Agreement on the Conservation of Albatrosses and Petrels

Joint Thirteenth Meeting of the Seabird Bycatch Working Group and Ninth Meeting of the Population and Conservation Status Working Group

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Point-based overlap of New Zealand's marine mega-avifauna with the world's fisheries

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SUMMARY

Effective conservation efforts must prioritise management in the jurisdictions and fisheries posing the greatest risk to seabirds. Identifying these high-risk areas is particularly challenging for wide-ranging seabirds as they cross multiple management boundaries and interact with a diverse range of fisheries. ACAP has described the ongoing decline of these seabirds as a global “conservation crisis” and has identified priority species. We tracked seven ACAP-listed seabird species to quantify their spatiotemporal overlap with fisheries and identify high-risk areas. This study represents one of the largest seabird tracking datasets assembled to date, comprising 15 populations and 506 individuals tracked between 2019 and 2025. Tracked species included Antipodean wandering albatross (*Diomedea antipodensis antipodensis*) (n = 205), Gibsons wandering albatross (*D. a. gibsoni*) (99), Southern Royal albatross (*D. epomophora*) (56), Northern Royal albatross (*D. sanfordi*) (52), Southern Buller’s albatross (*Thalassarche bulleri bulleri*) (55) and Northern Buller’s albatross (*T. b. platei*) (12), Campbell albatross (*T. impavida*) (10), Light-mantled Sooty albatross (*Phoebetria palpebrate*) (12), and Northern Giant petrel (*Macronectes halli*) (12). In total we obtained 1,160,624 bird locations and 1,925,001 tracked bird hours, covering latitudes from 18.6°S to 57.2°S across the Pacific, Indian, and Atlantic Ocean. We assessed broad-scale spatiotemporal overlap of tracked birds with pelagic and demersal longline, and trawl fisheries using fishing effort inferred from Automated Identification System (AIS) data

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provided by Global Fishing Watch. Tracked birds overlapped with 120,444 hours of fishing activity involving 709 unique vessels flagged to 25 different states. Overlap occurred across ten different Exclusive Economic Zones and seven Regional Fishery Management and Conservation Organizations. The unprecedented level of detail, scale, and range of our data enable us to identify priority regions, fisheries, and management bodies where bycatch mitigation will yield the greatest conservation benefit across the Southern Hemisphere.

RECOMMENDATIONS

We recommend that the SBWG13 and PaCSWG9:

1. *Note* the updated information on distribution and movements of New Zealand seabird species.
2. *Note* the identified spatiotemporal overlap between tracked seabirds and fishing effort across multiple jurisdictions.
3. *Recommend* that AC encourage ACAP and Parties to consider this spatial information when implementing the RFMCO Engagement Strategy.
4. *consider* developing best-practice guidelines for tag attachment methods for ACAP species as part of PaCSWG Work Programme to address limitations to data collection.
5. *Note* the development of the standardised workflow for point-based seabird-fisheries overlap analyses within the R package *ShareWater.*
6. *Encourage* the use of the standardised workflow within *ShareWater* to improve comparability and transparency.

Superposición de puntos de la megaavifauna marina de Nueva Zelanda con las pesquerías mundiales

RESUMEN

Las iniciativas de conservación eficaces deben dar prioridad a la ordenación en las jurisdicciones y pesquerías que suponen un mayor riesgo para las aves marinas. Identificar estas zonas de alto riesgo resulta especialmente complicado en el caso de las aves marinas con grandes áreas de distribución, ya que cruzan múltiples límites de ordenación e interactúan con una gran variedad de pesquerías. El ACAP ha calificado el continuo declive de estas aves marinas como una “crisis de conservación” a escala mundial y ha identificado las especies prioritarias. Hemos realizado un seguimiento de siete especies de aves marinas incluidas en la lista del ACAP para cuantificar su superposición espaciotemporal con las pesquerías e identificar las zonas de alto riesgo. Este estudio constituye uno de los mayores conjuntos de datos de rastreo de aves marinas recopilados hasta la fecha, ya que abarca 15 poblaciones y 506 ejemplares seguidos entre 2019 y 2025. Algunas de las especies a las que se hizo seguimiento son: Diomedea antipodensis antipodensis (n = 205), D. a. gibsoni (99), D. epomophora (56), D. sanfordi (52), Thalassarche bulleri bulleri (55), T. b.

platei (12), T. impavida (10), Phoebetria palpebrata (12) y Macronectes halli (12). En total, obtuvimos 1 160 624 localizaciones de aves y 1 925 001 horas de seguimiento, que abarcan latitudes comprendidas entre los 18,6° S y los 57,2° S a lo largo de los océanos Pacífico, Índico y Atlántico. Evaluamos la superposición espaciotemporal a gran escala entre las aves de las cuales se hizo seguimiento y las pesquerías de palangre pelágico y demersal, así como las de arrastre, utilizando el esfuerzo pesquero deducido a partir de los datos del sistema de identificación automática (AIS) facilitados por Global Fishing Watch. Las aves de las cuales se hizo seguimiento se superpusieron con 120 444 horas de actividad pesquera de 709 embarcaciones distintas, con pabellón de 25 Estados diferentes. Se produjeron superposiciones en diez Zonas Económicas Exclusivas diferentes y en siete Organizaciones Regionales de Ordenación y Conservación Pesquera (OROCP). El nivel sin precedentes de detalle, la escala y la amplitud de nuestros datos nos permiten identificar las regiones, las pesquerías y los organismos de ordenación prioritarios en los que la mitigación de captura secundaria reportará los mayores beneficios para la conservación en todo el hemisferio sur.

RECOMENDACIONES

Recomendamos que la GdTCS13 y la GdTPEC9:

1. Tomen nota de la información actualizada sobre la distribución y los desplazamientos de las especies de aves marinas de Nueva Zelanda.
2. Observen la superposición espaciotemporal detectada entre las aves marinas de las cuales se hizo seguimiento y el esfuerzo pesquero en múltiples jurisdicciones.
3. Recomienden que el Comité Asesor anime al ACAP y a las Partes a tener en cuenta esta información espacial al implementar la estrategia de interacción con las OROCP.
4. Consideren la elaboración de directrices sobre buenas prácticas para los métodos de colocación de marcas en las especies del ACAP, como parte del Programa de Trabajo del GdTPEC, con el fin de abordar las limitaciones en la recopilación de datos.
5. Tomen nota del desarrollo del flujo de trabajo estandarizado para los análisis de superposición de puntos entre las pesquerías y las aves marinas dentro del paquete R *ShareWater*.
6. Fomenten el uso del flujo de trabajo estandarizado en *ShareWater* para mejorar la comparabilidad y la transparencia.

Chevauchement ponctuel de l'avifaune marine mégafaunique de Nouvelle-Zélande avec les pêcheries mondiales

RÉSUMÉ

Les efforts de conservation efficaces doivent donner la priorité à la gestion dans les juridictions et les pêcheries présentant le plus grand risque pour les oiseaux marins. Identifier ces zones à haut risque est particulièrement difficile pour les oiseaux marins à large aire de répartition, car ils traversent plusieurs limites de gestion et interagissent avec une grande diversité de pêcheries. L'ACAP a décrit le déclin en cours de ces oiseaux marins comme une « crise mondiale de la conservation » et a identifié des espèces prioritaires. Nous avons suivi sept espèces d'oiseaux marins inscrites à l'ACAP afin de quantifier leur chevauchement spatiotemporel avec les pêcheries et d'identifier les zones à haut risque. Cette étude représente l'un des plus grands ensembles de données de suivi des oiseaux marins assemblés à ce jour, comprenant 15 populations et 506 individus suivis entre 2019 et 2025. Les espèces suivies comprenaient l'albatros errant antipodal (Diomedea antipodensis antipodensis) (n = 205), l'albatros errant de Gibson (D. a. gibsoni) (99), l'albatros royal du Sud (D. epomophora) (56), l'albatros royal du Nord (D. sanfordi) (52), l'albatros de Buller du Sud (Thalassarche bulleri bulleri) (55) et l'albatros de Buller du Nord (T. b. platei) (12), l'albatros de Campbell (T. impavida) (10), l'albatros fuligineux à manteau clair (Phoebetria palpebrata) (12) et le pétrel géant du Nord (Macronectes halli) (12). Au total, nous avons obtenu 1 160 624 positions d'oiseaux et 1 925 001 heures de suivi, couvrant des latitudes de 18,6°S à 57,2°S à travers les océans Pacifique, Indien et Atlantique. Nous avons évalué le chevauchement spatiotemporel à grande échelle entre les oiseaux suivis et les pêcheries à la palangre pélagique et démersale ainsi que les pêcheries au chalut, en utilisant l'effort de pêche déduit des données du système d'identification automatique (AIS) fournies par Global Fishing Watch. Les oiseaux suivis présentaient un chevauchement avec 120 444 heures d'activité de pêche impliquant 709 navires distincts battant pavillon de 25 États différents. Le chevauchement s'est produit dans dix zones économiques exclusives différentes et sept organisations régionales de gestion des pêches et de conservation (RFMCO). Le niveau de détail, l'échelle et l'étendue sans précédent de nos données nous permettent d'identifier les régions, les pêcheries et les organismes de gestion prioritaires où l'atténuation des captures accessoires apportera les plus grands bénéfices en matière de conservation dans l'hémisphère Sud.

RECOMMANDATIONS

Nous recommandons que le SBWG13 et le PaCSWG9 :

1. Prennent note des informations mises à jour sur la distribution et les déplacements des espèces d'oiseaux marins néo-zélandaises.
2. Prennent note du chevauchement spatiotemporel identifié entre les oiseaux marins suivis et l'effort de pêche dans plusieurs juridictions.
3. Recommandent que le Comité consultatif encourage l'ACAP et les Parties à prendre en compte ces informations spatiales lors de la mise en œuvre de la Stratégie d'engagement auprès des RFMCO.
4. Envisagent d'élaborer des lignes directrices de bonnes pratiques pour les méthodes de fixation des balises sur les espèces de l'ACAP dans le cadre du programme de travail du PaCSWG afin de remédier aux limites de la collecte de données.
5. Prennent note de l'élaboration d'un flux de travail standardisé pour les analyses de chevauchement oiseaux marins–pêcheries basées sur des points dans le package R *ShareWater.*
6. Encouragent l'utilisation du flux de travail standardisé dans *ShareWater* afin d'améliorer la comparabilité et la transparence.

1. Introduction

Albatrosses and large petrels are among the most threatened seabird taxa globally, with widespread population declines documented over recent decades (Croxall et al. 2012; Dias et al. 2019, Fischer et al. 2026). Incidental mortality arising from interactions with commercial fisheries, particularly pelagic and demersal longline and trawl operations, is widely recognised as a primary driver of these declines (Anderson et al. 2011; Lewison et al. 2014, Phillips et al. 2024). Species characterised by life-history traits such as high adult survival, delayed maturity, and low reproductive output are especially vulnerable to even small increases in adult mortality, rendering fisheries bycatch a critical conservation concern (Weimerskirch 2002; Pardo et al. 2017). Although a range of effective seabird bycatch mitigation measures has been developed and promoted through international frameworks (e.g., ACAP 2024a,b,c), their uptake and enforcement remain inconsistent across fleets and jurisdictions, and mortality levels continue to exceed thresholds compatible with population recovery for many species (Dias et al. 2019).

A key challenge in reducing seabird bycatch arises from the mismatch between the extensive spatial ranges of albatrosses and large petrels and the fragmented and disparate structure of fisheries governance. Many species are highly mobile, routinely traversing multiple Exclusive Economic Zones (EEZs), international waters, and ocean basins within a single annual cycle (Phillips et al. 2016; Weimerskirch et al. 2015). In contrast, fisheries management and bycatch mitigation obligations are distributed among fleets, flag states, national authorities, and a suite of Regional Fishery Management and Conservation Organisations (RFMCOs), each operating under distinct mandates, regulatory mechanisms, and levels of compliance. In the Southern Hemisphere, seabird–fishery interactions occur primarily within the jurisdictions of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), the Western and Central Pacific Fisheries Commission (WCPFC), the Indian Ocean Tuna Commission (IOTC), the International Commission for the Conservation of Atlantic Tunas (ICCAT), the Inter-American Tropical Tuna Commission (IATTC), the South Pacific Regional Fisheries Management Organisation (SPRFMO), and the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) (Phillips et al. 2016). Conservation coordination across these bodies is further supported (but not governed) by international agreements such as the Agreement on the Conservation of Albatrosses and Petrels (ACAP). This institutional fragmentation complicates responsibility and enforcement, and can dilute conservation outcomes, particularly where seabirds spend substantial portions of their range in jurisdictions with limited, inconsistent, or poorly implemented bycatch mitigation requirements (Tuck et al. 2011; Dias et al. 2019).

Recognising both the scale and urgency of seabird bycatch, ACAP has identified interactions with fisheries as a principal driver of population declines and has characterised the status of many listed species as a global conservation crisis (Croxall et al. 2012). In response, ACAP has prioritised species most at risk (ACAP 2025) and promoted the adoption of best-practice bycatch mitigation measures across relevant fisheries and management bodies (ACAP 2024a,b,c). However, the effectiveness of these efforts depends on identifying where and when interactions with fisheries pose the greatest risk, and which fisheries, vessels, ports, and jurisdictions are most relevant to threatened populations (e.g., Rowley et al. 2024, Rexer-Huber et al. 2025, Warwick-Evans 2025,2026). Point-based overlap analyses offer particular value in this context by enabling direct attribution of seabird-fishery interactions to individual vessels and ports of operation, providing actionable information for targeted engagement, compliance, and implementation of mitigation measures. Without spatially explicit information linking seabird distributions to fishing activity at appropriate scales, conservation actions risk being diffuse, inefficient, or focused on areas with limited potential to deliver population-level benefits (Phillips et al. 2016; Dias et al. 2019, Peatman et al. 2019, Anon. 2025).

Advances in both animal-borne tracking technologies and vessel monitoring systems now provide unprecedented opportunities to address these information gaps and to quantify seabird–fishery interactions at ecologically and management relevant scales. The widespread deployment of relatively light satellite transmitters and GPS loggers has transformed understanding of seabird movement ecology, enabling high-resolution characterisation of spatial distributions, habitat use, and connectivity across breeding and nonbreeding periods for wide-ranging species (Weimerskirch et al. 2015; Phillips et al. 2016). In parallel, the increasing global coverage and accessibility of vessel tracking data derived from Automated Identification System (AIS) transmissions has made it possible to infer fishing effort consistently across fleets, gear types, and ocean basins, including in areas beyond national jurisdiction (Lewison et al. 2014; Kroodsma et al. 2018). The integration of seabird tracking data with AIS-derived fishing activity has therefore emerged as a powerful approach for identifying spatiotemporal patterns of overlap and potential bycatch risk. However, to date, most applications of this framework have been limited in taxonomic scope, geographic extent, or temporal coverage, constraining their ability to support larger strategic prioritisation across multiple species, fisheries, and management bodies (e.g., Orben et al. 2021, Rutter et al. 2024, Warwick-Evans et al. 2025, 2026). Addressing these limitations requires largescale, multispecies analyses capable of resolving overlap patterns across jurisdictions and governance frameworks.

