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Antipodean albatross spatial distribution and fisheries overlap 2019

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Background

Antipodean albatross (*Diomedea antipodensis antipodensis*) is classified as 'Nationally Critical' under the New Zealand Threat Classification Status. Antipodean albatross is essentially endemic to Antipodes Island in the New Zealand subantarctic region, and range across the South Pacific, from Chile to Australia. The Antipodean Albatross population has more than halved since 2004 and continues to decline (Elliott & Walker 2020). Bycatch in fisheries, particularly those outside New Zealand's jurisdiction, has been identified as one of the largest threats to Antipodean Albatross. At the species level Antipodean albatross (*D. antipodensis*) was listed on Appendix 1 of the Convention on the Conservation of Migratory Species of Wild Animals (CMS) in February 2020 and the Antipodes Island population is recognised as a population of priority conservation concern by the Agreement on the Conservation of Albatrosses and Petrels (ACAP). The Concerted Action plan adopted by CMS focuses on the reduction of fisheries bycatch, supported by research including the deployment of tracking devices to better describe areas of fisheries overlap (Action 3.2).

Objectives

The objective of this work was to assess the first year of intensive satellite tracking of Antipodean albatross, in 2019, to describe areas of fisheries overlap. Specifically, we aimed to:

1. quantify the overlap of Antipodean albatross distribution with fishing activity.
2. describe fisheries overlap by bird age class, sex and breeding state.
3. identify fishing fleets that overlap with bird distribution and quantify the degree of overlap.
4. identify the ports most frequently used by vessels that fish in areas overlapping bird distribution.

Using the overlap of fishing effort with bird distribution as a proxy for potential bycatch risk, the findings from Objective 3 can be used to target seabird bycatch reduction outreach to certain fleets. Likewise, the results from Objective 4 can be used to identify which ports could be used to provide such outreach to vessels of interest.

Methods

We have developed a method of calculating cumulative overlap between satellite tracked seabirds and fishing effort data available from Global Fishing Watch (GFW; https://globalfishingwatch.org/). The method is intended to provide intuitive graphical representation of key areas of overlap with fisheries, be adaptable to precision of spatial data inputs and allow for quantitative assessment of overlap by vessel variable (e.g. fishing method, flag state, fishing company). Details of the method is provided in Appendix 1. Cumulative pelagic longline fishing effort for 2019 is shown in Figure M1.

Global Fishing Watch was chosen as our source of fisheries data because it is readily available, comprehensive, and is available at a global scale. The key dataset used is vessel tracking data from

Automatic Identification Systems (AIS) and Vessel Monitoring Systems (VMS), from which fishing activity has been derived.

The bird distribution data used was from the deployment of a range of satellite transmitting tracking devices deployed in early 2019, with some devices continuing to transmit until early 2020 (Elliott & Walker 2020). Full tracking data can be viewed and accessed through a web-based tracking app (https://docnewzealand.shinyapps.io/albatrosstracker/). An overview of all tracks obtained is shown in Figure M1.

We present results in two formats; distribution maps and charts.

The distribution maps are presented in panels, with two corresponding maps for each analysis; one showing bird distribution and the other overlap of that bird distribution with fishing activity. Bird distribution has been calculated and presented as the average number of hours a bird spends in each cell of a 100km by 100km grid. This is colour coded from dark green, representing a low number of hours, to red, representing a high number of hours. The fishing effort overlap map shows the sum total of daily fishing hours in a 100 km x 100 km grid cell corrected by the corresponding daily bird occurrence (bird hours) in that cell. These are similarly coded from green (low overlap) to red (high overlap), with the remainder of the bird distribution being indicated by semi-transparent green shade.

The result charts generally provide summed totals, or percentage of total, of average bird hours or overlap hours. This provides a quantitative comparison of bird distribution or overlap across areas, or quantification of overlap by vessel attribute (such as flag state).

Results

This paper represents work in progress. To date, overlap only with pelagic longline fishing effort has been assessed.

Note: at this stage overlap has been calculated with a correction for daily total tag sample size for all birds. We have produced maps and charts that separate age/sex classes, but the relative overlap between these classes will be influenced by the changing relative tag sample size between these cohorts over the year. Results should be viewed as indicatively only at this stage.

Note: The tag sampling was biased numerically towards adult females, resulting in a low sample size of adult males tagged. Many of these devices also failed early, with only one tag transmitting until December 2019. Male occurrence has been included in Figures C1 and M4 for information, but are not considered further due to the low sample size.

We highlight key initial findings to date and areas of ongoing investigation.

Key initial findings to date in relation to pelagic longline fishing overlap:

- While all birds spent a high proportion of time in the New Zealand EEZ, there was much greater bird overlap with pelagic longline fishing activity on the high seas compared to EEZs (Figures M2, C1, C2).
- Females and juveniles spent more time in the WCPFC high seas area, particularly the eastern WCPFC (Figures M3, M4, C1).

- Overlap with pelagic longline fishing activity occurred in only two EEZs, New Zealand and Australia (Figures M2,C2).
- Both adults and juveniles had overlap with pelagic longline fishing activity (Figures M3, C3).
- Overlap with pelagic longline fishing activity in more northern areas, particularly in the 25-30°S zone, was mainly with juveniles (Figure M3).
- Amongst adult females non-breeding females had particularly high overlap with pelagic longline fishing effort (Figures M5, C3).
- For adult females the area of highest overlap with pelagic longline fishing activity was in the high seas area of the WCPFC to the east of New Zealand, followed by the area to the west (Figures M4, C4).
- Juveniles had more overlap with pelagic longline fishing effort than adult females, particularly in the high seas of the WCPFC area, with slightly higher overlap west of New Zealand (Figures M3, C3, C4).
- Male and female juveniles had similar patterns of overlap with pelagic longline fishing activity (Figure M6).
- Most overlap with pelagic longline fishing effort occured in May-September, with particularly high overlap in May (Figure C5).
- Overlap with pelagic longline fishing effort in the eastern WCPFC area was mostly during May-June, overlap in the western WCPFC was more even dispersed between May-August, and most overlap in the IATTC area occurred in September (Figure C6).
- One hundred vessels were identified with pelagic longline fishing effort overlap, the highest number flagged to Chinese Taipei, followed by Japan, Vanuatu and China (Figure C7).
- When grouped by flag state, vessels flagged to Chinese Taipei had the most pelagic longline fishing effort overlap, followed by Vanuatu, Spain, New Zealand and China (Figure C8).
- Juvenile overlap with pelagic longline fishing effort was across all flag states identified with highest overlap for Chinese Taipei, while female overlap was predominantly with vessels flagged to Chinese Taipei, Vanuatu and Spain (Figure C9).

Areas of ongoing investigation:

- Calculate overlap with pelagic longline fisheries separately for females and juveniles for improved comparability.
- Investigate further the influence of varying tag sample sizes between age/sex classes.
- Test the effect of conducting overlap analyses at different spatial scales.
- Investigate overlap with pelagic longline fishing effort by port used (to be assessed for all birds all birds, adult females and juveniles).
- Investigate overlap with pelagic longline fishing effort by operator/company (to be assessed for all birds, adult females and juveniles).
- Investigate overlap with other fishing methods (trawl and demersal longline; see Figure M7 for comparative historic fishing effort data).
- Compare Global Fishing Watch derived fishing effort with other data sources (e.g. New Zealand commercial records and RFMO data).
- Investigate the relative utility of the different tags used in this study to inform fishing effort overlap assessments.

