# Preliminary estimates of seabird bycatch from tuna longline fisheries for the southern Atlantic and southwestern Indian Oceans, based on three different methods

Winker, H[1], Sant'Ana, R[2]. Kerwath, S.[1], Parker, D.[1], Rice, J.[3], Sharma, R.[4], Kim, D.N.[5], Lee, S.I.[5].

*SUMMARY*

*Population declines of many seabirds, including albatross and petrels, are caused by a range of impacts, notably environmental change and fisheries bycatch. Despite the scale and importance of longline fishing in the southern hemisphere, the impact of this type of fishery on seabird populations is poorly understood. To date, there has been no broad scale fleet-specific assessment of seabird bycatch throughout the southern hemisphere, mainly due to the spatial and temporal limitations in observer data coverage. Here we use three approaches to estimate total bird bycatch across the southern Atlantic and southwestern Indian Oceans: (1) a simple, stratified, ratio based estimator, (2) generalised additive models (GAMs) and (3) the computationally intensive Integrated Nested Laplace Algorithms (INLA). To estimate the total birds captured (N), stratified estimates of Bird catch Per Unit of Effort (BPUE) were multiplied with the total reported pelagic longline effort . A comparison of preliminary estimates of N based on a common data set is presented to illustrate the various methods.*

*KEYWORDS*

*Seabirds, INLA, GAM, BPUE, bycatch, longline, southern ocean*

[1] Department of Agricultur, Forestry and Fisheries (DAFF), Fisheries Branch, Cape Town, South Africa
[2] Universidade do Vale do Itajaí / Projeto Albatroz, Brazil
[3] Rice Marine Analytic Consulting
[4] NOAA Fisheries, Portland, OR, USA
[5] National Institute of Fisheries Science, Distant Water Fisheries Resources Division, Republic of Korea

## Introduction

Many seabird populations are vulnerable to bycatch mortality from commercial longline fishing due to their long life span, low fecundity and low natural mortality. Due to the threat posed by large scale fishing operations, seabird bycatch mitigation measures have been a requirement for longline vessels operating in the southern hemisphere south of 25°S. Regional Fisheries Management Organizations (RFMOs) have made various resolutions and recommendations to mitigate the potential impacts of the tuna and tuna-like fisheries on seabird populations. Specific conservation and management measures (CMMs) were adopted in July 2013, south of 25°S in the ICCAT convention area and from July 2014, south of 25°S in the IOTC convention area. These CMMs require the adoption of two of the following three mitigation measures, use of bird scaring lines (Tori Lines), night setting, and branch-line weighting (ICCAT Rec11-09, IOTC Res12/06), noting that the recommendations for branch-line weighting have changed over time.

Altough these measures have now been in place for a number of years no recent, large scale assessment of seabird bycatch has been attempted. Such an assessment is highly complex due to the paucity of reliable observer data, difficulties arising from variability in fishing methods, fleet characteristics, inconsistent reporting and because of challenges with respect to adequately accounting for the spatiotemporal variability in seabird presence and fishing effort. These factors need to be accounted for to estimate a standardised BPUE.

This report examines potential approaches for analysis of a large observer dataset that contains information on seabird bycatch, which was created through collaboration between Brazil, South Africa and the Republic of Korea. The combined dataset, spanning the southern Atlantic and Indian Oceans, was used in combination with environmental and biological data to develop multiple estimates of seabird bycatch. Specifically three different principal approaches were employed and outcomes compared (1) a simple, statrified ratio-based estimator, (2) an approach based on generalized additive modelling (GAM), where environmental, temporal, spatial and fisheries-dependent factorswere included as covariates and (3) Integrated Nested Laplace Algorithms (INLA) which are hierarchical Bayesian spatiotemporal models.

## Materials and Methods

### Data

Data were available at longline set level and spanned the years 1997-2015. The following were data fields common to all datasets:

**Set Date:** Set date, including day, month and year were available for each of the set locations

**Set ID:** An individual identifier for each set was available

**Observer Trip ID**: A unique trip identification code

**Flag ID:** A categorical variable based on the nationality of the vessel (Table 1), noting that some Japanese charter vessels operating within South African waters accrue their observer data to South Africa

**Vessel ID**: A unique identification number (or code) for each vessel

**Hooks set:** The total number of hooks per set

**Bird scaring lines:** The number of bird scaring (streamer) lines deployed per set

**Latitude:** The latitude of the start of the set

**Longitude**: The longitude of the start of the set

**Proportion in daylight**: The proportion of the set in daylight was calculated using the set location and the 'suncalc' package in R (https://cran.rproject.org/web/packages/suncalc/suncalc.pdf)