In response to this need, New Zealand has undertaken extensive multiyear satellite tracking programmes since 2019, deploying devices across multiple albatross and petrel species, breeding sites, age classes, and breeding stages. Here, we synthesise tracking data from seven ACAP species to quantify their spatiotemporal overlap with pelagic and demersal longline and trawl fisheries across the Southern Hemisphere. By integrating one of the largest seabird tracking datasets assembled to date with fishing effort inferred from AIS data, this study aims to identify priority regions, fisheries, and management jurisdictions where targeted bycatch mitigation is likely to deliver the greatest conservation benefit.

2. Methods

2.1 Study species and device deployment

We deployed a range of GPS, PTT and GPS/PTT satellite tracking devices on seven ACAP-listed seabird species from 14 breeding populations across the Southern Hemisphere between 2019 and 2025. Tracked species and populations included Antipodean Albatrosses (*Diomedea antipodensis antipodensis*) from Moutere Mahue/Antipodes Island (n = 205), Gibson’s Albatrosses (*D. a. gibsoni*) from Adams Island, Motu Maha/Auckland Islands (n = 99), Southern Royal Albatrosses (*D. epomophora*) from Motu Ihupuku/Campbell Island (n = 51) and Enderby Island, Motu Maha (n = 5), Northern Royal Albatrosses (*D. sanfordi*) from Pukekura/Taiaroa Head (n = 22) and Motuhara/The Forty-fours (n = 30), Southern Buller’s Albatrosses (*Thalassarche bulleri bulleri)* from Tini Heke/Snares Island (n = 25) and Hautere/Solander Island (n = 20), Northern Buller’s Albatrosses (*T. b. platei*) from

Motuhara/The Forty-fours (n = 10), Campbell Albatrosses (*T. impavida*) from Motu Ihupuku (n = 10), Light-mantled Sooty Albatrosses (*Phoebetria palpebrata*) from Motu Ihupuku (n = 10) and Adams Island (n = 2), and Northern Giant Petrel (*Macronectes halli*) from Motuhara (n = 8) and Motu Ihupuku (n = 4) (Figure 1). All devices were attached using feather mounts, but fin details on device models, attachment protocols, deployment timing, and ethical approvals are provided in Table S1 and associated field method reports.

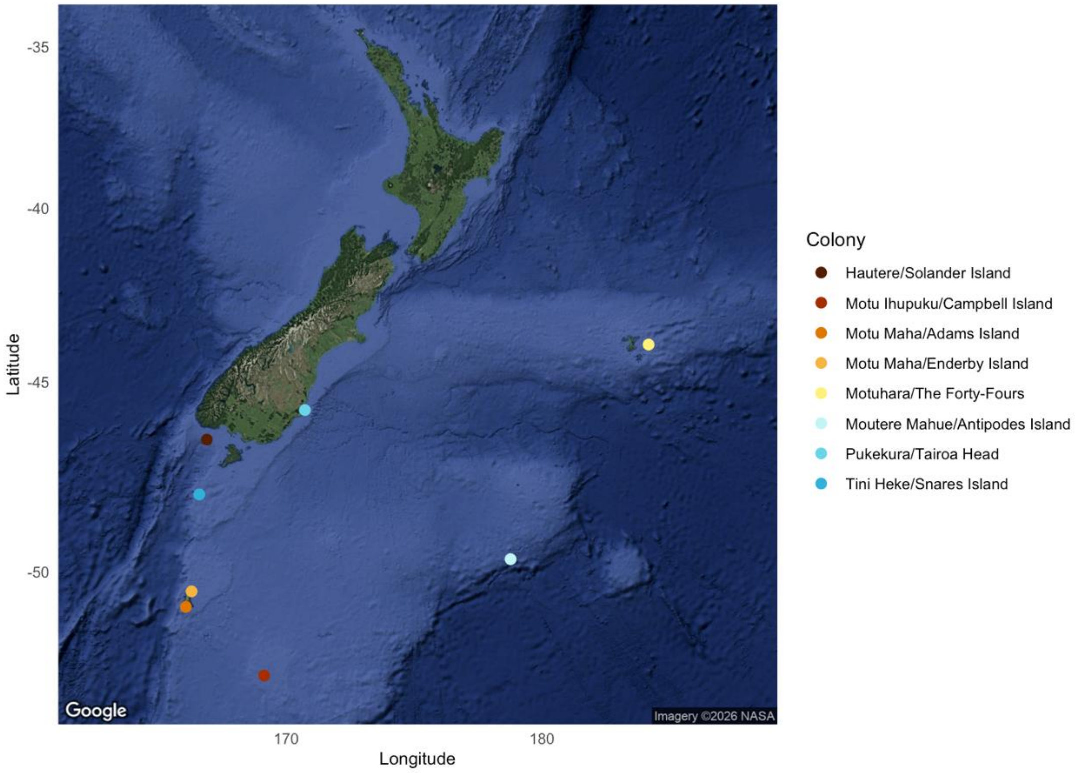


Figure 1: Locations of breeding colonies where tracking devices were deployed.

2.2 Tracking data processing

Following deployment, all tracking data were compiled and pre-processed using a standardised workflow (Rowley et al. 2024) to ensure consistency and positional reliability across species and device types. Pre-processing included the following steps:

Argos quality filtering: PTT-derived locations with Argos location classes A, B, or Z were excluded due to low positional accuracy (Douglas et al., 2012).

Error ellipse filtering: Argos locations with an estimated error radius greater than 100 km were removed, as this was the maximum distance between bird and vessel still considered an overlap event.

Speed filtering: A speed filter was applied to exclude positions implying sustained flight speeds greater than 50 m s^{-1}, which were considered biologically implausible for the study species (Merkel et al., 2016; Bose & Debski, 2020).

After filtering, a total of 1,160,560 location fixes were retained across all species. Filtered tracks were linearly interpolated to a regular temporal resolution of 1 h to standardise sampling effort among individuals and device types. Locations falling over land were removed using a land mask, to retain only at-sea positions for subsequent analyses.

2.3 Weighting of tracking effort

Tracking effort varied markedly among months within species and among species, reflecting differences in deployment timing, track duration, and life-history stage. To minimise bias in spatial distribution estimates arising from uneven sampling, bird locations were weighted by monthly sampling effort. Each bird location (equivalent to 1 bird-hour) was assigned a weight:

$$w_{i,m} = \frac{H_i}{H_m}$$

where is the weight for location in month , is one bird-hour, and is the total number of tracked bird-hours in month . This approach increases the relative contribution of locations from under-represented months. When comparing distributions among species, tracking data were pooled across species within each month prior to weighting.

2.4 Jurisdictional attribution

We quantified the relative occurrence of tracked seabirds across geopolitical and management jurisdictions. Each bird location was assigned to an Exclusive Economic Zone (EEZ) and to relevant Regional Fishery Management and Conservation Organisations (RFMCOs) using spatial overlays. EEZ boundaries were obtained from MarineRegions.org (Flanders Marine Institute, 2026). Spatial boundaries for RFMCOs were sourced from official RFMO documentation and websites (CCAMLR, WCPFC, IOTC, ICCAT, SPRFMO, CCSBT). As several RFMCOs overlap spatially and, in some cases, include EEZ waters, proportional distributions across jurisdictions are not mutually exclusive and may sum to greater than one. All jurisdictional summaries were calculated using weighted bird-hour values.

2.5 Fishing effort data and overlap estimation

To quantify spatiotemporal overlap between seabird movements and fishing activity, we used AIS-derived fishing effort data from Global Fishing Watch (GFW; Kroodsma et al., 2018). Global Fishing Watch uses machine learning models to classify vessel behaviour based on movement characteristics such as vessel speed, turning angle and temporal patterns in AIS transmission. Classified fishing events are then aggregated in space and time and gridded to produce raster surfaces of fishing activity (classified as ‘effort’). Analysis protocols established by Rowley et al. (2024) were followed. Fishing effort was analysed at an hourly temporal resolution as 0.01 X 0.01°. Overlap events were identified based on spatiotemporal proximity thresholds between bird locations and positions of actively fishing vessels, with thresholds varying by gear type to reflect differences in operational scale and bycatch risk. A bird location (equivalent to a single bird-hour) was classified as an overlap event if it occurred:

Within 100 km and within 1 hr of a pelagic longline vessel, or

Within 5 km and within 1 hr of a demersal longline or trawl vessel.

Pelagic longlines can extend 100 km from the vessel (Song et al., 2015), with potential for hooks to surface even when weighted (Goad et al., 2025; Rutter et al., 2026a). Although some demersal longlines may reach 50 km, their hooks are unlikely to surface (Favero et al., 2013). Trawlers and demersal longlines were thus assigned a smaller 5 km buffer.

Each hour spent in proximity to a fishing vessel was treated as an independent overlap event. Fishing effort associated with each event was defined as the number of vessel-hours occurring within the relevant distance threshold. To account for uneven tracking effort across months, fishing effort associated with overlap events was standardised by multiplying vessel-hours by the corresponding weighted bird-hour values (). For each fishery type, overlap was calculated using only RFCMOs with jurisdiction over the fishery. For pelagic longline fisheries, distributions were calculated across the WCPFC, IATTC, IOTC, CCSBT, and ICCAT convention areas, and for demersal longline and trawl fisheries across SIOFA, CCAMLR, SEAFO, and SPRFMO convention areas.

2.6 Analysis workflow - *Sharewater*

The methods described in Sections 2.2–2.5 have been standardised into a suite of functions that form the basis of *Sharewater*, an R package under development for analysing overlap between marine megafauna and fisheries. The package automates track preparation (including interpolation and land masking), assigns jurisdictions (EEZs and RFMOs) to tracking locations, enables efficient extraction of large-scale fishing effort data from Global Fishing Watch, and disseminates overlap output. Overlap metrics can be tailored to bycatch risk assessments and Marine Stewardship Council certification. These standardised analyses will be made accessible on GitHub and improve reproducibility and comparability across studies in the near-future.

3. Results

3.1 At-sea species distribution across jurisdictions

Tracking data was obtained from 506 birds representing seven species and two subspecies, yielding a total of 1,160,560 location fixes and 2,094,267 tracked bird hours (Table S1). Across species, the highest occurrence fell within the (overlapping) jurisdictions of CCSBT (76.3% of tracked bird-hours standardised across months and species) and the WCPFC (76.2%) in the Southern Pacific Ocean (Table S2). High occurrence was also found in the SPRFMO (39.4%) and IATTC (15.1%) Convention Areas, and some occurrence in IOTC (0.027), CCAMLR (2.3%), ICCAT (2.2%), and SIOFA (0.2%) Convention Areas. Within domestic waters, the highest occurrence fell within the New Zealand EEZ (41.5%), which encompasses all breeding colonies of tagged birds. Occurrence was also high in the Australian EEZ (6.3%), and in South American EEZs including Chile (7.4%), Argentina (1.4%), and Peru (0.1%).

Antipodean Albatrosses (breeding, non-breeding) were distributed across the Pacific Ocean, with high occurrence areas east of New Zealand (37.6% tracked bird hours standardised by month for adults, 42.3% for juveniles) and across the Pacific in Chile (14% vs. 1.6%) (Figure 2a; Table S3a). Juveniles also spent a large proportion of time in the mid-Tasman Sea and Australian EEZ (6.1%). Their distribution fell largely within the WCPFC (63.4% for adults, 90.8% for juveniles), CCSBT (79.3% vs. 94.8%), SPRFMO (45.1% vs. 49.9%), and IATTC (36.6% vs. 12.9%) convention areas. Gibson's Albatrosses (breeding and non-breeding adults, and juveniles) also utilized New Zealand (85.3% for adults, 46.7% for juveniles) and the Australian EEZ (3.2% and 19.5%) but birds did not cross the Pacific to South America (Figure 2b; Table S3b). Relative occurrence was thus greater in WCPFC (99.3% and 95.2%), and CCSBT (94.9% and 92.8%) Convention Areas. In addition, Gibson's albatrosses utilized SPRFMO (11.4% and 33.0%) and IOTC (1.2% and 5.2%) Convention Areas.

The core distribution of Northern Royal Albatrosses (breeding, non-breeding, and juveniles) fell within the New Zealand EEZ (47.5%) and southern South America, primarily in Chile (30.3%), as well as Argentina (9.4%), and Uruguay (0.014) (Figure 3a; Table S3c). With a circumpolar distribution, Northern Royal Albatrosses range across CCSBT (71.2%), WCPFC (54%), IATTC (32.9%), ICCAT (12.3%), SPRFMO (6.8%), and IOTC (0.2%) Convention Areas.

The core distribution of Southern Royal Albatrosses fell similarly within the New Zealand EEZ (61.8%) and southern South America, but with a more pronounced presence on the eastern seaboard (Argentina: 16% vs. Chile 0.6%). Southern Royal Albatrosses (breeding and non-breeding adults) additionally utilized the Tasman Sea and Tasmanian waters in the Australian EEZ (6.1%) (Figure 3b; Table S3d). Southern Royal Albatrosses occupied similar RFMCOs as their sister species: CCSBT (62.8%), WCPFC (70.7%), IATTC (0.3%), ICCAT (24.9%), SPRFMO (5.3%), and IOTC (1.6%) Convention Areas.