RESULTS - DISTRIBTION MAPS

Input datasets

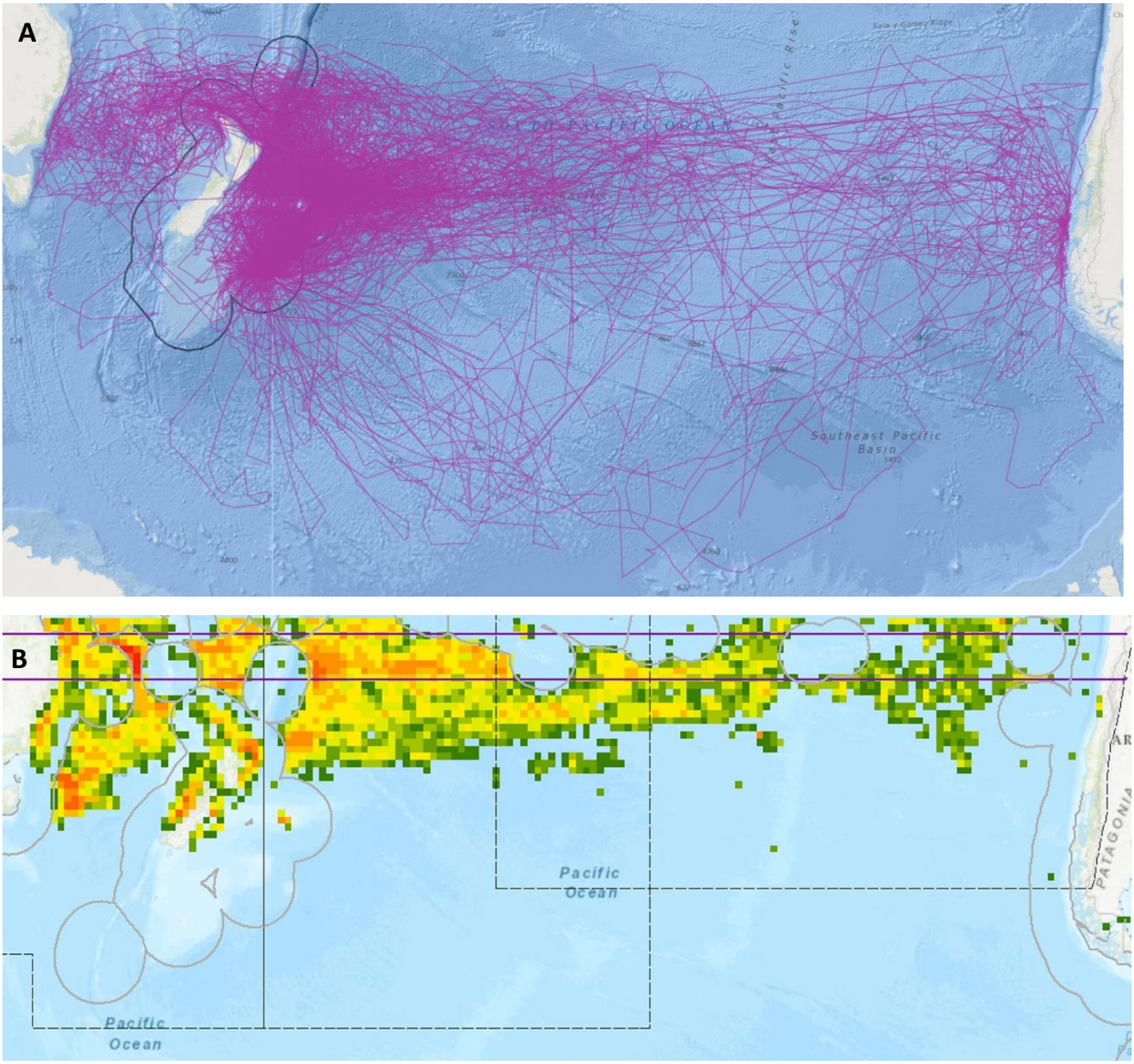

Figure M1. Tracks from all birds (A) and cumulative pelagic longline fishing effort (B) by per 100km x 100km grid. Dashed lines indicate RFMO boundaries and purple lines represent 25°S and 30°S latitude.

All birds

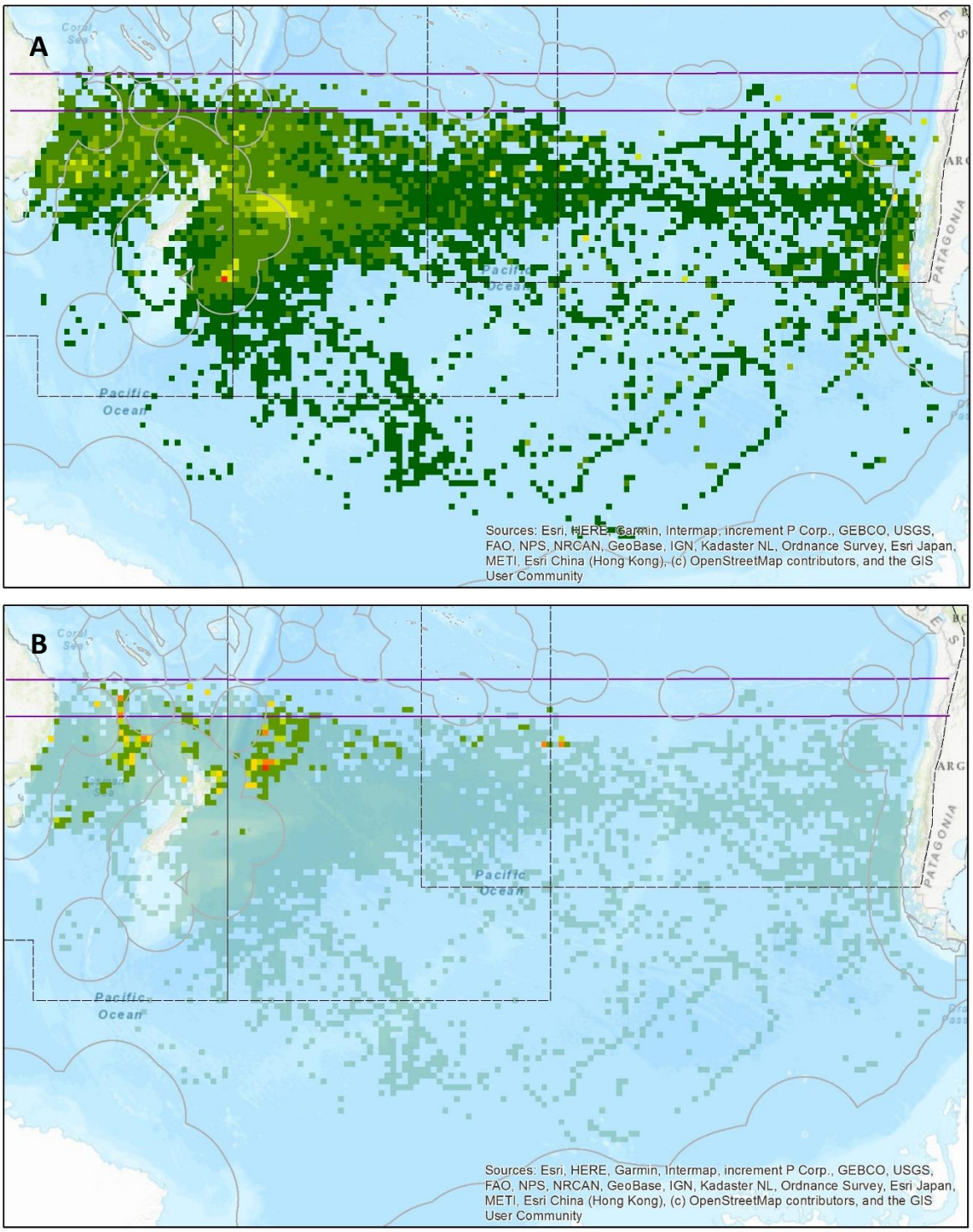

Figure M2. Year-round spatial distribution of all tracked birds (A; average number of bird hours per 100km x 100km grid cell) and corresponding overlap with pelagic longline fishing effort (B). Dashed lines indicate RFMO boundaries and purple lines represent 25°S and 30°S latitude.