**Moonphase:** The moonphase based on the set date was calculated via the 'suncalc' package in R

**Birds caught**: The number of observed birds caught. South African data had some information on this element

**Set duration:** The length of time from start to end of set

**Depth:** This information was extracted from the National Oceanic and Atmospheric Administration (NOAA) website

**Depth (SD):** Standard Deviation of Depth, calculated from NOAA depth data to infer changes in seafloor relief that is commonly aassociated with an increase in biological activity (i.e. shelf edge, seamounts, ocean ridges)

**Breeding season**: A categorical variable for non-breeding (October-April) and breeding seasons (May-September) based on the month of the set date

The resulting data set contained approximately 13,000 spatially explicit records bounded by -50°W, -20 °S, -60°S, and 50°E (Figure 1). Initial examination of the raw data showed high average BPUE clustered around the area off the coast of Brazil and South Africa (Figure 2).

The proportion of sets completed during daylight hours (defined as between nautical dawn and nautical dusk) was determined based on the start and end time of the set and the vessel location. This proportion of sets showed a bimodal trend (Figure 4) with peaks at zero (indicating night setting) and a decline towards one (daytime setting). Of all the sets, 57% showed night setting only, 32% showed less than half the set was set during daylight (but not fully night), and 9% were sets that occurred completely during daylight hours.

The observed sets showed a bimodal distribution throughout the year, with a peak of observed sets at the end of the breeding season towards the beginning of the non-breeding season, and another during the middle of the breeding season (Figure 5). The median size of the set, measured in hooks per set, was slightly larger during the non-breeding season (Figure 6), with the overall range being greater during the end of breeding season (April) and the non-breeding season. Sets were nearly evenly spaced throughout the month by moon phase (Figure 7).

For modelling purposes, the dataset was confined to consider sets that fell between 2 and 8 hours of duration and at least 500 hooks per set, under the assumption that any sets outside those ranges were failed or non-standard sets.

## Analyses

Geospatial modelling can take many forms, from including location in generalised linear/additive models (GLMs/GAMs) to more advanced models such as Integrated Nested Laplace Algorithms (INLA), and Vector Autoregressive Spatio-Temporal (VAST) models. These methods estimate density in areas with little data, taking into account (to the extent possible) the operational factors relating to the fishing technique, the species distribution and the distribution of fishing that occurs in each area, and the spatial auto-correlation between these processes. The more advanced, techniques allow for the estimation of spatio-temporal variation in density, and can be used to predict range shifts over time and account for other covariates i.e. non-random selection of fishing locations. These methods estimate BPUE in space and time that is unbiased with respect to the other model covariates. To estimate the total number of birds caught in the area considered per year (N), the total pelagic longline fishing effort is incorporated into the modelling framework.

Many different methods have previously been applied to estimate total seabird bycatch from fishing activity (Lewison and Crowder, 2003; Benjamins et al., 2008; Jiménez et al., 2010). In general, most of these studies used data collected by observers on individual fishing operations. The data are then scaled up from observed catch to total catch. This approach estimates seabird bycatch via a bycatch rate for individual strata, usually area/time/fishery (or fleet) and is termed stratified ratio-based estimator. To estimate the total bycatch for broad area/time strata such as a RFMO convention area, a second step is required to extrapolate bycatch estimates to all substrata of interest, by multiplying the stratified BPUE estimate by the effort in that strata, and then to aggregate all of the results.

## Stratified Ratio Based Estimator for Seabird Bycatch

Ratio based estimators were generated for 5° by 5° cells south of 20°S, between the eastern coast of South America and the eastern coast of South Africa (extended to western Indian Ocean area as previously defined). Estimates had to be extrapolated for the majority of strata (90%) and hence the results of this method are conditioned on the available data. Stratifying the dataset by time (year-quarter) and area resulted in many empty cells and was found to provide too coarse coverage of strata. Essentially, assumptions on time-invariant catch rates are used to generate these estimates, with either a grand mean for strata with no coverage/or use of nearest neighbour.