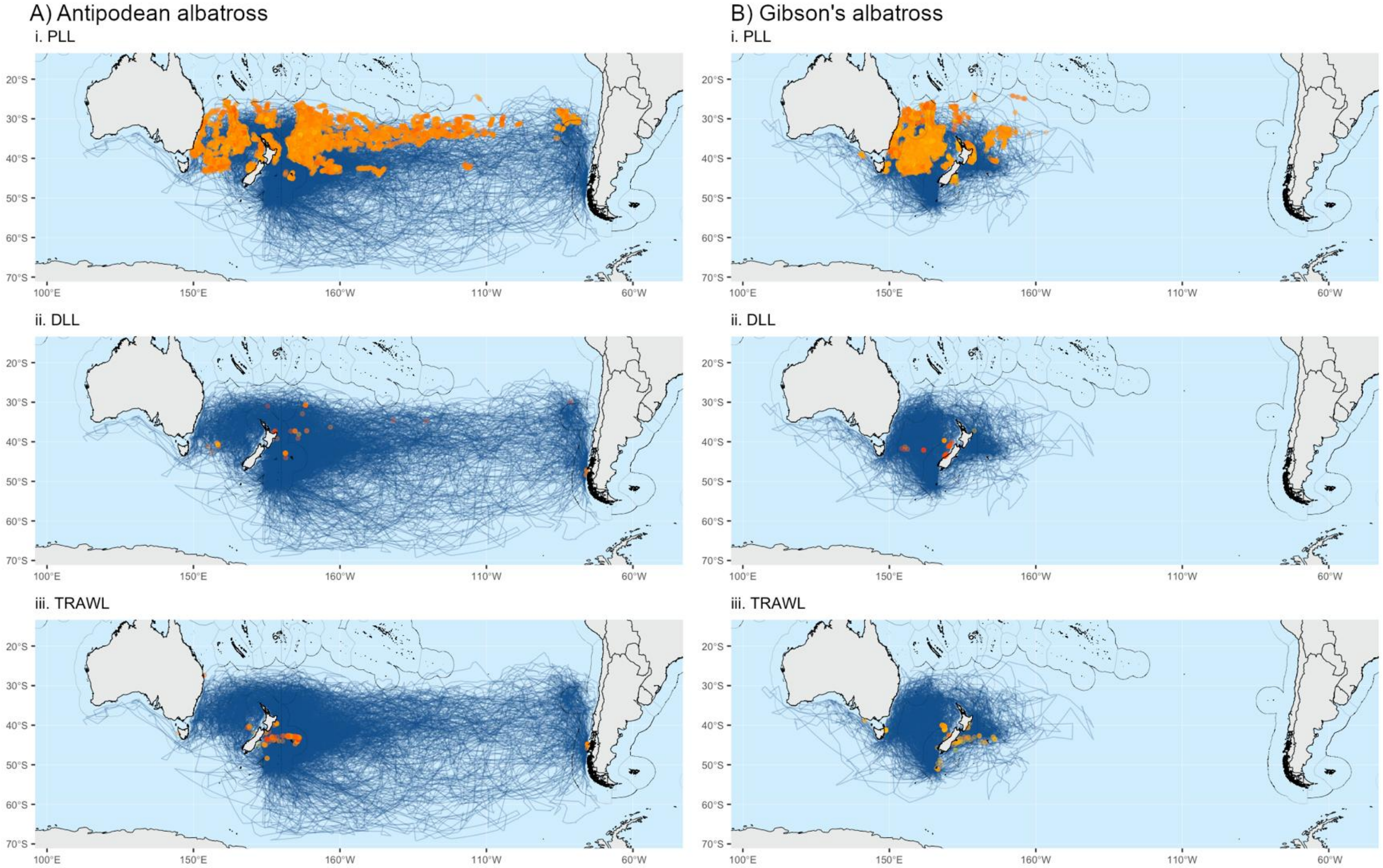


Figure 2. Spatiotemporal overlap between Antipodean (a) and Gibson's (b) albatrosses and pelagic longline (i), demersal longline (ii), and trawl (iii) fisheries. Points represent overlap events, coloured by overlap magnitude (relative scale from yellow – low to red - high) with gear-specific overlap buffers (100 km & 1 hr for pelagic longline; 5 km & 1 hr for demersal longline/trawl). EEZs shown for reference.

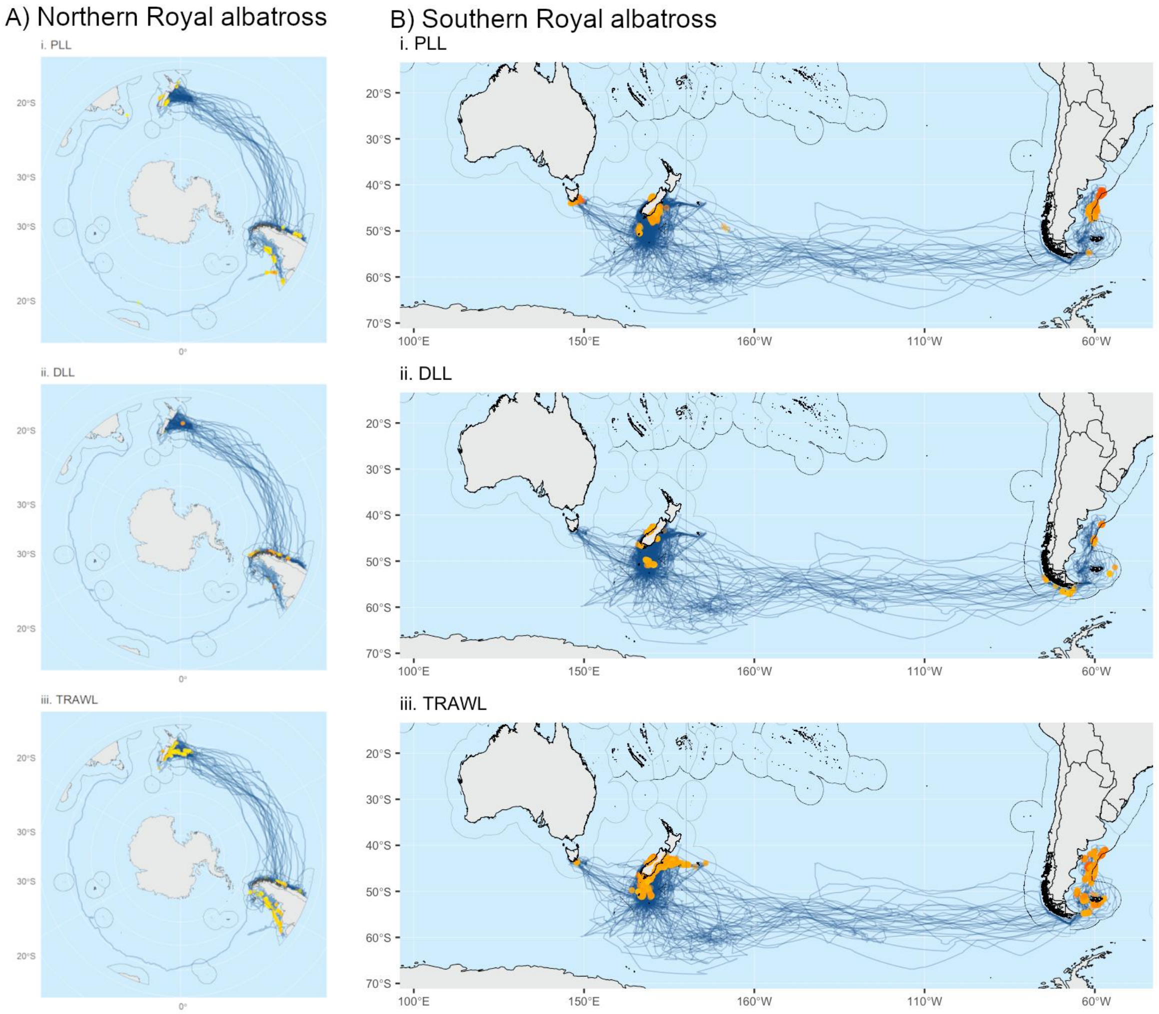
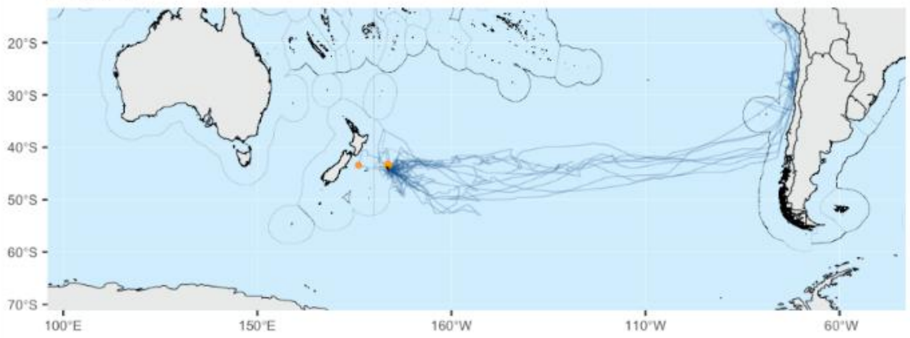


Figure 3. Spatiotemporal overlap between Northern Royal (a) and Southern Royal (b) Albatrosses and pelagic longline (i), demersal longline (ii), and trawl (iii) fisheries. Points represent overlap events, coloured by overlap magnitude (relative scale from yellow – low to red - high)) with gear-specific overlap buffers (100 km & 1 hr for pelagic longline; 5 km & 1 hr for demersal longline/trawl).

Northern Buller's Albatrosses (failed breeding adults) ranged from the eastern side of New Zealand (24.3%) to Chile (25.3%) and Peru (27.9%), with use of IATTC (61.2%), CCSBT (47.6%), WCPFC (42.5%), and SPRFMO (21%) Convention Areas (Figure 4a; Table S3e). Southern Buller's Albatrosses followed a similar distribution, occurring within IATTC (28.6%), CCSBT (45.4%), WCPFC (72.5%), and SPRFMO (14.8%) Convention Areas and ranging across the Pacific to Chile (23.1%) and Peru (00.7%) (Figure 4b; Table S3f). Southern Buller's Albatrosses (breeding) utilized New Zealand (40.5%) and the Australian (19.4%) EEZ more heavily, with high occurrences areas in Southern New Zealand, across the Tasman Sea, and around Tasmania, and crossing into the IOTC Convention Area (17.7%). Note, some of the observed differences in ranges between subspecies may be attributed to the larger sample size of Southern (n = 45) compared to Northern Buller's Albatrosses (10).

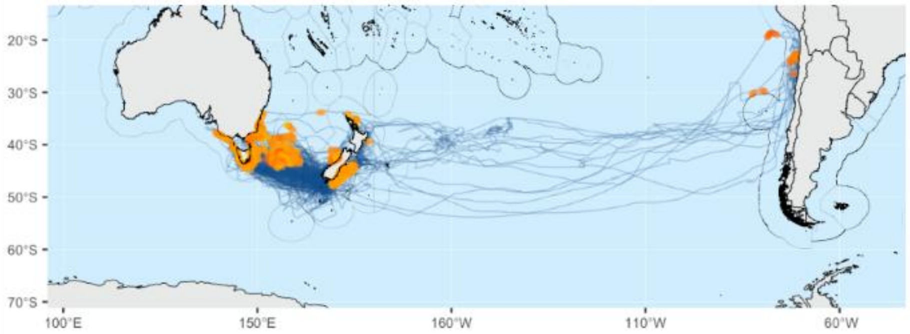
A) Northern Buller's albatross

i. TRAWL

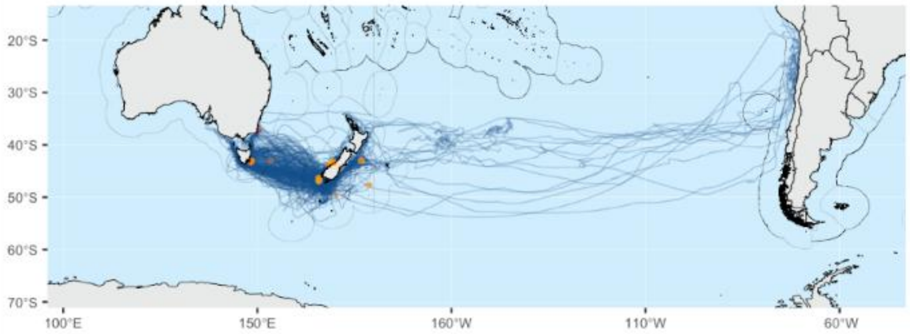


B) Southern Buller's albatross

i. PLL



ii. DLL



iii. TRAWL

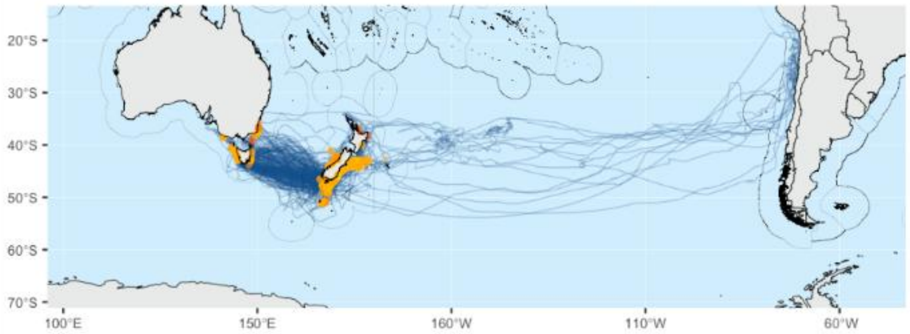


Figure 4. Spatiotemporal overlap between Northern Buller's Albatrosses (a) and i) trawl fisheries, and Southern Buller's (b) Albatrosses and pelagic longline (i), demersal longline (ii), and trawl (iii) fisheries. Points represent overlap events, coloured by overlap magnitude (relative scale from yellow – low to red - high)) with gear-specific overlap buffers (100 km & 1 hr for pelagic longline; 5 km & 1 hr for demersal longline/trawl).

Campbell Albatrosses (breeding) ranged from the Great Australian Bight (AUS EEZ: 19.4%) to Chile (6.0%), with their core distribution between their breeding site on Campbell Island, New Zealand (22.1%), and the Antarctic Circumpolar Current (Figure 5; Table S3g). They occurred within CCSBT (64.7%), WCPFC (53.2%), SPRFMO (35.5%), IOTC (26.6%), CCAMLR (17.6%) and IATTC (7.1%) Convention Areas.