Adults

Juveniles

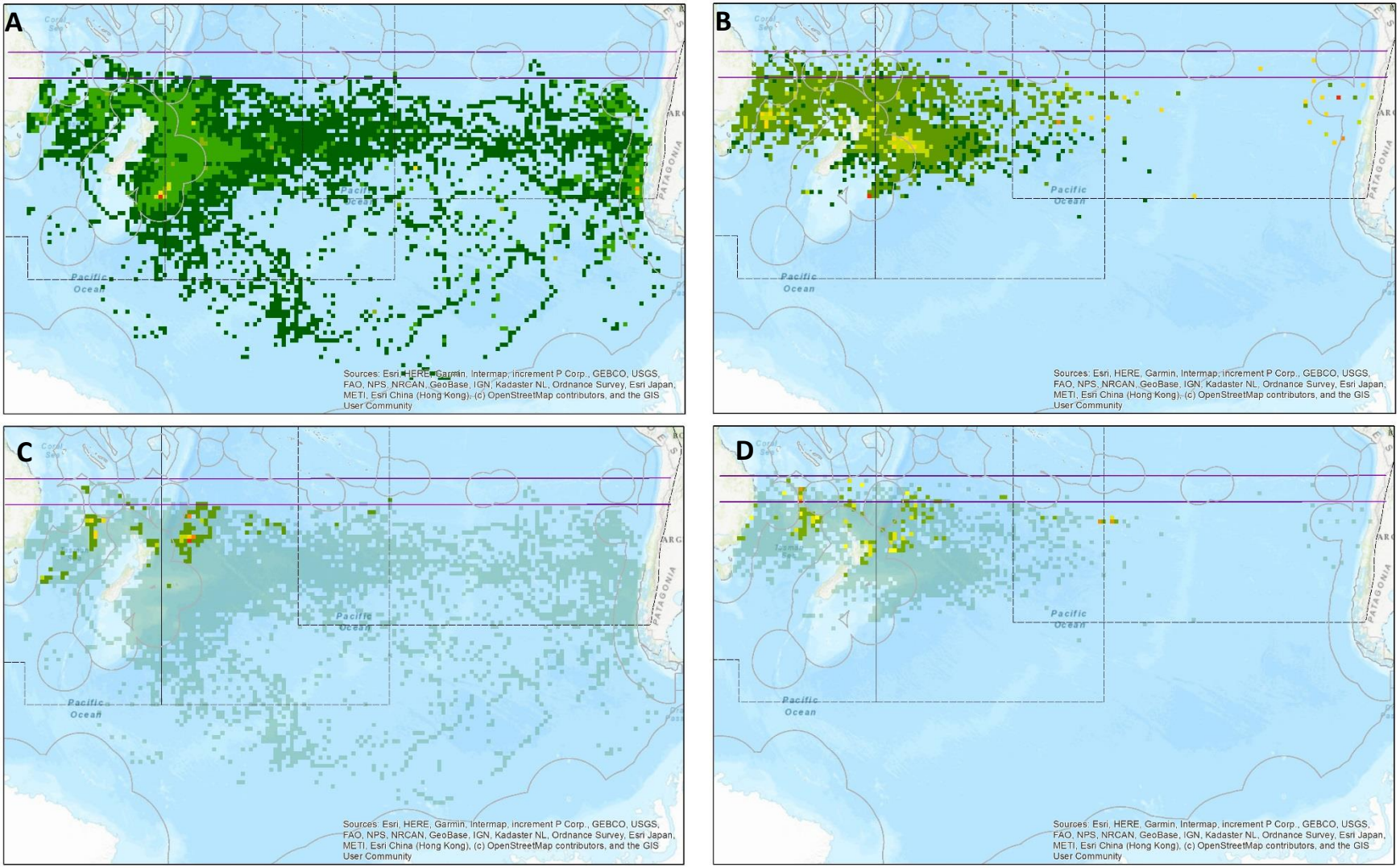

Figure M3. Year-round spatial distribution of all adult (A) and juvenile birds (B) in average number of bird hours per 100km x 100km grid cell and corresponding overlap with pelagic longline fishing effort (C, D). Dashed lines indicate RFMO boundaries and purple lines represent 25°S and 30°S latitude. Note: overlap has not been corrected for sample size separately for each cohort at this stage.

Adult males

Adult females

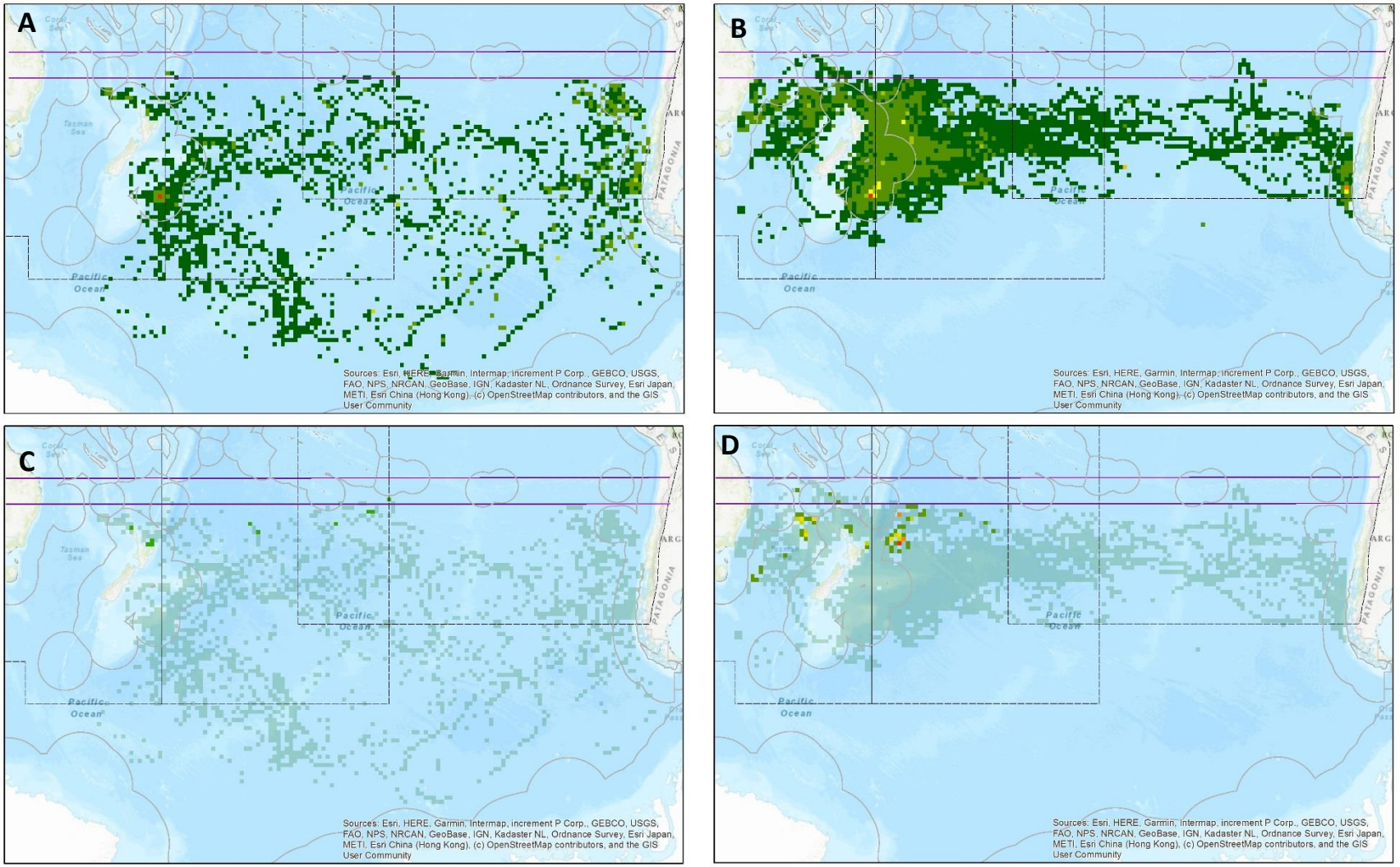

Figure M4. Year-round spatial distribution of adult male (A) and adult female birds (B) in average number of bird hours per 100km x 100km grid cell and corresponding overlap with pelagic longline fishing effort (C, D). Dashed lines indicate RFMO boundaries and purple lines represent 25°S and 30°S latitude. Note: overlap has not been corrected for sample size separately for each cohort at this stage.