Three datasets (Brazil, Republic of Korea and South Africa including Japanese flagged joint-venture vessels), were combined for the years 2012-2015 to estimate bycatch rates by fleet and area and expanded to effort in the strata where these data existed. Data were pooled across years to estimate BPUE according to breeding season or non-breeding season. Estimates of overall observed strata and catches are shown in Figures 8-15 for 2012, 2013, 2014 and 2015. The points in the lower panel indicate where the sampling occured for that year and where effort occurred. Catch estimates using all BPUE data observed in all strata were estimated as shown below. Different fleets were used to estimate these bycatch rates, total seabird bycatch estimates shown in Table 1. The basic estimator is shown in equation 1:

$$\hat{C}_{s,t} = \overline{BPUE}_{s,t} E_{s,t} \tag{1}$$

where *s* is strata (5° by 5° cell and season), *t* denotes the year, *C* is the number of estimated bycatch of seabirds across all species, BPUE is the bird bycatch per unit effort (1000 hooks), and *E* is the effort (1000 hooks).

Estimates appear to be increasing from 2012 to 2013 when multiple tRFMOs were instituting CMMs. Between 2013 and 2015 there is a decline in bycatch rates, but this is statistically not significant, as indicated in Figure 16. Species-specific rates are difficult to estimate but if some known proportion of mortalities can be estimated by time and area, this can also be enumerated using eq. 2:

$$\hat{C}_{SP,s,t} = P_{SPP,s,t} \overline{BPUE}_{s,t} E_{s,t} \tag{2}$$

Where *SP* indicates species and *P* is the proportion of catch by species in strata *s* and time *t*. Data at that level of resolution remain unavailable at this time.

## Generalised Additive Models (GAMs)

GAMs provide a flexible tool for estimating catch per unit of effort in space and time. Often the objective of the modelling is to identify whether there is evidence for a space-time interaction in abundance, which may suggest local aggregation (hotspots) or strong seasonal variability. The combined dataset was fitted with a GAM to produce spatio-temporal estimates of the BPUE in the southern Atlantic and western Indian oceans. Multiple models were explored. The model presented here assumes that BPUE follows a Tweedie distribution, which provides a efficient means to account for high proportion of zeros in the data. The functional relationships between BPUE and environmental variables are likely to be non-linear (Bigelow et al., 1999). The GAM for the BPUE standardisation therefore included splines (*s*) and was specified as:

*BPUE = s(Depth) +s(sd.Depth) +s(Moonphase)+s(Proportion Daylight)+Season+ s(Latitude:Seanson)+ Flag +* $\varepsilon$ *(3*)

where the *s* denotes splines, the ":" denotes interactions and ε errors distributed according to the Tweedie distribution. The partial effect plots (the effect of each of the factors individually) are shown in Figure 17. To calculate the total seabird bycatch, a multi-dimensional prediction matrix was constructed to predict BPUE on a 5°×5° resolution disaggregated by season, fleet and different moon-phases. *Proportion Daylight* was set to fleet-specific averages. These predicted BPUE surfaces are then multiplied by the fleet-specific reported effort, after aggregating the mean BPUE to 10°x 10° resolution. Reported effort for fleets that were not represented by available observer data were assigned to preliminary clusters. For example, stratified Taiwanese (province of China) longline effort was multiplied by the mean BPUE predicted for Japan and Korea. Estimates from the GAM model are shown in Table 2 and indicate decreasing catches between the years 2010 and 2015, with values between 11,000 and 17,000 seabirds caught per year.

## Integrated Nested Laplace Algorithms (INLA)

Like many fisheries datasets, seabird bycatch data are characterised by complicated statistical features, such as excess of zeros, nonlinearity, nonconstant variance structure and spatiotemporal correlation. Althouigh INLA has several principles in common with generalized linear models and GAMs, INLA can more adequeatly model datasets with complex spatial structure. The main difference is that instead of representing space as a set of fixed or continuous variables, INLA constructs flexible fields that are able to capture the characteristics of the dataset. In practice, INLA is implented as a hierarchical Bayesian spatiotemporal estimation model.

This analysis presents estimates of total seabird bycatch based on three distinct scenarios for the specification of spatial and temporal interactions. The first scenario consists of estimating the total bycatch for all longline fisheries fleets and assuming a spatial correlation between the years. The second scenario is aimed to estimate the total bycatch for all longline fleets with a spatial correlation between the months. The third scenario is aimed at estimateing the total capture with spatial correlation between seasons.