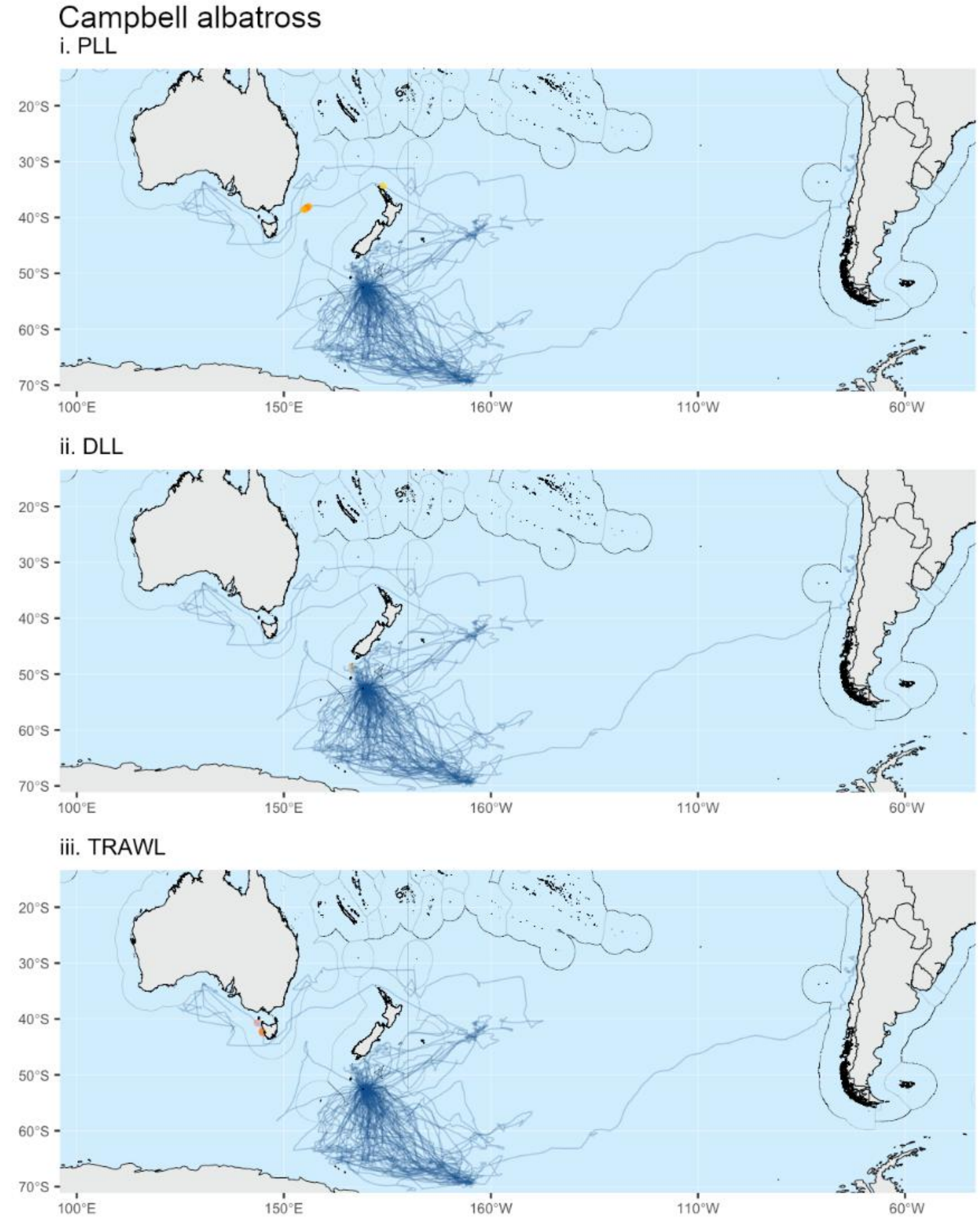


Figure 5. Spatiotemporal overlap between Campbell Albatrosses and pelagic longline (i), demersal longline (ii), and trawl (iii) fisheries. Points represent overlap events, coloured by overlap magnitude (relative scale from yellow – low to red - high) with gear-specific overlap buffers (100 km & 1 hr for pelagic longline; 5 km & 1 hr for demersal longline/trawl).

Light-mantled Sooty Albatrosses (non-breeding) exhibited a circumpolar distribution with particularly high occurrence in the New Zealand EEZ, and in the WCPFC (54.4%), SPRFMO (42.5%), CCSBT (42.2%), and CCAMLR (30.1%) Convention Areas (Figure 6; Table S3h). They also used the Convention Areas of IOTC (8.9%), ICCAT (5.9%), SIOFA (4.7%), IATTC (2.6%), and SEAFO (4.7%).

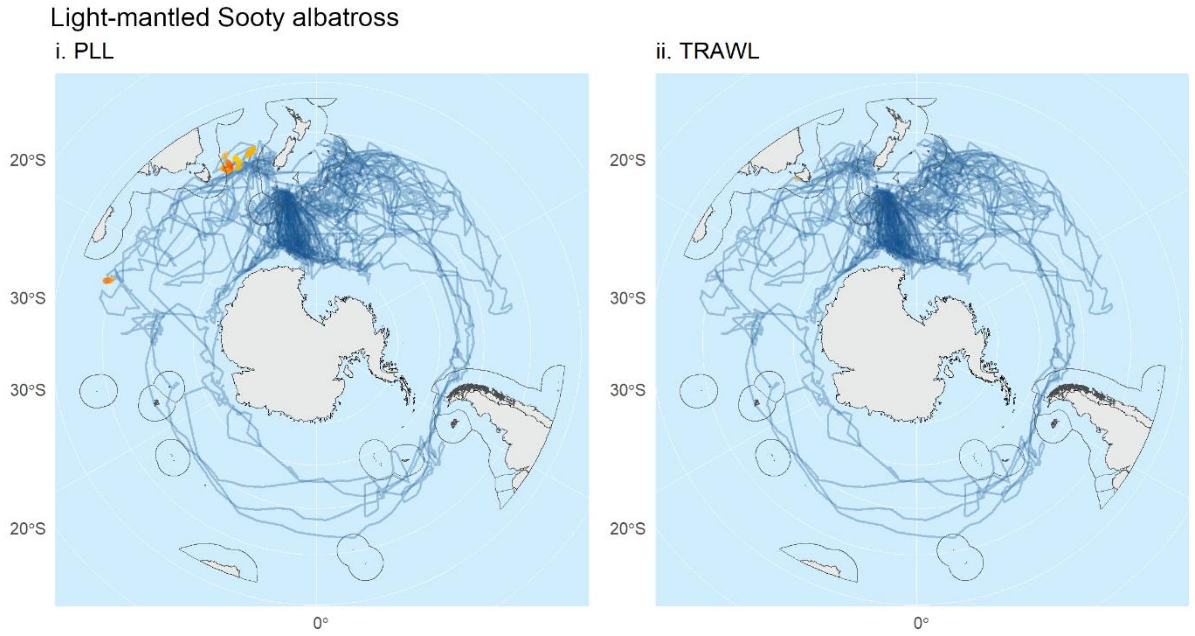
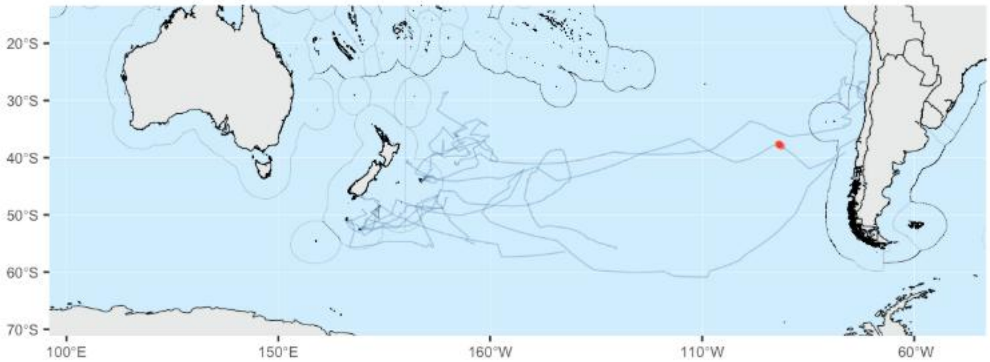


Figure 6. Spatiotemporal overlap between Light-mantled Sooty Albatrosses and pelagic longline (i) and trawl (ii) fisheries. Points represent overlap events, coloured by overlap magnitude (orange = low, red = high) with gear-specific overlap buffers (100 km & 1 hr for pelagic longline; 5 km & 1 hr for demersal longline/trawl).

Northern Giant Petrels (juveniles) ranged east of New Zealand EEZ (27.5%) across to Chile (21%), using the convention areas of IATTC (52.5%), SPRFMO (38.3%), WCPFC (39%), CCSBT (32.1%), and CCAMLR (0.1%) (Figure 7; Table S3i).

Northern Giant petrel

i. PLL



ii. TRAWL

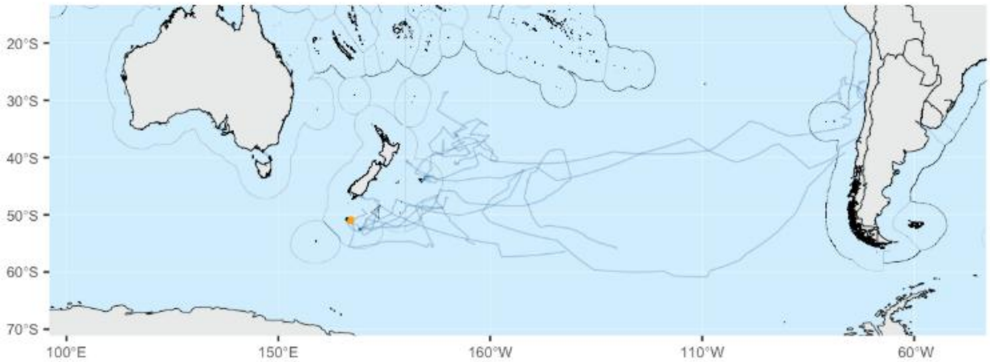


Figure 7. Spatiotemporal overlap between Northern Giant petrels and pelagic longline (i) and trawl (ii) fisheries. Points represent overlap events, coloured by overlap magnitude (relative scale from yellow – low to red - high) with gear-specific overlap buffers (100 km & 1 hr for pelagic longline; 5 km & 1 hr for demersal longline/trawl).

3.2 Point-based overlap with fisheries

All seven study species overlapped with fishing overlap in space and time. For 379 of the 506 tracked birds (74.9%), 49,495 overlap events were detected involving 716 vessels from 25 flag states (Table S2). These overlap events occurred across eight exclusive economic zones (EEZs) and eight regional fisheries management and conservation organization (RFMCOs) (Figure 8a-c; Table S2). Birds overlapped most frequently with pelagic longliners (62.2% of total overlap) and trawlers (33.8%). Substantially less overlap was detected with demersal longliners (3.8%). The majority of pelagic longliners were Chinese-flagged vessels, while most demersal longliners were New Zealand flagged vessels (Table S4, S5a-i). Trawl overlap involved vessels mainly flagged to Argentina, New Zealand, Vanuatu, and China. Pelagic longline overlap occurred predominantly within the CCSBT (75% of total overlap, standardised across months and species), ICCAT (58.9%), and WCPFC (38.5%) convention areas (Table S2). Trawl overlap was concentrated within the EEZs of Argentina (38.7%) and New Zealand (19.4%), whereas demersal longline overlap occurred mainly within the New Zealand EEZ (71.4%).

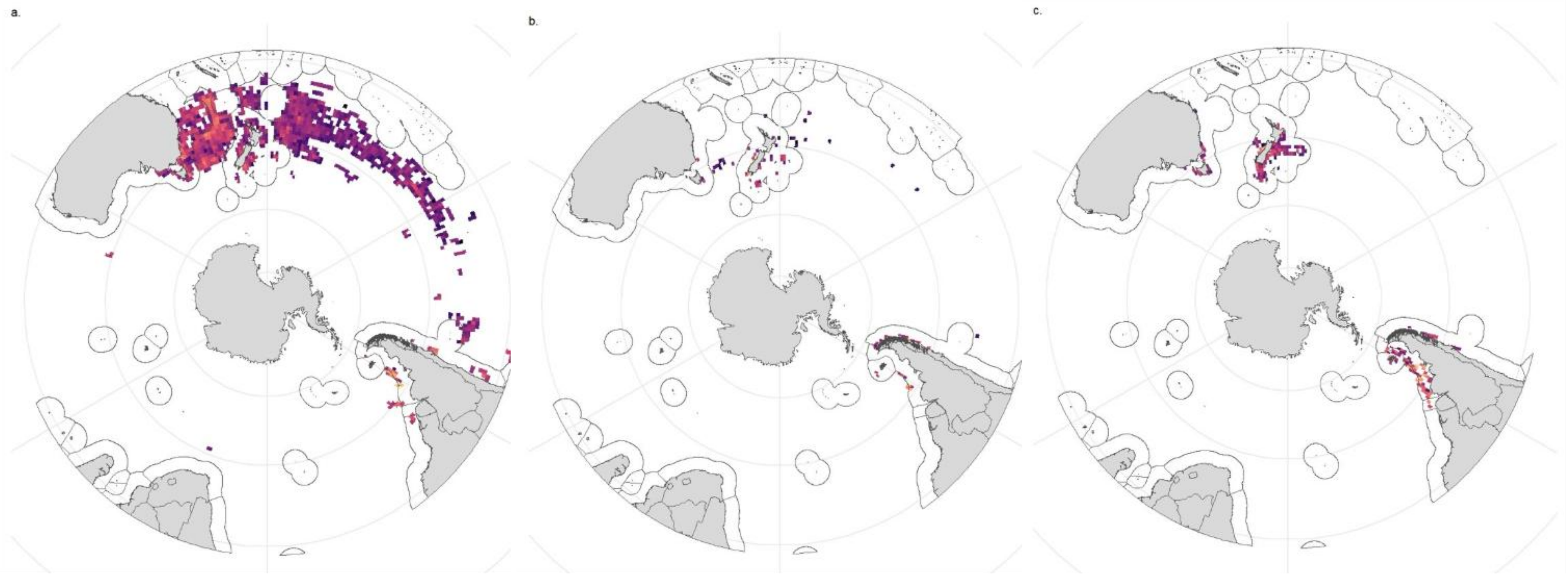


Figure 8. Spatiotemporal overlap of all species with a) pelagic longline b) demersal longline and c) trawl fisheries, coloured by summed overlap across species at 100x100 km resolution

Antipodean Albatrosses overlapped primarily with pelagic longliners (95.8% of total overlap for adults and 98.5% for juveniles, standardised across months) (Figure 2a; Table 3a). Overlap with pelagic longliners occurred in WCPFC (86% and 91.5%), CCSBT (77.3% and 85.2%), and IATTC (17.7% and 16%) Convention Areas and New Zealand (4.1% and 7.1%), Chilean (4.1%), and Australian (0.8% and 11.6%) EEZs. Antipodean Albatrosses also overlapped with trawl (3.8% and 1.4%) and demersal longliners (0.4% and 0.1%) fisheries. The majority of trawl overlap for both adults and juveniles occurred within New Zealand the EEZ. Gibson's Albatrosses also overlapped most with pelagic longlines (0.990 for adults and 99.1% for juveniles) (Figure 2b; Table 3b). This occurred in the WCPFC (100% and 99.9%) and CCSBT (90.4% and 78.9%) Convention Areas, and in Australian (17.4% and 25.5%) and New Zealand (1.2% and 5.2%) EEZs. Most of the demersal longline overlap occurred in SPRFMO and the New Zealand EEZ, though this comprised > 0.1% of total overlap for adults, and only 0.4% of overlap for juveniles. Overlap with trawl fisheries (0.9% and 0.5% of total overlap) occurred within national jurisdictions of New Zealand (77.5% and 96.6%) and Australia (22.5% and 3.4%).