Breeding female | Failed breeding female | Non-breeding female

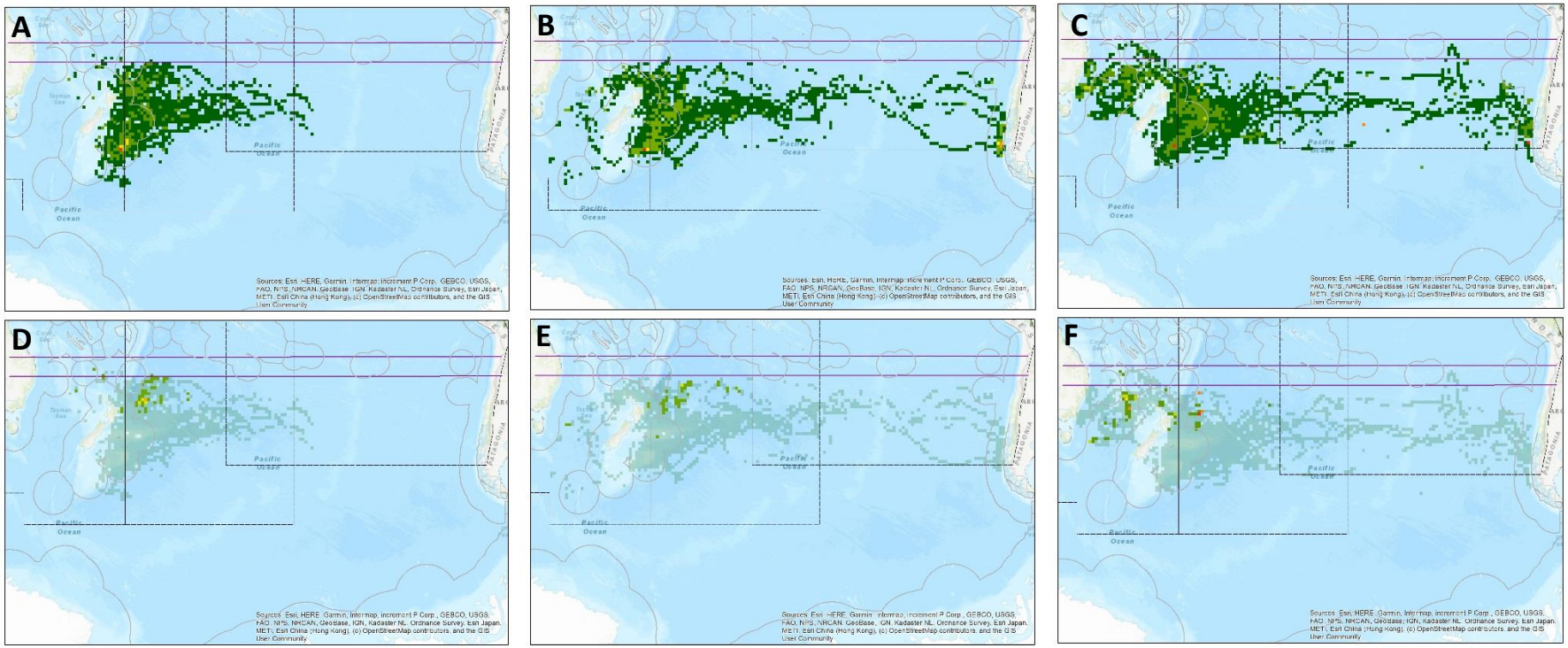

Figure M5. Year-round spatial distribution of breeding females (A), failed breeding females (B) and non-breeding females (C) in average number of bird hours per 100km x 100km grid cell and corresponding overlap with pelagic longline fishing effort (D, E, F). Dashed lines indicate RFMO boundaries and purple lines represent 25°S and 30°S latitude. Note: overlap has not been corrected for sample size separately for each cohort at this stage.

Juvenile females

Juvenile males

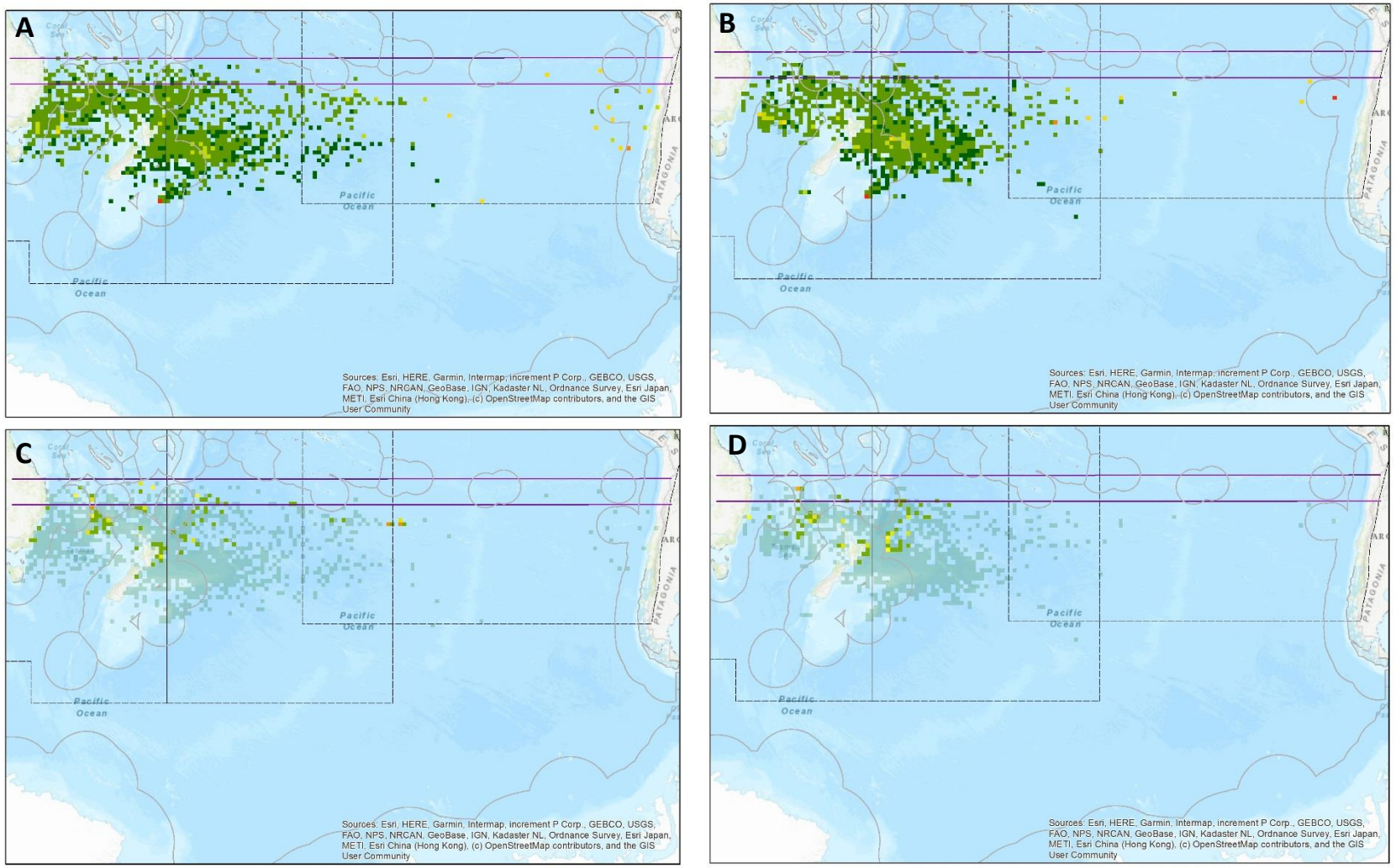

Figure M6. Year-round spatial distribution of juvenile females (A) and juvenile males (B) in average number of bird hours per 100km x 100km grid cell and corresponding overlap with pelagic longline fishing effort (C, D). Dashed lines indicate RFMO boundaries and purple lines represent 25°S and 30°S latitude. Note: overlap has not been corrected for sample size separately for each cohort at this stage.

