk assessments (Anon. 2024; Edwards et al. 2023a,b; Abraham et al. 2019; Peatman et al. 2019). Through multi-year tracking of both populations, we have identified important areas within the WCPFC Convention Area and illustrated where these taxa overlap most with pelagic longline vessels.

Notably, both Gibson's and Southern Buller's Albatross overlapped with fishing activity almost exclusively within the convention area of WCPFC. Gibson's Albatross primarily overlapped with pelagic longlines in the High Seas regions, with particularly high probability of overlap and fishing effort in the area between 25°S and 30°S. Southern Buller's Albatross also overlapped with pelagic longline fishing activity within the WCPFC High Seas. However, the majority of overlap occurred within the EEZs of New Zealand and Australia, where effective management and extensive electronic monitoring regimes are in place, particularly within the New Zealand EEZ where Best Practice Advice from the Agreement for the Conservation of Albatrosses and Petrels (ACAP) (combined use of branch line weighting, night setting, and bird scaring lines, or the use of hook-shielding devices) has been mandated.

Identifying areas of significant spatial overlap between albatross distributions and pelagic longline fisheries, particularly those areas with high probability of overlap, is critical for informing conservation measures. This study highlights that Gibson's Albatross, the taxon experiencing the most rapid population decline, exhibits the highest levels of overlap in the region between 25°S and 30°S where seabird bycatch mitigation requirements are currently reduced under CMM 2018-03. We note that this area is also important for the endangered and declining Antipodean albatross (Rowley et al., 2024). Under CMM 2018-03, vessels fishing between 25°S and 30°S are only required to use one mitigation measure (out of weighted branch lines; tori lines; or hook-shielding devices).

To address this conservation concern, we recommend aligning mitigation requirements in the 25°S to 30°S band with those of south of 30°S – which requires vessels to use at least two of the following: night setting, weighted branch lines and tori lines, or hook-shielding devices. Such alignment would represent a meaningful step towards reducing bycatch risk and mitigating ongoing population declines. It is important to note, that spatial overlap does not equate directly to bycatch risk. Therefore, increased observer coverage and improved data collection are essential to better quantify the actual bycatch rates and validate risk assessments.

Collectively, the findings presented here provide robust empirical support for the review of CMM 2018-03, reinforcing the need for strengthened and spatially consistent mitigation measures across important seabird habitats in the WCPFC Convention Area.

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5. SUPPLEMENTARY MATERIAL

	Gibson's		Southern Buller's	
Zone	Distribution of bird hours	Distribution of overlap events	Distribution of bird hours	Distribution of overlap events
AUS	0.177	0.174	0.301	0.350
NZL	0.431	0.033	0.433	0.500
HS WCPFC	0.373	0.793	0.168	0.146
Both	-	-	0.027	-
HS IATTC	-	-	0.026	0.001
PER	-	-	0.005	-
CHL	-	-	0.066	0.003
WCPFC*	0.935	0.973	0.865	0.982
IATTC*	-	-	0.097	0.004
Other	0.064	0.027	0.011	0.014

*RFMOs including EEZs

Supplementary material 1. Distributions and overlap values for Gibson's and Southern Buller's Albatross across EEZs and RFMOs as presented in Figure 2. For each species we present their distributions as the proportion of bird hours and their overlap as the proportion of overlap events across EEZs and High Seas RFMOs (prefixed on table with HS for High Seas) and separately their distribution across EEZ-inclusive RFMOs.

Latitude	Gibson's			Southern Buller's		
	Distribution of bird hours	Overlap events / total bird hours	Fishing effort per overlap event	Distribution of bird hours	Overlap events / total bird hours	Fishing effort per overlap event
-15 to -20	-	-	-	0.007	-	-
-20 to -25	-	0.174	0.990	0.031	0.003	1.203
-25 to -30	0.013	0.206	1.953	0.026	-	0.980
-30 to -35	0.163	0.041	1.349	0.012	0.011	0.974
-35 to -40	0.309	0.029	1.344	0.143	0.263	1.685
-40 to -45	0.319	0.018	1.779	0.413	0.698	1.284
-45 to -50	0.120	0.001	0.926	0.363	0.024	1.371
-50 to -55	0.073	-	-	0.006	-	-
-55 to -60	0.002	-	-	-	-	-
-60 to -65	0.001	-	-	-	-	-

Supplementary material 2. Distributions and overlap values for Gibson's and Southern Buller's Albatross across latitudes as presented in Figure 2. For each species we present the distribution of bird hours across latitudes, the proportion of overlap events out of the total bird hours for each latitudinal band, and the average fishing effort for each overlap event for each latitudinal band. Cells are coloured by increasing value for each column.