Northern Royal Albatrosses overlapped primarily with pelagic longline (58.9% of total overlap) and trawl fisheries (37.7%) (Figure 3a; Table S3c). The majority of pelagic longline overlap occurred in ICCAT (81.7%), CCSBT (52.9%) convention areas, and in Argentina (42.7%) and Chile (10.3%). Trawl overlap occurred exclusively in domestic waters, primarily of Argentina (48.4%) and New Zealand (20%). There was some Northern Royal Albatross overlap with demersal longliners (3.4% of total overlap) in Chile (84.9%), New Zealand (11.6%), and Argentina (0.4%). Southern Royal Albatrosses also overlapped with pelagic longline (51.9%) and trawl (42.5%) fisheries to a greater extent than demersal longlines (5.3%) (Figure 3b; Table S3d). Overlap with pelagic longline and trawl fisheries was distributed similarly to Northern Royal Albatrosses, with the majority of pelagic longline overlap in ICCAT (96.8%) and CCSBT (77.3%) convention areas and in the Argentinian EEZ (37.8%). Trawl overlap was primarily located in the Argentinian (41.8%) and New Zealand EEZ (10.8%). Most overlap of demersal longline fisheries with Southern Royals occurred in New Zealand (79.7%).

Northern Buller's Albatrosses only overlapped with trawlers within the New Zealand EEZ (Figure 4a; Table S3e). Southern Buller's Albatrosses also overlapped with trawlers (29.8% of total overlap) primarily in the New Zealand EEZ (0.921) but also overlapped with pelagic (69.8% of total overlap) and demersal longliners (0.4%) (Figure 4b; Table S3f). Overlap with pelagic longliners occurred in the WCPFC (95.8%), CCSBT (63.7%) and IOTC (3.4%) Convention Areas and in New Zealand (41.7%) and Australia (34.4%) EEZs. Overlap with demersal longliners occurred in New Zealand (58%) and Australia (39.6%) EEZs, and in the SPRFMO Convention Area (2.5%).

Campbell Albatrosses overlapped with pelagic longline (67.7%), trawl (31%), and demersal longline (1.4%) fisheries (Figure 5; Table S3g). Overlap with pelagic longliners occurred in and around New Zealand (8.1%) all within CCSBT (100%) and WCPFC (100%) Convention Areas. All trawl overlap occurred in the Australian EEZ, and all demersal longline overlap occurred in the New Zealand EEZ. Light-mantled Sooty Albatrosses overlapped almost exclusively with pelagic longliners (99.4%) in CCSBT (100%), WCPFC (90.7%) and IOTC (9.3%). Some overlap with trawl fisheries (0.6%) occurred in the Australian EEZ (100%) (Figure 6; Table S3h). Northern Giant Petrels overlapped with trawl (51.5%) and pelagic longliners (48.5%) (Figure 7; Table S3i). All trawl overlap occurred in the New Zealand EEZ, and all pelagic longline overlap in the CCSBT and IATTC Convention Areas.

4. Discussion

Our multi-species, multi-year point-based overlap analysis provides one of the most comprehensive fine-scale assessments to date of how albatrosses and large petrels interact with pelagic and demersal longline and trawl fisheries across the Southern Hemisphere. By integrating high-resolution tracking data with AIS-derived fishing effort, we reveal that exposure to fisheries is neither diffuse nor uniform; instead, it is concentrated in predictable hotspots shaped by species-specific movement patterns, oceanographic features, and the distribution of major industrial fleets (Figure 8a-c). These findings reinforce earlier work demonstrating that wide-ranging seabirds routinely traverse multiple EEZs and high-seas jurisdictions (e.g., Peatman et al. 2019, Rowley et al. 2024, Anon. et al. 2025, Düssler et al. 2025, Rexer-Huber et al. 2025, Rutter et al. 2026a) but build upon previous work by quantifying transitions at finer spatial and temporal scales and across a broader suite of species and fleets. The hemispheric scope and consistent analytical workflow applied here allow direct comparison among species, populations, and management areas, an advance over earlier studies that were typically limited to single species or regions.

We identified widespread multi-species overlap hotspots with pelagic longline, demersal longline, and trawl fisheries across multiple EEZs and RFMCO jurisdictions, revealing both concentrated risk areas and gaps in bycatch mitigation coverage (Table S3a-i). Overlap with pelagic longline fisheries was the most extensive, with four dominant high-risk regions (Figure 8a). The largest hotspot occurred in the Tasman Sea, spanning WCPFC and CCSBT jurisdictions, with a substantial proportion within the Australian EEZ. This is comprised largely of overlap with Antipodean, Gibson’s, and Southern Buller’s Albatrosses (Figure 2, 3), though all tracked albatross species utilised this high-risk area to some extent. A second prominent band of overlap was identified in the western Pacific east of New Zealand (25°S–45°S), fully within WCPFC waters but overlapping with CCSBT and IATTC Convention Areas. The observed overlap in this area was predominantly with Antipodean Albatrosses (Figure 2). Smaller yet ecologically important hotspots were evident off South America, including areas within IATTC jurisdiction and the Chilean EEZ on the Pacific coast, as well as within CCSBT and ICCAT areas in the Argentine and Uruguayan EEZs on the Atlantic coast. Across these regions, all relevant RFMCOs mandate only one or two of three ACAP-recommended measures or the use of hook shielding devices south of 25°S (ACAP 2024a). These standards fall short of best practice, which calls for the concurrent implementation of all three measures, highlighting a clear disconnect between risk concentration and regulatory stringency (Rexer-Huber et al. 2025).

In contrast, overlap with demersal longliners was more spatially constrained, occurring primarily within the New Zealand and Chilean EEZ (Figure 8b). Importantly, equivalent levels of spatial overlap do not translate directly into equivalent bycatch risk (Waipoua et al. 2026). Chilean demersal longlines typically use rapidly sinking gear that poses minimal seabird bycatch risk (ACAP, 2024b), whereas New Zealand floated demersal longlines present a substantially higher risk profile and therefore require the use of bespoke mitigation technologies (Goad, 2024). Additional demersal longline overlap hotspots were identified in the Tasman Sea and across the western Pacific between 30°S and 40°S, and extensively in Chile. Overlap in Chile can be attributed majority to Northern and Southern Royal Albatrosses.

Overlap with trawl fisheries was largely concentrated within the New Zealand and Argentinian EEZs, with the majority of trawl vessels flagged to these two nations (Figure 8c; Table S3-4). Overlap with trawl was most notable in Northern Royal, Southern Royal, and Southern Buller’s

Albatrosses. Together, these patterns emphasise that exposure landscapes are highly fishery- and jurisdiction-specific, with important implications for tailoring mitigation and regulatory responses.

While classifying overlap by gear type provides a necessary foundation for identifying where conservation outreach and mitigation implementation efforts should be targeted, overlap alone does not equate to bycatch risk, nor is risk uniform within a given fishery (Edwards et al. 2023, Anon. 2025, Waipoua et al. 2026). Vulnerability to capture is mediated by a combination of seabird behaviour and morphology, with diving and pursuit-plunging Procellariiformes particularly susceptible to longline hooks during setting and soak periods (Gilman et al. 2014; Düssler et al. 2026). Some species not only experience elevated individual risk but may also increase exposure for conspecifics and other seabirds by bringing baited hooks back to the surface during escape attempts, amplifying localised mortality events (Brothers et al. 2010; Gilman et al. 2014). Risk is further structured by fleet-specific practices and regulatory environments. For example, pelagic longline vessels operating within the New Zealand EEZ are now required to deploy all three ACAP-endorsed mitigation measures simultaneously (or an approved hook-shielding device) representing one of the most stringent regulatory regimes globally (ACAP 2024a). In contrast, mitigation requirements on the high seas and across RFMCOs remain heterogeneous in scope, enforcement, and compliance monitoring (Phillips et al. 2016; Dias et al. 2019). These differences mean that similar levels of spatial overlap may correspond to markedly different biological risk depending on jurisdiction and fleet. Accordingly, overlap analyses such as those presented here are best interpreted as an entry point for risk prioritisation, which should be combined with behavioural ecology, mitigation efficacy, and governance context to inform proportionate, evidence-based conservation action.

All overlap metrics presented here are derived exclusively from Automated Identification System (AIS) data and therefore represent a minimum estimate of seabird exposure to fisheries. AIS captures only a subset of global fishing activity, with coverage predominantly limited to larger industrial vessels while many smaller coastal, artisanal, and semi-industrial fleets, which can also pose substantial bycatch risk to seabirds, remain poorly represented or entirely absent from AIS datasets. This is particularly true within EEZs of developing coastal states (Taconet et al. 2019; Kroodsma et al. 2018). Even among AIS-equipped vessels, transmission gaps occur due to technical limitations in satellite reception, high vessel density, or intentional disabling, resulting in spatially and temporally uneven coverage (Kroodsma et al. 2018; Welch et al. 2024, Rutter et al. 2026b). Recent analyses suggest that up to 24–36% of overlap between marine predators and fishing vessels may go undetected when relying solely on AIS, with blind spots especially pronounced in equatorial regions and near continental margins (Welch et al. 2024). In this context, the extensive overlap detected in our analysis, despite relying solely on AIS, provides a strong indication that actual interactions between seabirds and fisheries is likely greater than those quantified here. This consideration is particularly relevant given that some tracking data extend back to 2019, when satellite AIS coverage and vessel classification algorithms were less developed than at present.

While AIS coverage, classification accuracy, and data continuity continue to improve rapidly through expanded satellite constellations and machine-learning-based fishing detection (Kroodsma et al. 2018; Taconet 2019), important gaps remain. Accordingly, the results presented here should be interpreted not as a complete representation of fisheries exposure, but as a conservative baseline that reveals substantial risk. A critical next step is to integrate AIS-based analyses with complementary data streams, including Vessel Monitoring Systems

(VMS), electronic monitoring (e.g, Rutter et al. 2026a), port-based monitoring (Rowley et al. 2026), or vessel-borne GPS data (e.g., Cruz et al. 2026), to better capture nearshore, artisanal, and regionally regulated fleets that fall outside AIS coverage. Such integration would substantially reduce uncertainty in overlap estimates and provide a more complete picture of seabird–fishery interactions, thereby strengthening the capacity of ACAP, RFMCOs, and national authorities to prioritise and target bycatch mitigation across the full spectrum of fleets affecting threatened seabirds.

The tracking data underpinning this study were generated from devices attached using feather-mount techniques, which are widely used for large seabirds due to their relatively low handling time and minimal invasive impacts during deployment (McMahon et al. 2011; Geen et al. 2019). However, a well-recognised limitation of feather mounts is that tag retention is constrained by feather wear and the post-breeding moult, resulting in tracks that typically capture only one phase of an annual cycle and terminate following migration (Barron et al. 2010). In our study, feather loss and tag detachment were not uniform among individuals or species, reflecting interspecific differences in moult strategy and duration. While Thalassarche and Royal albatrosses undergo a relatively rapid, largely annual moult that limits tag retention to several months, some species tracked here exhibited substantially longer moult cycles. In particular, Light-mantled Sooty Albatrosses Phoebetria palpebrata, which replace their flight feathers gradually over a multi-year cycle, retained devices for extended periods, yielding notably longer tracks that captured a greater proportion of the non-breeding phase. Consequently, exposure to fisheries outside the deployment window, particularly during subsequent non-breeding periods, cannot be quantified for most individuals. While alternative attachment methods such as body harnesses, leg-loops, or wing-mounted devices can enable multi-year tracking, these approaches involve different trade-offs in terms of handling time, drag, behavioural impacts, and ethical considerations, and remain unevenly tested across Procellariiformes (Barron et al. 2010; Longarini et al. 2023). Importantly, the published literature is likely affected by reporting bias, with unsuccessful deployments or adverse tag effects less frequently documented, limiting the evidentiary base for method selection (Geen et al. 2019). At present, there is no ACAP-wide or internationally agreed set of best-practice guidelines for long-term tag attachment methods tailored to seabirds, despite their central role in informing spatial management. Developing such guidelines, drawing on both published and unpublished outcomes, would directly address data limitations identified here, improve animal welfare, and increase the comparability and longevity of tracking datasets used to guide global bycatch mitigation.

The policy implications of our findings are clear. Conservation agencies such as ACAP should prioritise engagement with RFMCOs to improve bycatch mitigation implementation in regions where overlap is highest and mitigation uptake is weakest. Harmonising bycatch mitigation standards across RFMCOs, particularly for pelagic longline fleets, would help reduce risk for species that move across multiple jurisdictions, while simultaneously improving practicability of implementation for fleets that move across jurisdictions. Increased monitoring and compliance verification, including electronic monitoring, is especially important in high-risk areas with notorious and persistent low observer coverage. The spatial patterns identified here also provide ACAP and its Parties with a robust evidence base to refine species- and region-specific conservation priorities and to target diplomatic, technical, and capacity-building efforts where they are most likely to yield measurable conservation gains.

More broadly, this study demonstrates the value of large-scale, multispecies tracking combined with global fishing-effort datasets for informing conservation at ecologically and politically meaningful scales. The approach provides a transferable framework for other regions and taxa facing similar governance fragmentation and highlights the value of standardised analytical tools such as *ShareWater* for accelerating global progress in bycatch reduction. Effective implementation of targeted mitigation in the identified hotspots has the potential to deliver substantial conservation gains for some of the world's most threatened seabirds.