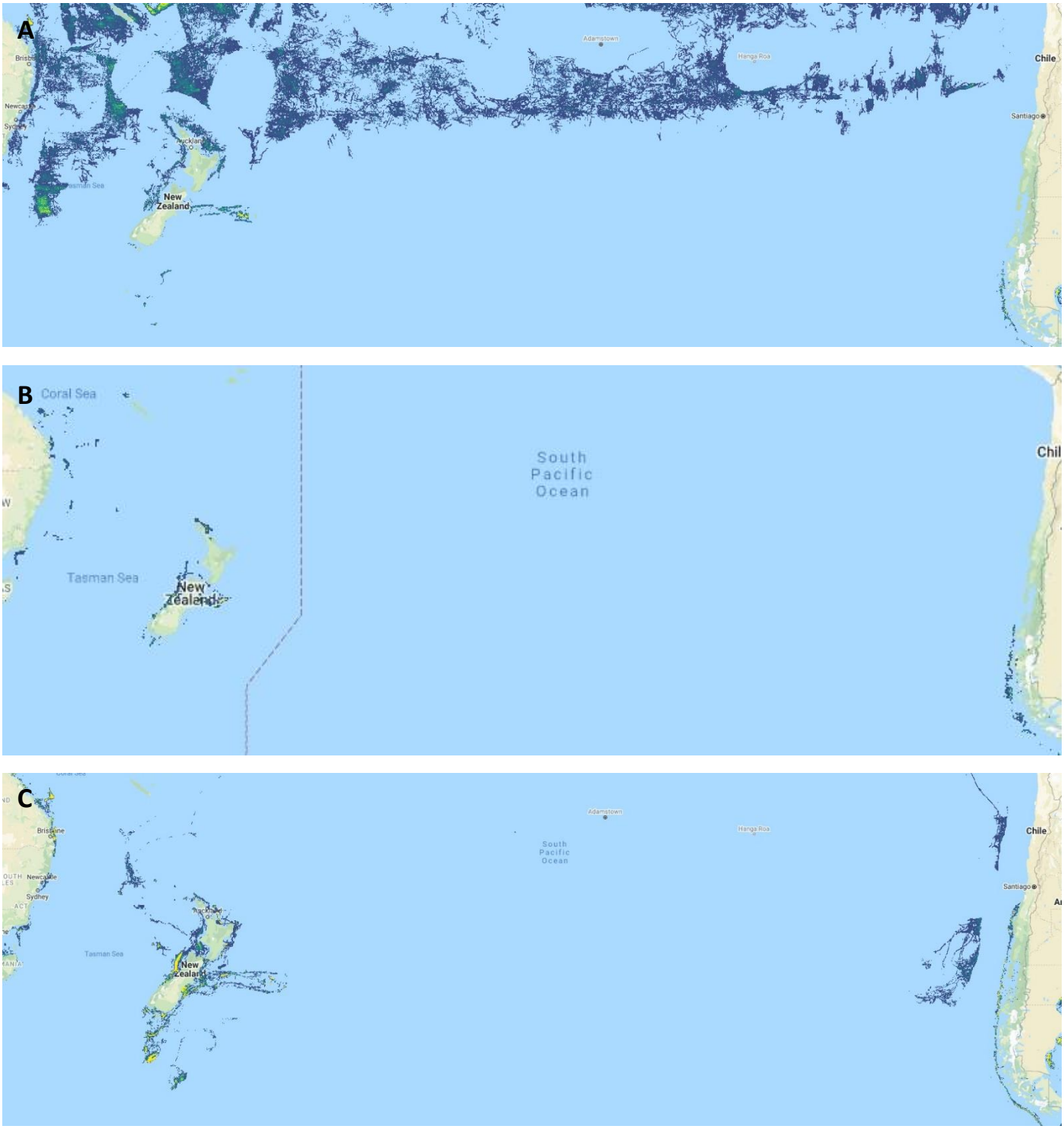

Figure M7. Comparative plots of pelagic longline (A), demersal longline (B) and trawl (C) in 2016 based on publicly available Global Fishing Watch data.

RESULTS - CHARTS

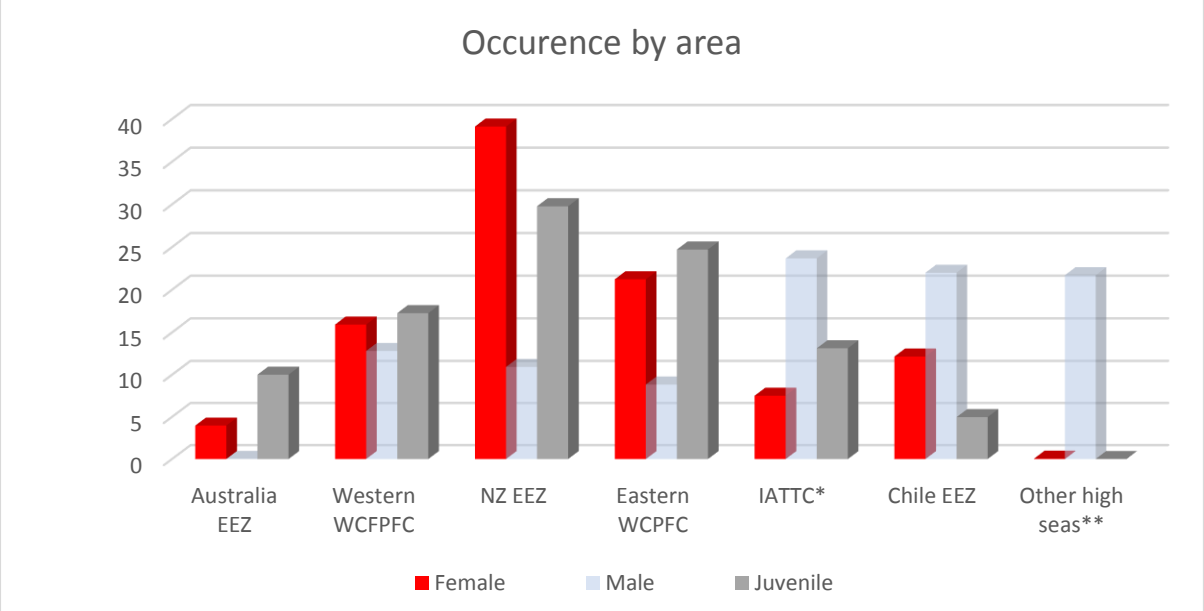

Figure C1. Distribution of bird occurrence (% total bird hours) by Jurisdiction, for adult females, adult males and juveniles. Note there was a small year-round sample size for males. RFMO areas are for high seas only. *Includes overlap area with WCPFC. **Areas south of WCPFC and IATTC.

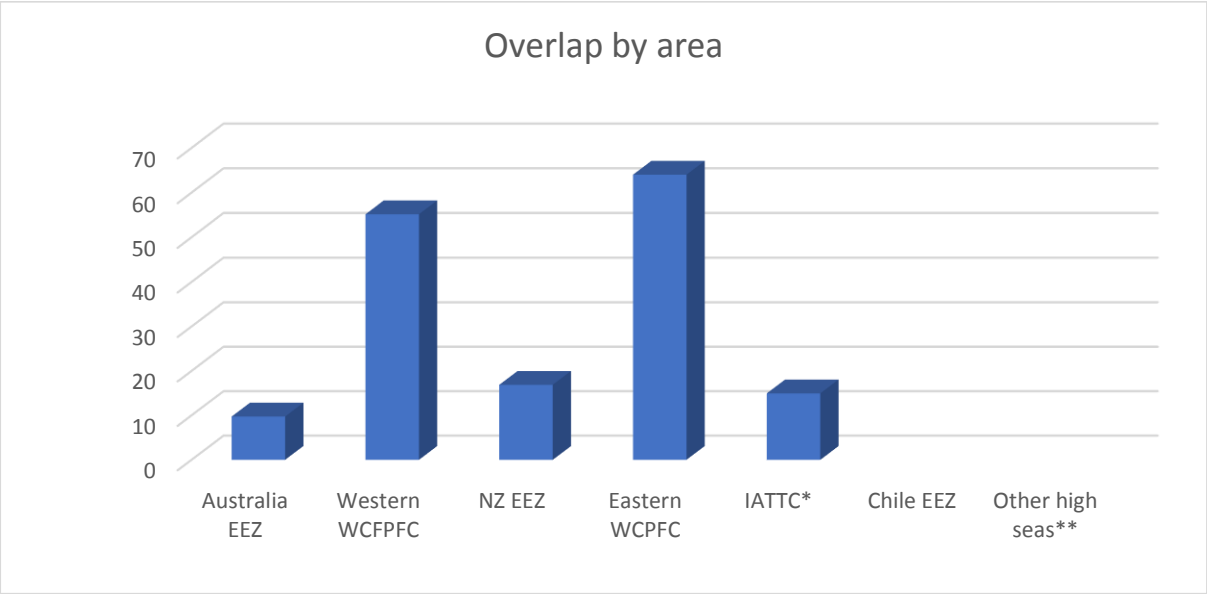

Figure C2. Distribution of pelagic longline fishing effort overlap by Jurisdiction. Overlap is the sum total of daily fishing hours in a 100 km x 100 km grid cell corrected by the corresponding daily bird occurrence (bird hours) in that cell. RFMO areas are for high seas only. *Includes overlap area with WCPFC. **Areas south of WCPFC and IATTC.

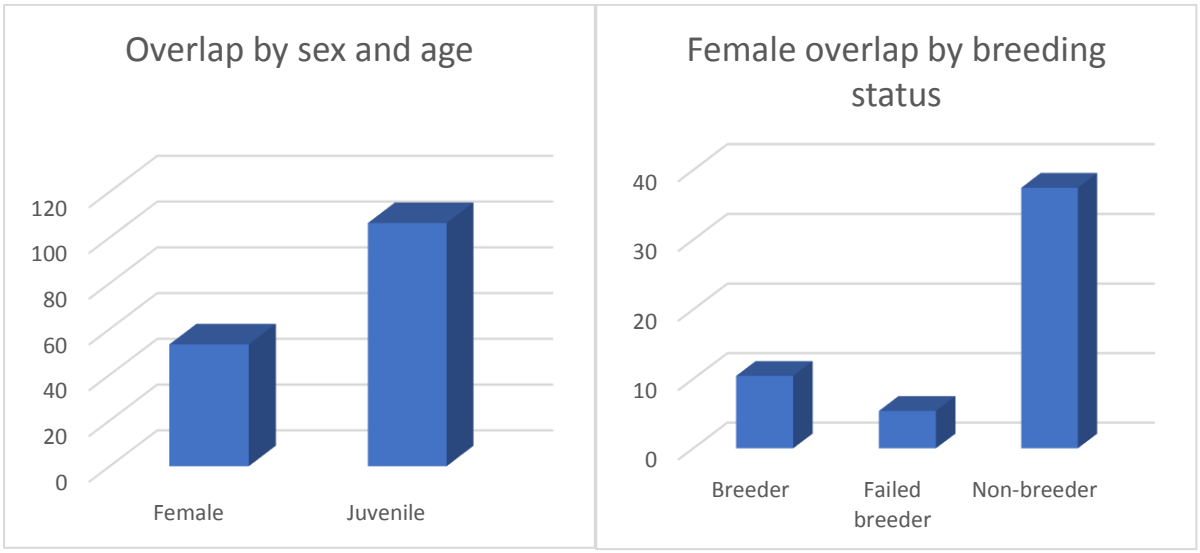

Figure C3. Distribution of pelagic longline fishing effort overlap for adult females and juveniles, and by breeding status for adult females. Overlap is the sum total of daily fishing hours in a 100 km x 100 km grid cell corrected by the corresponding daily bird occurrence (bird hours) in that cell. Note: overlap has not been corrected for sample size separately for each cohort at this stage.

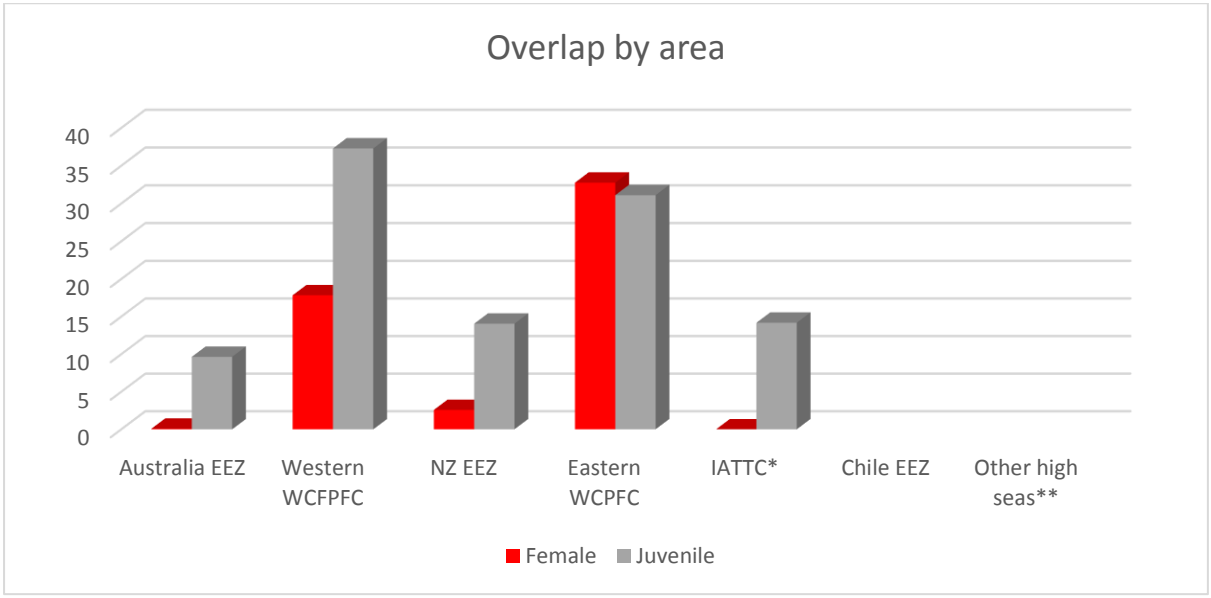

Figure C4. Distribution of pelagic longline fishing effort overlap by Jurisdiction, for adult females and juveniles. Overlap is the sum total of daily fishing hours in a 100 km x 100 km grid cell corrected by the corresponding daily bird occurrence (bird hours) in that cell. *Includes overlap area with WCPFC. **Areas south of WCPFC and IATTC. Note: overlap has not been corrected for sample size separately for each cohort at this stage.