5. Acknowledgements

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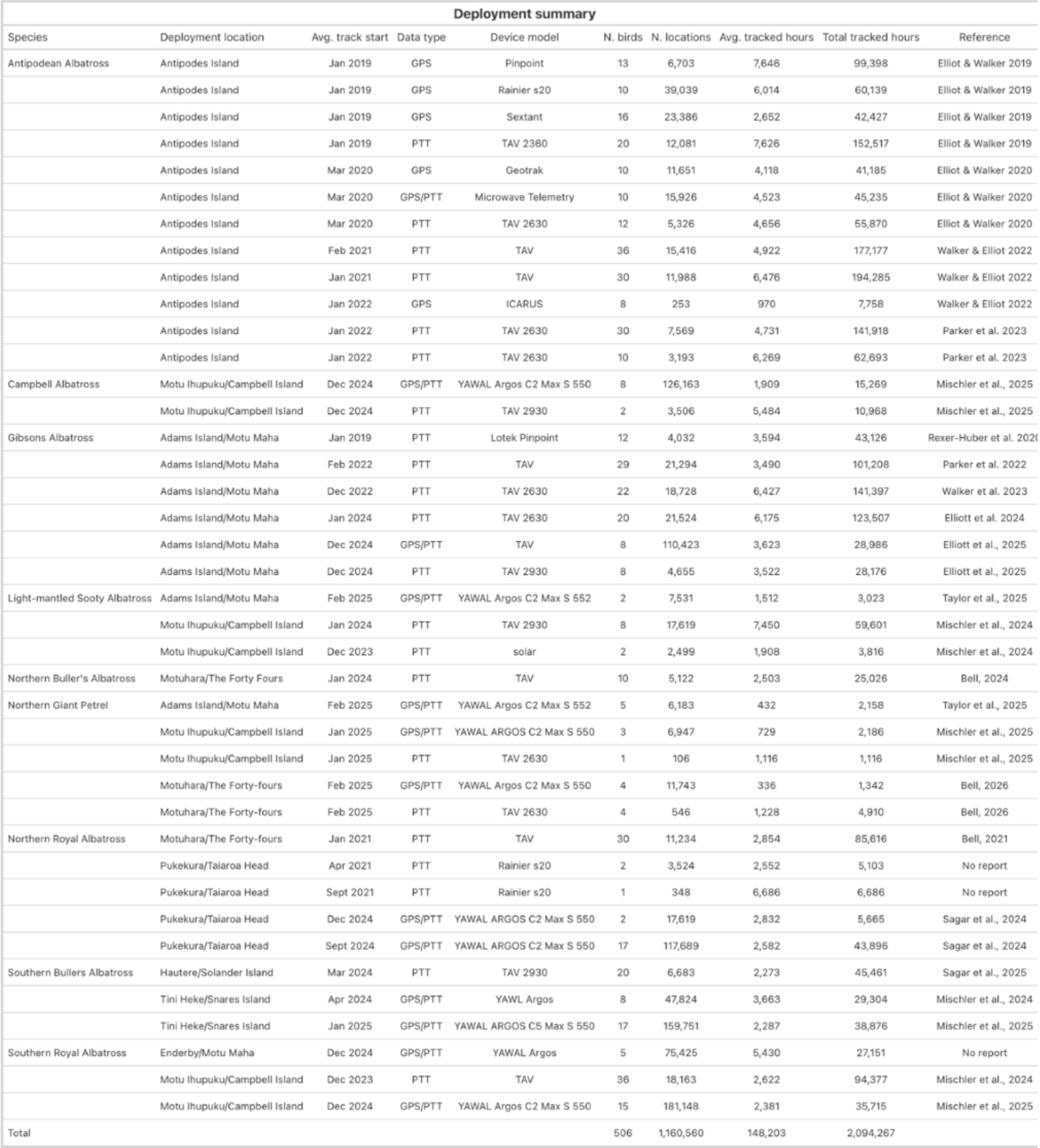
7. Supplementary Material

Supplementary material 1: Details for each deployment with citations for associated field reports with further information on tag attachment methods, ethical approvals, and personnel.



Deployment summary

Species	Deployment location	Avg. track start	Data type	Device model	N. birds	N. locations	Avg. tracked hours	Total tracked hours	Reference
Antipodean Albatross	Antipodes Island	Jan 2019	GPS	Pinpoint	13	6,703	7,646	99,398	Elliot & Walker 2019
	Antipodes Island	Jan 2019	GPS	Rainier s20	10	39,039	6,014	60,139	Elliot & Walker 2019
	Antipodes Island	Jan 2019	GPS	Sextant	16	23,386	2,652	42,427	Elliot & Walker 2019
	Antipodes Island	Jan 2019	PTT	TAV 2360	20	12,081	7,626	152,517	Elliot & Walker 2019
	Antipodes Island	Mar 2020	GPS	Geotrak	10	11,651	4,118	41,185	Elliot & Walker 2020
	Antipodes Island	Mar 2020	GPS/PTT	Microwave Telemetry	10	15,926	4,523	45,235	Elliot & Walker 2020
	Antipodes Island	Mar 2020	PTT	TAV 2630	12	5,326	4,656	55,870	Elliot & Walker 2020
	Antipodes Island	Feb 2021	PTT	TAV	36	15,416	4,922	177,177	Walker & Elliot 2022
	Antipodes Island	Jan 2021	PTT	TAV	30	11,988	6,476	194,285	Walker & Elliot 2022
	Antipodes Island	Jan 2022	GPS	ICARUS	8	253	970	7,758	Walker & Elliot 2022
	Antipodes Island	Jan 2022	PTT	TAV 2630	30	7,569	4,731	141,918	Parker et al. 2023
	Antipodes Island	Jan 2022	PTT	TAV 2630	10	3,193	6,269	62,693	Parker et al. 2023
Campbell Albatross	Motu Ihupuku/Campbell Island	Dec 2024	GPS/PTT	YAWAL Argos C2 Max S 550	8	126,163	1,909	15,269	Mischler et al., 2025
	Motu Ihupuku/Campbell Island	Dec 2024	PTT	TAV 2930	2	3,506	5,484	10,968	Mischler et al., 2025
Gibsons Albatross	Adams Island/Motu Maha	Jan 2019	PTT	Lotek Pinpoint	12	4,032	3,594	43,126	Rexer-Huber et al. 202
	Adams Island/Motu Maha	Feb 2022	PTT	TAV	29	21,294	3,490	101,208	Parker et al. 2022
	Adams Island/Motu Maha	Dec 2022	PTT	TAV 2630	22	18,728	6,427	141,397	Walker et al. 2023
	Adams Island/Motu Maha	Jan 2024	PTT	TAV 2630	20	21,524	6,175	123,507	Elliott et al. 2024
	Adams Island/Motu Maha	Dec 2024	GPS/PTT	TAV	8	110,423	3,623	28,986	Elliott et al., 2025
	Adams Island/Motu Maha	Dec 2024	PTT	TAV 2930	8	4,655	3,522	28,176	Elliott et al., 2025
Light-mantled Sooty Albatross	Adams Island/Motu Maha	Feb 2025	GPS/PTT	YAWAL Argos C2 Max S 552	2	7,531	1,512	3,023	Taylor et al., 2025
	Motu Ihupuku/Campbell Island	Jan 2024	PTT	TAV 2930	8	17,619	7,450	59,601	Mischler et al., 2024
	Motu Ihupuku/Campbell Island	Dec 2023	PTT	solar	2	2,499	1,908	3,816	Mischler et al., 2024
Northern Buller's Albatross	Motuhara/The Forty Fours	Jan 2024	PTT	TAV	10	5,122	2,503	25,026	Bell, 2024
Northern Giant Petrel	Adams Island/Motu Maha	Feb 2025	GPS/PTT	YAWAL Argos C2 Max S 552	5	6,183	432	2,158	Taylor et al., 2025
	Motu Ihupuku/Campbell Island	Jan 2025	GPS/PTT	YAWAL ARGOS C2 Max S 550	3	6,947	729	2,186	Mischler et al., 2025
	Motu Ihupuku/Campbell Island	Jan 2025	PTT	TAV 2630	1	106	1,116	1,116	Mischler et al., 2025
	Motuhara/The Forty-fours	Feb 2025	GPS/PTT	YAWAL Argos C2 Max S 550	4	11,743	336	1,342	Bell, 2026
	Motuhara/The Forty-fours	Feb 2025	PTT	TAV 2630	4	546	1,228	4,910	Bell, 2026
Northern Royal Albatross	Motuhara/The Forty-fours	Jan 2021	PTT	TAV	30	11,234	2,854	85,616	Bell, 2021
	Pukekura/Taiaroa Head	Apr 2021	PTT	Rainier s20	2	3,524	2,552	5,103	No report
	Pukekura/Taiaroa Head	Sept 2021	PTT	Rainier s20	1	348	6,686	6,686	No report
	Pukekura/Taiaroa Head	Dec 2024	GPS/PTT	YAWAL ARGOS C2 Max S 550	2	17,619	2,832	5,665	Sagar et al., 2024
	Pukekura/Taiaroa Head	Sept 2024	GPS/PTT	YAWAL ARGOS C2 Max S 550	17	117,689	2,582	43,896	Sagar et al., 2024
Southern Bullers Albatross	Hautere/Solander Island	Mar 2024	PTT	TAV 2930	20	6,683	2,273	45,461	Sagar et al., 2025
	Tini Heke/Snares Island	Apr 2024	GPS/PTT	YAWL Argos	8	47,824	3,663	29,304	Mischler et al., 2024
	Tini Heke/Snares Island	Jan 2025	GPS/PTT	YAWAL ARGOS C5 Max S 550	17	159,751	2,287	38,876	Mischler et al., 2025
Southern Royal Albatross	Enderby/Motu Maha	Dec 2024	GPS/PTT	YAWAL Argos	5	75,425	5,430	27,151	No report
	Motu Ihupuku/Campbell Island	Dec 2023	PTT	TAV	36	18,163	2,622	94,377	Mischler et al., 2024
	Motu Ihupuku/Campbell Island	Dec 2024	GPS/PTT	YAWAL Argos C2 Max S 550	15	181,148	2,381	35,715	Mischler et al., 2025
Total					506	1,160,560	148,203	2,094,267	

Supplementary material 2: Proportional distribution of birds across species, and vessel-bird overlap by management jurisdiction.

Bird distribution is based on a monthly-standardised bird-hour metric. Overlap is calculated as fishing effort within each spatiotemporal overlap event, weighted by bird hours. Proportions are calculated separately for each fishing gear type. CCAMLR, CCSBT, IATTC, and WCPFC represent pelagic longline fisheries and include EEZs; SPRFMO represents demersal longline and trawl fisheries and excludes EEZs. Overlap proportions may sum to >1 because some jurisdictions spatially overlap.

	All species			
Zone	Bird hours	PLL overlap	DLL overlap	Trawl overlap
Total overlap	-	479328	29128	260639
Proportion overlap	-	0.622	0.038	0.338
ARG	0.014	0.242	0.005	0.387
AUS	0.063	0.088	0.004	0.010
BRA	-	0.002	-	-
CHL	0.074	0.014	0.105	0.009
GBR*	0.003	-	0.004	0.022
NZL	0.415	0.075	0.714	0.194
PER	0.001	-	-	-
URY	-	-	-	0.007
CCAMLR	0.023	-	-	-
CCSBT	0.763	0.750	-	-
IATTC	0.151	0.028	-	-
ICCAT	0.022	0.589	-	-
IOTC	0.027	0.036	-	-
SIOFA	0.002	-	-	-
SPRFMO	0.394	-	0.003	-
WCPFC	0.762	0.385	-	-

Supplementary material 3a: Proportional distribution of Antipodean Albatross adults and juveniles, and vessel-bird overlap by management jurisdiction. Bird distribution is based on a monthly-standardised bird-hour metric. Overlap is calculated as fishing effort within each spatiotemporal overlap event, weighted by bird hours. Proportions are calculated separately for each fishing gear type. CCAMLR, CCSBT, IATTC, and WCPFC represent pelagic longline fisheries and include EEZs; SPRFMO represents demersal longline and trawl fisheries and excludes EEZs. Overlap proportions may sum to >1 because some jurisdictions spatially overlap.

	Antipodean Albatross							
	Adult				Juvenile			
Zone	Bird hours	PLL overlap	DLL overlap	Trawl overlap	Bird hours	PLL overlap	DLL overlap	Trawl overlap
Total overlap	-	7,876.253	30.508	312.193	-	11,206.846	12.389	156.022
Proportion overlap	-	0.958	0.004	0.038	-	0.985	0.001	0.014
AUS	0.002	0.008	-	-	0.061	0.116	-	0.018
CHL	0.140	0.014	0.104	0.033	0.016	-	-	-
NZL	0.376	0.041	0.334	0.967	0.423	0.071	0.473	0.982
CCAMLR	0.017	-	-	-	-	-	-	-
CCSBT	0.793	0.773	-	-	0.948	0.852	-	-
IATTC	0.366	0.177	-	-	0.129	0.160	-	-
SPRFMO	0.451	-	0.562	-	0.499	-	0.527	-
WCPFC	0.634	0.860	-	-	0.908	0.915	-	-

Supplementary material 3b: Proportional distribution of Gibson's Albatross adults and juveniles, and vessel-bird overlap by management jurisdiction. Proportions are calculated separately for each gear type.

	Gibson's Albatross							
	Adult				Juvenile			
Zone	Bird hours	PLL overlap	DLL overlap	Trawl overlap	Bird hours	PLL overlap	DLL overlap	Trawl overlap
Total overlap	-	5340	2	51	-	7027	27	33
Proportion overlap	-	0.990	-	0.009	-	0.991	0.004	0.005
AUS	0.032	0.174	-	0.225	0.195	0.255	-	0.034
NZL	0.853	0.012	0.278	0.775	0.467	0.052	0.911	0.966
CCSBT	0.949	0.904	-	-	0.928	0.789	-	-
IOTC	0.012	-	-	-	0.052	0.005	-	-
SPRFMO	0.114	-	0.722	-	0.330	-	0.089	-
WCPFC	0.993	1.000	-	-	0.952	0.999	-	-

Supplementary material 3c: Proportional distribution of Northern Royal Albatrosses, and vessel-bird overlap by management jurisdiction. Proportions are calculated separately for each gear type.

	Northern Royal Albatross			
Zone	Bird hours	PLL overlap	DLL overlap	Trawl overlap
Total overlap	-	4022	231	2571
Proportion overlap	-	0.589	0.034	0.377
ARG	0.094	0.427	0.004	0.484
AUS	-	0.002	-	-
BRA	-	0.020	-	-
CHL	0.303	0.103	0.849	0.069
GBR*	0.003	-	-	0.001
NZL	0.475	0.077	0.116	0.200
URY	0.014	0.001	-	0.056
CCSBT	0.712	0.529	-	-
IATTC	0.329	0.103	-	-
ICCAT	0.123	0.817	-	-
IOTC	0.002	0.002	-	-
SPRFMO	0.068	-	-	-
WCPFC	0.540	0.079	-	-

Supplementary material 3d: Proportional distribution of Southern Royal Albatrosses, and vessel-bird overlap by management jurisdiction. Proportions are calculated separately for each gear type.