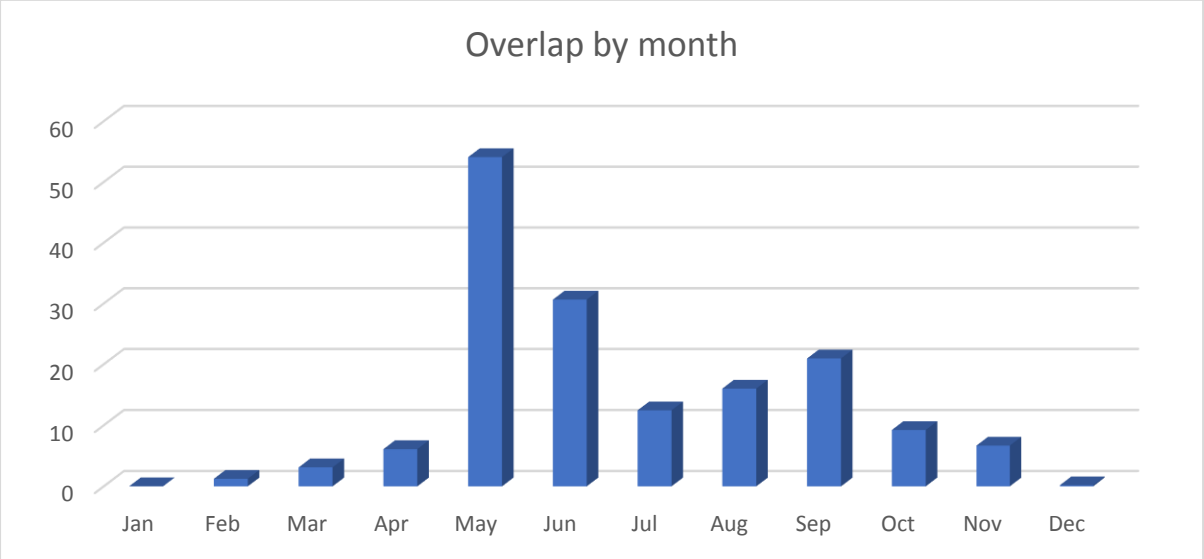

Figure C5. Monthly pelagic longline fishing effort overlap. Overlap is the sum total of daily fishing hours in a 100 km x 100 km grid cell corrected by the corresponding daily bird occurrence (bird hours) in that cell.

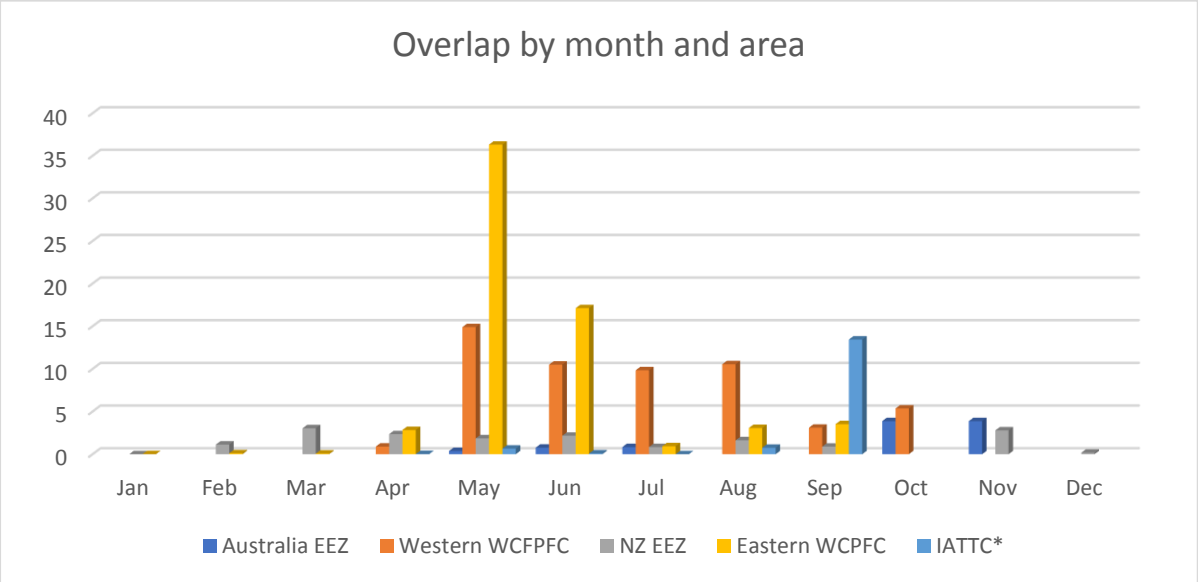

Figure C6. Monthly pelagic longline fishing effort overlap. Overlap is the sum total of daily fishing hours in a 100 km x 100 km grid cell corrected by the corresponding daily bird occurrence (bird hours) in that cell. *Includes overlap area with WCPFC.

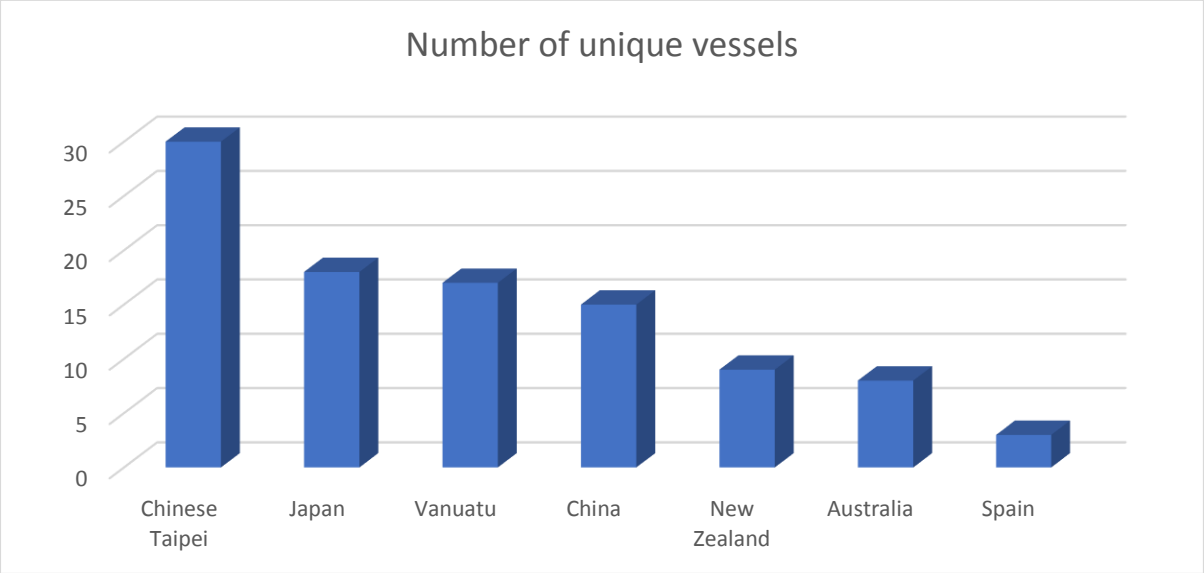

Figure C7. Number of unique vessels identified with pelagic longline fishing effort overlap, by flag state.