	Southern Royal Albatross			
Zone	Bird hours	PLL overlap	DLL overlap	Trawl overlap
Total overlap	-	16114	1661	13195
Proportion overlap	-	0.519	0.053	0.425
ARG	0.160	0.378	0.006	0.418
AUS	0.061	0.011	-	-
CHL	0.006	-	0.019	-
GBR*	0.051	-	0.004	0.028
NZL	0.618	0.021	0.787	0.108
CCAMLR	0.012	-	-	-
CCSBT	0.628	0.773	-	-
IATTC	0.003	-	-	-
ICCAT	0.249	0.968	-	-
IOTC	0.016	0.011	-	-
SPRFMO	0.053	-	-	-
WCPFC	0.707	0.032	-	-

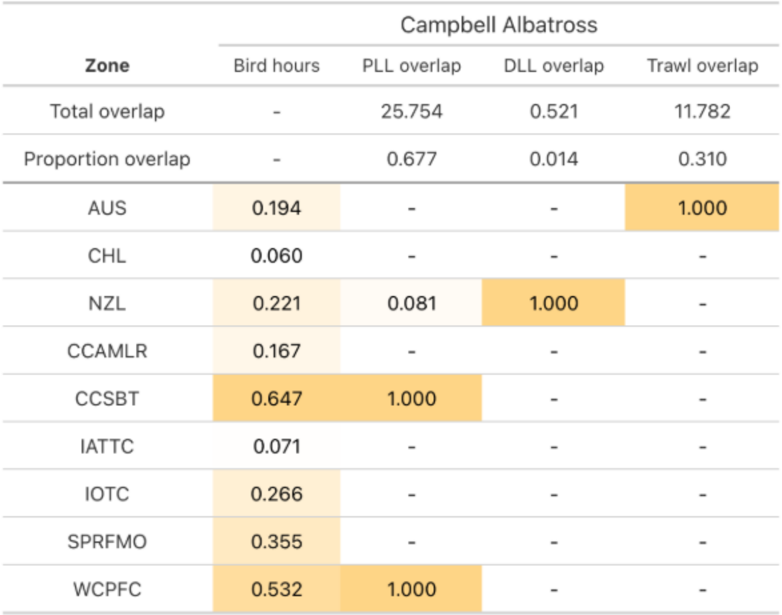
Supplementary material 3e: Proportional distribution of Northern Buller's Albatrosses, and vessel-bird overlap by management jurisdiction. Proportions are calculated separately for each gear type.

	Northern Buller's Albatross	
Zone	Bird hours	Trawl overlap
Total overlap	-	13
Proportion overlap	-	1.000
CHL	0.253	-
NZL	0.243	1.000
PER	0.279	-
CCSBT	0.476	-
IATTC	0.612	-
SPRFMO	0.210	-
WCPFC	0.425	-

Supplementary material 3f: Proportional distribution of Southern Buller's albatross, and vessel-bird overlap by management jurisdiction. Proportions are calculated separately for each gear type.

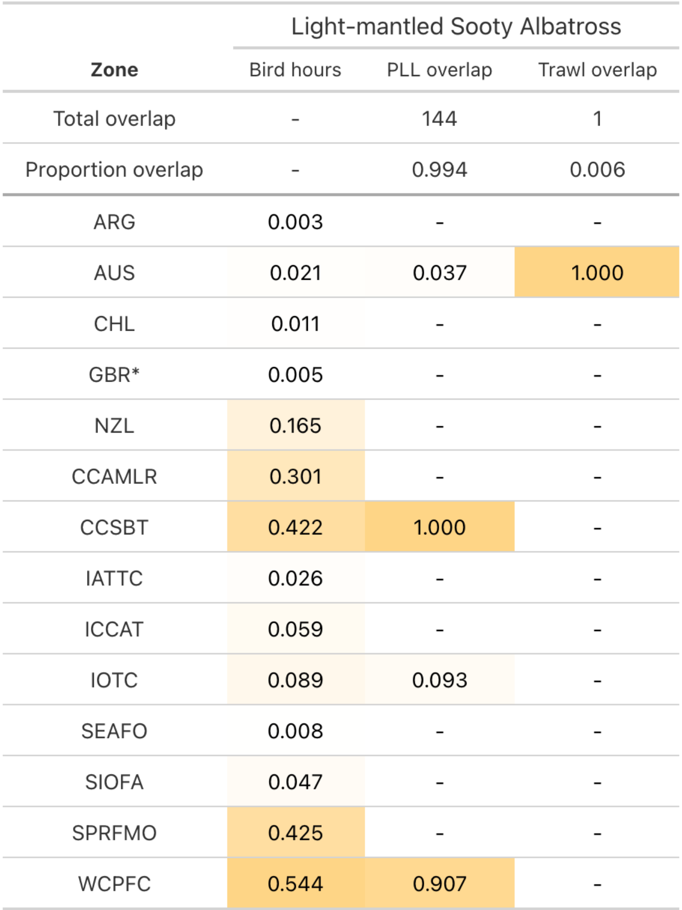
	Southern Buller's Albatross			
Zone	Bird hours	PLL overlap	DLL overlap	Trawl overlap
Total overlap	-	3711	22	1582
Proportion overlap	-	0.698	0.004	0.298
AUS	0.194	0.344	0.396	0.079
CHL	0.231	0.022	-	-
NZL	0.405	0.417	0.580	0.921
PER	0.007	-	-	-
CCSBT	0.454	0.637	-	-
IATTC	0.286	0.034	-	-
IOTC	0.177	0.268	-	-
SPRFMO	0.148	-	0.025	-
WCPFC	0.725	0.958	-	-

Supplementary material 3g: Proportional distribution of Campbell Albatrosses, and vessel-bird overlap by management jurisdiction. Proportions are calculated separately for each gear type.



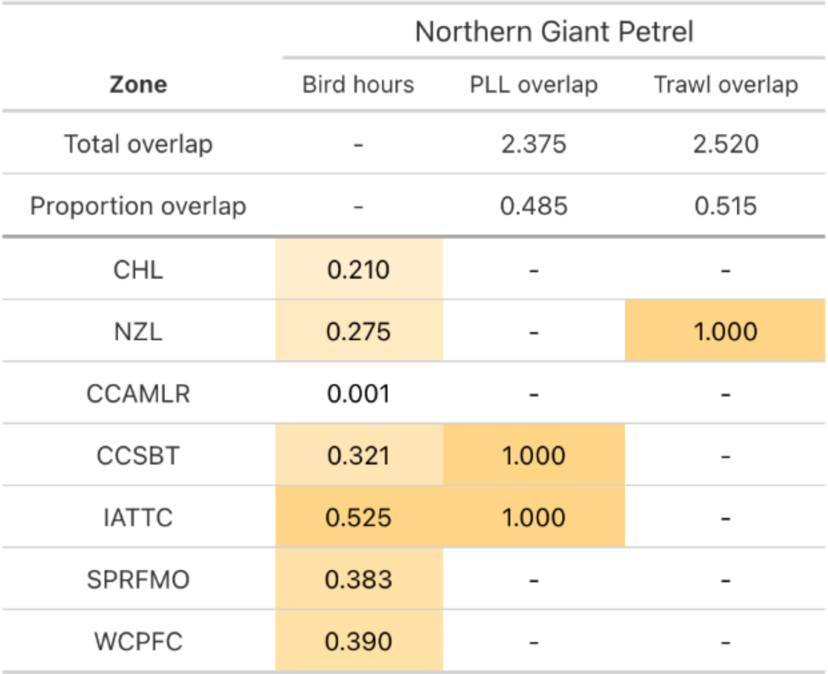
	Campbell Albatross			
Zone	Bird hours	PLL overlap	DLL overlap	Trawl overlap
Total overlap	-	25.754	0.521	11.782
Proportion overlap	-	0.677	0.014	0.310
AUS	0.194	-	-	1.000
CHL	0.060	-	-	-
NZL	0.221	0.081	1.000	-
CCAMLR	0.167	-	-	-
CCSBT	0.647	1.000	-	-
IATTC	0.071	-	-	-
IOTC	0.266	-	-	-
SPRFMO	0.355	-	-	-
WCPFC	0.532	1.000	-	-

Supplementary material 3h: Proportional distribution of Light-mantled Sooty albatross, and vessel-bird overlap by management jurisdiction. Proportions are calculated separately for each gear type.



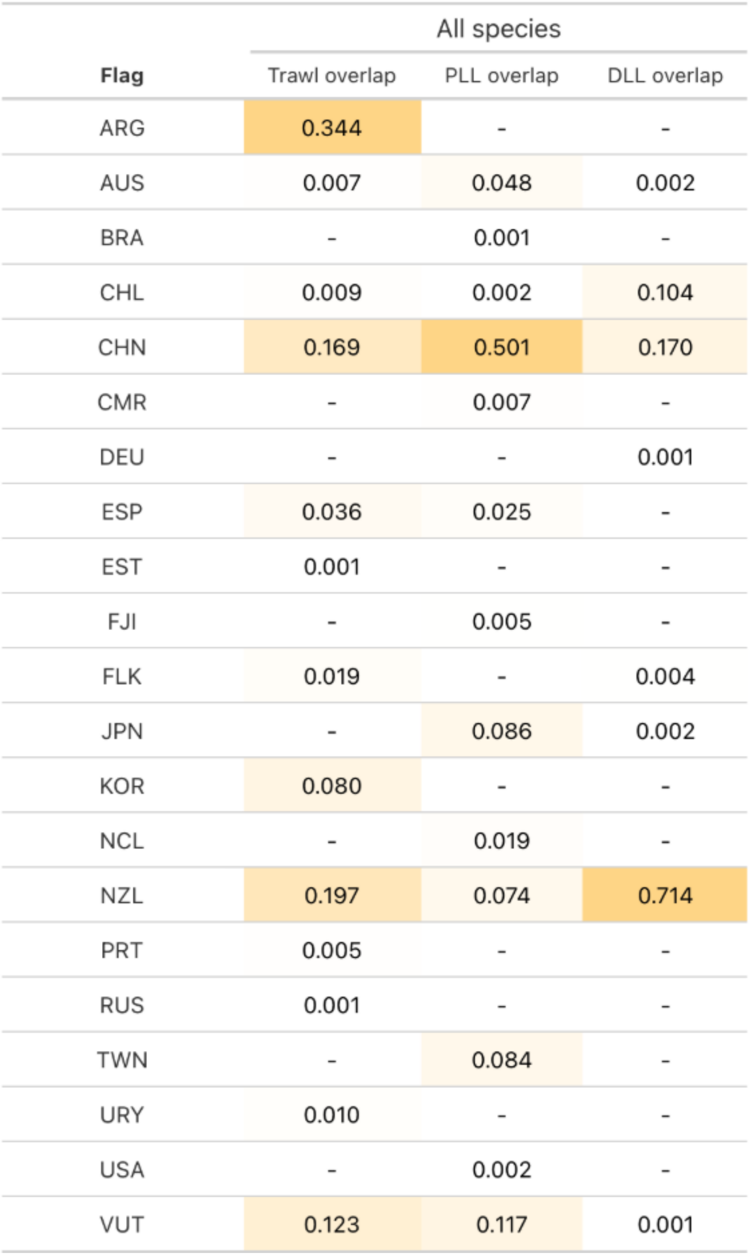
	Light-mantled Sooty Albatross		
Zone	Bird hours	PLL overlap	Trawl overlap
Total overlap	-	144	1
Proportion overlap	-	0.994	0.006
ARG	0.003	-	-
AUS	0.021	0.037	1.000
CHL	0.011	-	-
GBR*	0.005	-	-
NZL	0.165	-	-
CCAMLR	0.301	-	-
CCSBT	0.422	1.000	-
IATTC	0.026	-	-
ICCAT	0.059	-	-
IOTC	0.089	0.093	-
SEAFO	0.008	-	-
SIOFA	0.047	-	-
SPRFMO	0.425	-	-
WCPFC	0.544	0.907	-

Supplementary material 3i: Proportional distribution of Northern Giant petrels, and vessel-bird overlap by management jurisdiction. Proportions are calculated separately for each gear type.



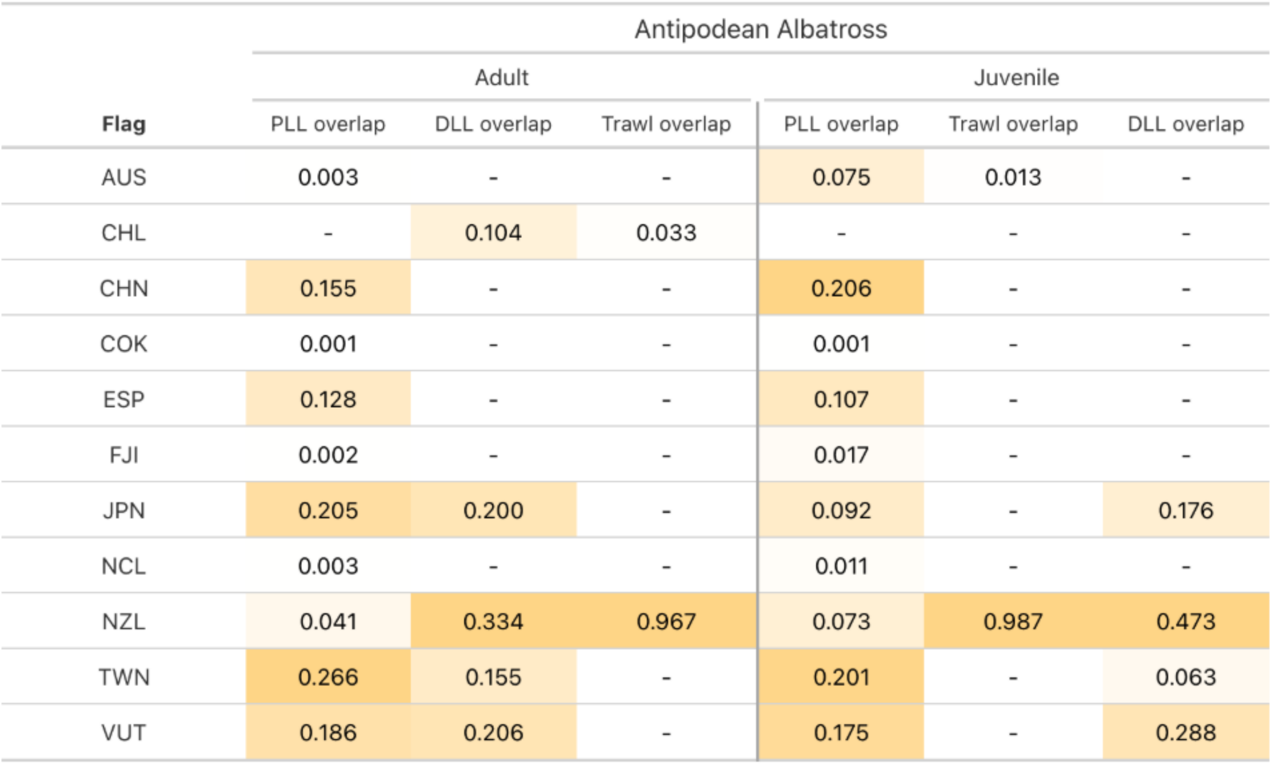
	Northern Giant Petrel		
Zone	Bird hours	PLL overlap	Trawl overlap
Total overlap	-	2.375	2.520
Proportion overlap	-	0.485	0.515
CHL	0.210	-	-
NZL	0.275	-	1.000
CCAMLR	0.001	-	-
CCSBT	0.321	1.000	-
IATTC	0.525	1.000	-
SPRFMO	0.383	-	-
WCPFC	0.390	-	-

Supplementary material 4: Proportion of vessel–bird overlap attributed to vessel flag states across all species. Overlap is calculated as fishing effort within each spatiotemporal overlap event, weighted by monthly-standardised bird hours. Proportions are calculated separately for each fishing gear type.