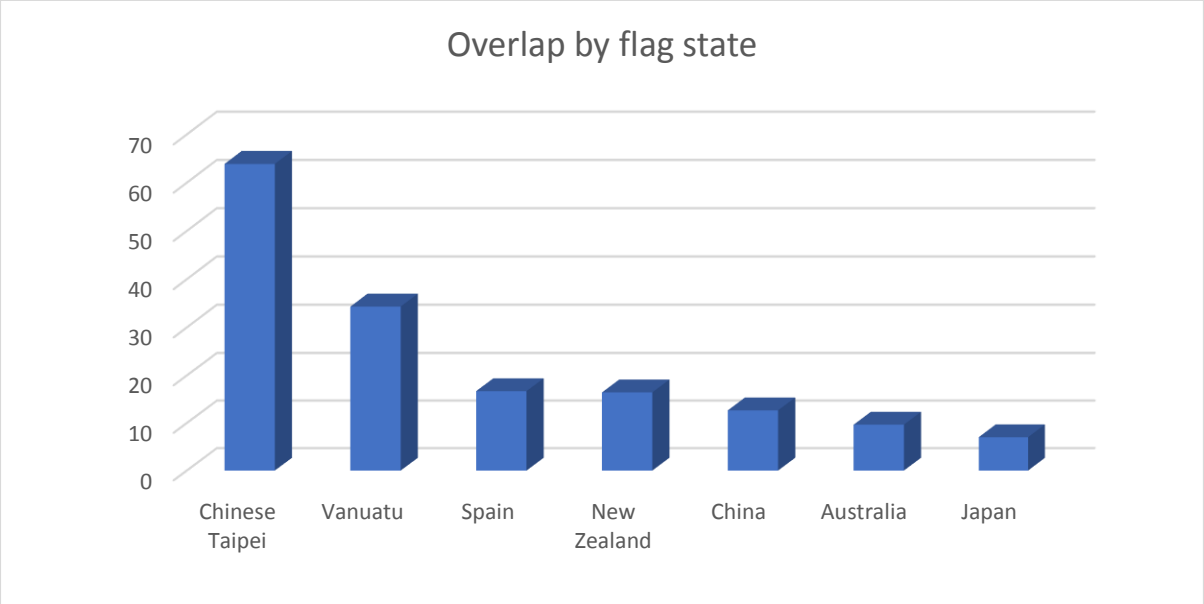

Figure C8. Pelagic longline fishing effort overlap by flag state. Overlap is the sum total of daily fishing hours in a 100 km x 100 km grid cell corrected by the corresponding daily bird occurrence (bird hours) in that cell.

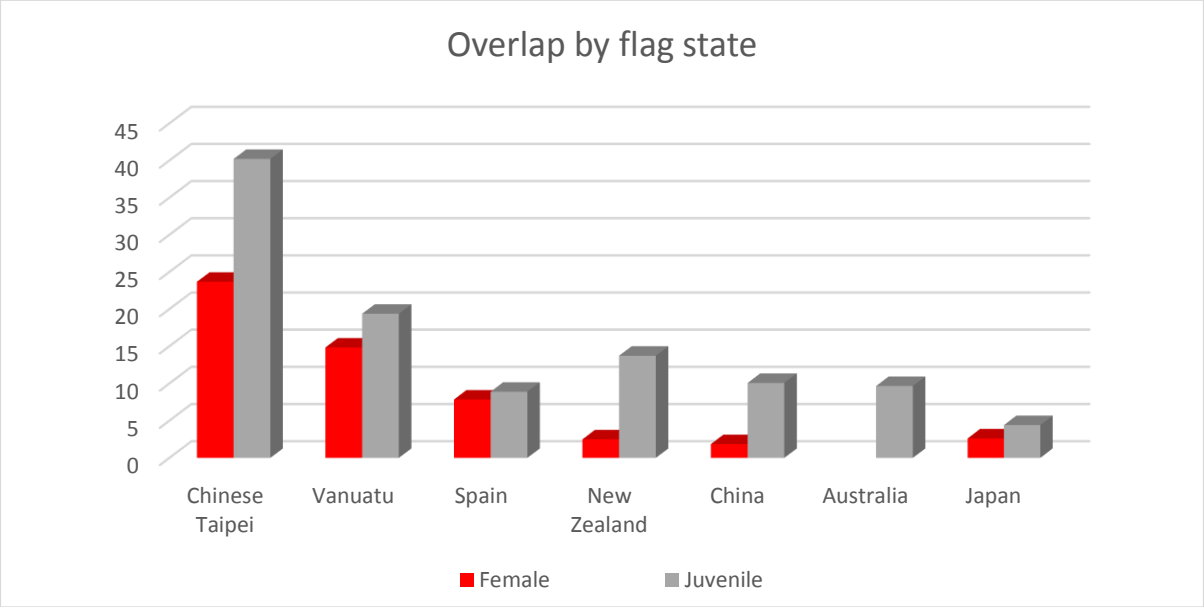

Figure C9. Pelagic longline fishing effort overlap by flag state, for adult females and juveniles. Overlap is the sum total of daily fishing hours in a 100 km x 100 km grid cell corrected by the corresponding daily bird occurrence (bird hours) in that cell. Note: overlap has not been corrected for sample size separately for each cohort at this stage.

Acknowledgements

Field research to deploy tracking devices was funded by DOC and undertaken by Kath Walker and Graeme Elliott using methods approved by the DOC Animal Ethics Committee (AEC 338). Satellite tracking tags were jointly funded by DOC and Fisheries New Zealand, and we particularly acknowledge William Gibson for development of the tracking app. We are also very grateful to the support provided by Global Fishing Watch in facilitating access to relevant fishing activity data.

References

Elliott, G.; Walker, K. 2020. Antipodean wandering albatross: satellite tracking and population study Antipodes Island 2020. Department of Conservation Research Report.

Appendix 1. Methods.

Data used

Data on Antipodean albatross distribution was from the deployment of a range of satellite tracking devices on Antipodean albatross in Jan-Feb 2019, as described by Elliott & Walker (2020). The grooming process used is described in stage 2 below. The satellite transmitters provided location details at a range of frequencies and accuracies, with the most precise providing up 28 GPS fixes per day.

Daily fishing effort data for South Pacific was obtained from Global Fishing Watch (GFW) as csv files in two resolutions. The first dataset included fishing effort and vessel presence by flag state and gear type at 100th degree resolution and was used for estimating fishing effort and overlap. The second dataset included fishing effort data at 10th degree resolution by MMSI and was used to identify unique vessels fishing in the South Pacific.

Antipodean albatross may fly more than 100kms in an hour, so, given the frequency of bird positions obtained, a minimum appropriate spatial resolution of 100km x 100km grid was used. Any grid size greater or equal to 0.01 degrees, used in the GFW data extract, could be used to match the resolution of bird data obtained. Point-based overlap was not possible as the GFW extract used comprised binned, rather than point, fisheries data.

Process to quantify fishing effort overlap

1. **Mapping fishing hours from GFW data extract**
   - Fishing hour data for each day was acquired from GFW in csv format and were converted to point shape file.
   - A 100km x 100km fishnet grid was created and fishing hours for a day within a grid were summed to assign value (total fishing hours) to the grids
   - Daily grids were then converted to raster layers and used for the overlap analysis
   - The daily fishing hour raster layers were stacked and the fishing hours for each 100km x 100km cell was summed across the dates to obtain the cumulative fishing hours in each cell to highlight the fishing hotspots.

2. **Mapping bird hours from tracking data**
   - Bird location data consisted of both GPS fixes and PTT locations derived by ARGOS. Any PTT-derived location with ARGOS accuracy 0, A, B, and Z were discarded from the data set. In addition, consecutive bird locations that were too far apart (i.e. having required over 50m/s of sustained flight speed to traverse) were also discarded.
   - The time difference between two clean consecutive locations for each bird were first calculated. If a GPS accuracy location was followed by ARGOS location and had time difference lesser than the frequency of acquisition of GPS fixes of the tag (every 6 hours for Pinpoint tag and every hour for Rainier and Sextant tags) then the Argos location was discarded to avoid introduction of noise in GPS accuracy data. ARGOS locations for GPS tags the dataset were only considered when there were missing GPS fixes.
   - Time difference between the retained consecutive locations were then recalculated. The time difference was halved and the final time (hence forth birdhour) against each location was derived as the sum of half the time of time difference between the preceding location and half the time difference with the successive location.

- The derived birdhour was divided by the number of birds actively tracked (i.e. with working tags) on that day to correct for difference in sample size (progressively smaller) over time.
- The final bird location data (including birdhour data) was then added to the map as a spatial layer and birdhour was summed for each 100km x 100km grid cell to identify the amount of time spent by birds in a grid over the time period.

3. Deriving the cumulative fishing hour overlap for each grid cell

- The final bird location dataset was overlaid on daily fishing hour raster layers and value of grid cell (hours of fishing in that cell for a day) was extracted for each bird location matched by the date.
- The total fishing hour extracted against a location was divided by 24 to give an estimate of hourly fishing effort for the location and then multiplied by the birdhour for that cell on that day to give the estimate of overlap of the bird with fishing effort at that location.
- The derived overlap value for each cell was then summed over the 100km x 100km grid to represent the cumulative overlap with fishing effort.