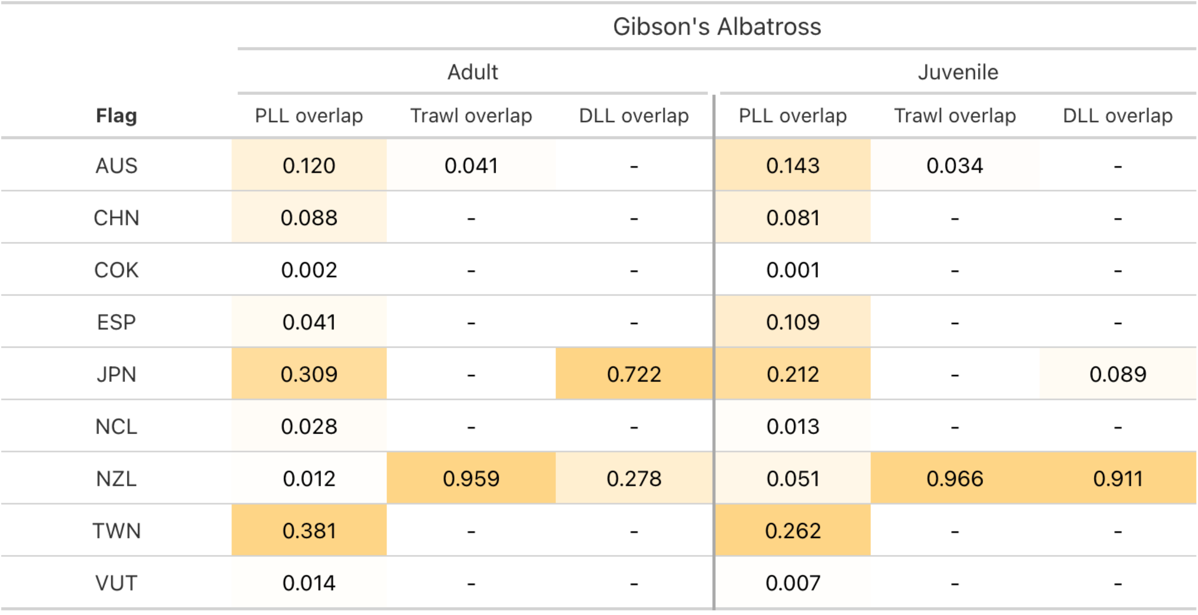
	All species		
Flag	Trawl overlap	PLL overlap	DLL overlap
ARG	0.344	-	-
AUS	0.007	0.048	0.002
BRA	-	0.001	-
CHL	0.009	0.002	0.104
CHN	0.169	0.501	0.170
CMR	-	0.007	-
DEU	-	-	0.001
ESP	0.036	0.025	-
EST	0.001	-	-
FJI	-	0.005	-
FLK	0.019	-	0.004
JPN	-	0.086	0.002
KOR	0.080	-	-
NCL	-	0.019	-
NZL	0.197	0.074	0.714
PRT	0.005	-	-
RUS	0.001	-	-
TWN	-	0.084	-
URY	0.010	-	-
USA	-	0.002	-
VUT	0.123	0.117	0.001

Supplementary material 5a: Proportion of vessel–bird overlap attributed to vessel flag states for Antipodean Albatross adults and juveniles. Overlap is calculated as the summed fishing effort within each spatiotemporal overlap event, multiplied by a standardised bird-hour metric. Proportions are calculated separately for each gear type.



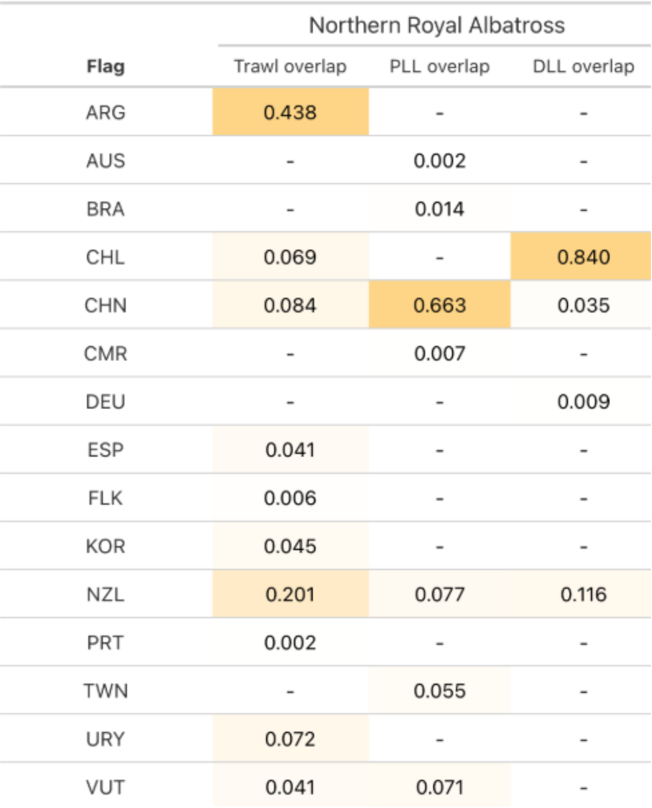
	Antipodean Albatross					
	Adult			Juvenile		
Flag	PLL overlap	DLL overlap	Trawl overlap	PLL overlap	Trawl overlap	DLL overlap
AUS	0.003	-	-	0.075	0.013	-
CHL	-	0.104	0.033	-	-	-
CHN	0.155	-	-	0.206	-	-
COK	0.001	-	-	0.001	-	-
ESP	0.128	-	-	0.107	-	-
FJI	0.002	-	-	0.017	-	-
JPN	0.205	0.200	-	0.092	-	0.176
NCL	0.003	-	-	0.011	-	-
NZL	0.041	0.334	0.967	0.073	0.987	0.473
TWN	0.266	0.155	-	0.201	-	0.063
VUT	0.186	0.206	-	0.175	-	0.288

Supplementary material 5b: Proportion of vessel–bird overlap attributed to vessel flag states for Gibson's Albatross adults and juveniles. Proportions are calculated separately for each gear type.



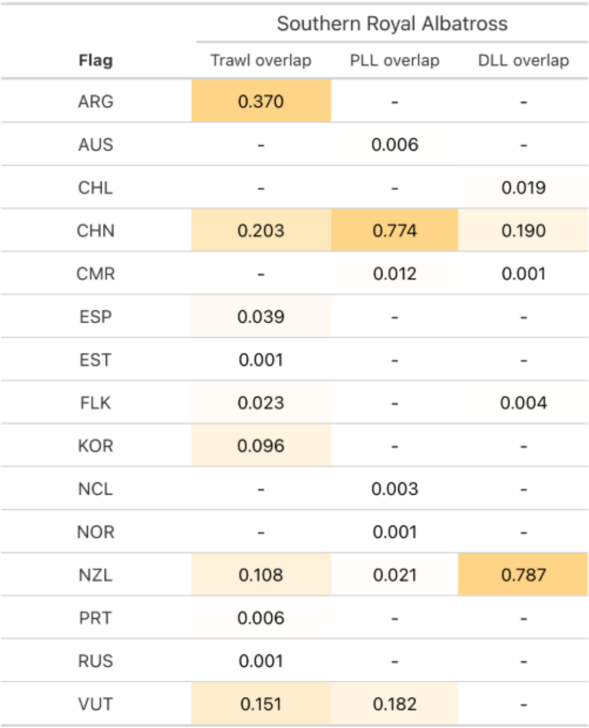
	Gibson's Albatross					
	Adult			Juvenile		
Flag	PLL overlap	Trawl overlap	DLL overlap	PLL overlap	Trawl overlap	DLL overlap
AUS	0.120	0.041	-	0.143	0.034	-
CHN	0.088	-	-	0.081	-	-
COK	0.002	-	-	0.001	-	-
ESP	0.041	-	-	0.109	-	-
JPN	0.309	-	0.722	0.212	-	0.089
NCL	0.028	-	-	0.013	-	-
NZL	0.012	0.959	0.278	0.051	0.966	0.911
TWN	0.381	-	-	0.262	-	-
VUT	0.014	-	-	0.007	-	-

Supplementary material 5c: Proportion of vessel–bird overlap attributed to vessel flag states for Northern Royal Albatrosses. Proportions are calculated separately for each gear type.



	Northern Royal Albatross		
Flag	Trawl overlap	PLL overlap	DLL overlap
ARG	0.438	-	-
AUS	-	0.002	-
BRA	-	0.014	-
CHL	0.069	-	0.840
CHN	0.084	0.663	0.035
CMR	-	0.007	-
DEU	-	-	0.009
ESP	0.041	-	-
FLK	0.006	-	-
KOR	0.045	-	-
NZL	0.201	0.077	0.116
PRT	0.002	-	-
TWN	-	0.055	-
URY	0.072	-	-
VUT	0.041	0.071	-

Supplementary material 5d: Proportion of vessel–bird overlap attributed to vessel flag states for Southern Royal Albatrosses. Proportions are calculated separately for each gear type.



	Southern Royal Albatross		
Flag	Trawl overlap	PLL overlap	DLL overlap
ARG	0.370	-	-
AUS	-	0.006	-
CHL	-	-	0.019
CHN	0.203	0.774	0.190
CMR	-	0.012	0.001
ESP	0.039	-	-
EST	0.001	-	-
FLK	0.023	-	0.004
KOR	0.096	-	-
NCL	-	0.003	-
NOR	-	0.001	-
NZL	0.108	0.021	0.787
PRT	0.006	-	-
RUS	0.001	-	-
VUT	0.151	0.182	-

Supplementary material 5e: Proportion of vessel–bird overlap attributed to vessel flag states for Northern Buller's Albatrosses. Proportions are calculated separately for each gear type.

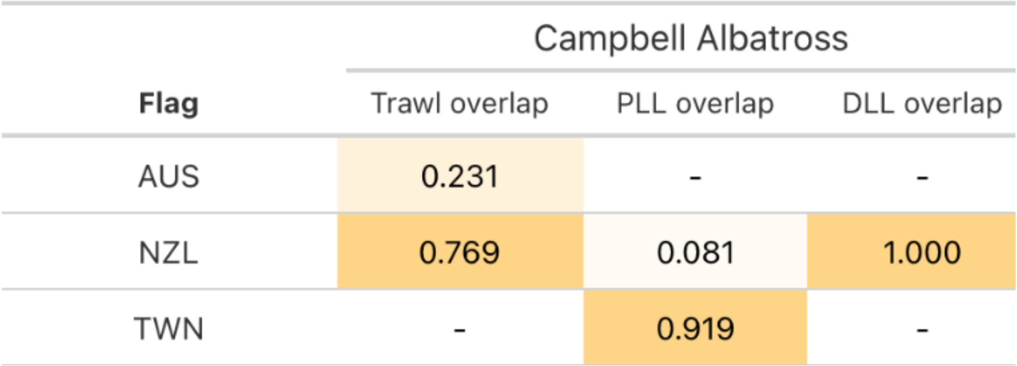
	Northern Buller's Albatross
Flag	Trawl overlap
NZL	1.000

Supplementary material 5f: Proportion of vessel–bird overlap attributed to vessel flag states for Southern Buller's Albatrosses. Proportions are calculated separately for each gear type.

	Southern Buller's Albatross		
Flag	PLL overlap	DLL overlap	Trawl overlap
AUS	0.159	0.166	0.076
CHL	0.021	-	-
ESP	0.011	-	-
JPN	0.196	0.025	-
NCL	0.127	-	-
NZL	0.417	0.580	0.924
TWN	0.010	-	-

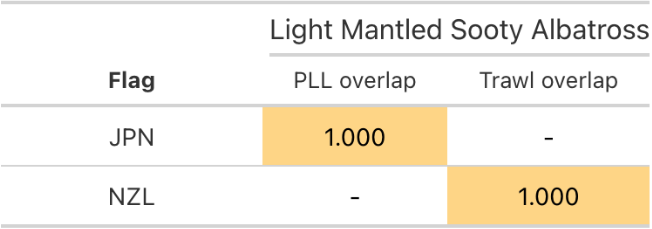
	Southern Buller's Albatross		
Flag	PLL overlap	DLL overlap	Trawl overlap
AUS	0.159	0.166	0.076
CHL	0.021	-	-
ESP	0.011	-	-
JPN	0.196	0.025	-
NCL	0.127	-	-
NZL	0.417	0.580	0.924
TWN	0.010	-	-

Supplementary material 5g: Proportion of vessel–bird overlap attributed to vessel flag states for Campbell Albatrosses. Proportions are calculated separately for each gear type.



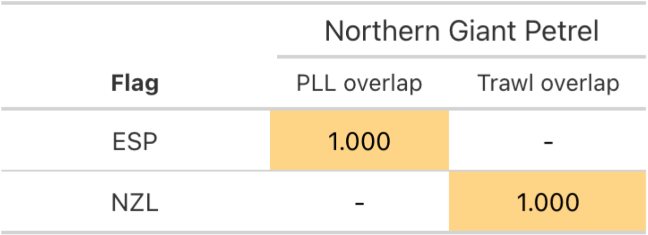
	Campbell Albatross		
Flag	Trawl overlap	PLL overlap	DLL overlap
AUS	0.231	-	-
NZL	0.769	0.081	1.000
TWN	-	0.919	-

Supplementary material 5h: Proportion of vessel–bird overlap attributed to vessel flag states for Light Mantled sooty Albatrosses. Proportions are calculated separately for each gear type.



	Light Mantled Sooty Albatross	
Flag	PLL overlap	Trawl overlap
JPN	1.000	-
NZL	-	1.000

Supplementary material 5i: Proportion of vessel–bird overlap attributed to vessel flag states for Northern Giant petrels. Proportions are calculated separately for each gear type.



	Northern Giant Petrel	
Flag	PLL overlap	Trawl overlap
ESP	1.000	-
NZL	-	1.000