Each scenario was analysed using INLA models that use a Bayesian framework. INLA implements a basic generalised additive model of the form:

$$\eta_i = \beta_0 + \sum_{m=1}^{M} \beta_m x_m + \sum_{l=1}^{L} f_l(z_{li}) \qquad (4)$$

where $\eta_i$ is the linear predictor structured as an additive function of $\Phi_i$ (usually the mean $E(y_i)$) and this relation is observed by a link function g(.), such that $g(\Phi_i) = \eta_i$. $\beta_0$ is a scalar representing the intercept; βm quantify the (linear) effect of some covariate *x* on the response, and; fi = $\{f_1(.), \ldots, f_L(.)\}$ is a collection of functions defined in terms of a set of covariates $z = (z_1, \ldots, z_L)$. The terms $f_l(.)$ can assume different forms such as smooth and nonlinear effects of covariates, time trends and seasonal effects, random intercept and slopes as well as temporal or spatial random effects (Rue et al., 2009; Blangiardo and Cameletti, 2015; Zuur et al., 2017).

Additionally, the models implemented were structured with spatial dependency through the neighborhoods of first order, in other terms, only the squares immediately neighboring were considered to be a spatial influence to seabird bycatch estimation. This spatial dependency was treated with an Intrinsic Conditional Autoregressive (iCAR) structure. The final model was structured as follows:

$$BPUE = \beta_0 + \sum_{l=1}^{L} f_l(year) + \sum_{m=1}^{M} f_m(month) + \sum_{n=1}^{N} f_n(flag) + \beta_1 daylight + \beta_2 moonphase + f(.)$$

where $\beta_0$ is the intercept, and $\beta_1$ and $\beta_2$ are the linear regression coefficients for the covariates; the functions $f$ represents the sum of smooth functions defining as the random effect of year – with an autoregressive structure with order 1; month – with an autoregressive structure with order 1 and flag – structures with independent random variable. The function f(.) is a semiparametric function defining the spatiotemporal random effect.

In general, BPUE refers to the birds catch by the fishing gear (dead or alive) and year has an autoregressive correlation with order 1, as does month. Flag is included as a random variable without specific structure, daylight and moonphase as a linear numeric regression, and the spatial was structured as an iCAR with correlation between seasons.

## Results

The estimates of seabird bycatch based on the stratified ratio based, GAM, and INLA models are broadly comparable as shown in Tables 1 ,2, and 4, respectively. Comparison of estimates of total seabirds caught are presented in Figure 22 along with a comparison to a reference estimate made based on a direct ratio estimate, assuming 0.2 birds per 1000 hooks.

In general, the majority of the estimates range between 10 000-20 000 birds caught per year in the study area. The exception is the estimates from the stratified ratio-based estimates using the Brazilian observer data and also the INLA based estimates which range from approximately 10 000- 50 000 birds caught per year.

The results from the GAM vary by breeding and non-breeding season. The GAM predicts high (potential) seabird bycatch in the most southern latitudes (breeding areas) during breeding season and high densities between 35° S and 45° S Latitude during the non-breeding season (presumably core foraging areas). This is illustrated in Figure 18. The standardised mean BPUE (5°x5°) and the aggregated mean annual effort in 1000 hooks (10°x10°) are shown in Figure 19. This provides an broad approximation of the overlap between the estimated BPUE and the reported effort – the combination of which forms our estimates of seabird bycatch. The total estimated annual seabird bycatch ranged between 11500 and 17620 birds for 2010-2015 with the mean of 14200. At this point all estimates are considered preliminary and subject to revision.

Three spatial correlations between times were tested a) spatial was structured as an iCAR with correlation between seasons; b) spatial was structured as an iCAR with correlation between months and c) spatial was structured as an iCAR with correlation between years (Table 3). Judging by the Watanabe-Akaike information criterion (WAIC) the best model was the model with model (a) where the spatial correlation was structured as an iCAR with correlation between seasons. All models showed no failures in convergence (i.e. FAIL in Table 3) and in the Conditional Predictive Ordinates (CPO). The CPO is the probability of an observed response based on the model to fit to the rest of data. In general, it is important to see low values in this metric. The final step in the analysis is to conduct the prediction and estimation of total seabird bycatch. This step was completed by predicting the total bycatch based on the predicted BPUE and reported effort obtain the total estimates of birds caught on an annual basis (Table 4).

## Conclusions

This paper considered multiple analytical approaches for producing estimates of seabird bycatch (including live releases) for all birds caught in the study area. This is a initial step towards developing and comparing methods for seabird bycatch estimation on a global scale. Although this work should be regarded as preliminary, the relatively small range of estimates produced by the different methods is encouraging. More work needs to be done to estimate uncertainty, align the different assumptions among the methods, standardize estimates to the same prediction data matices and refine the incorporation of environmental and biological covariates. However, there are limitations to statistical inference based on a relatively small (<10%) subset of time area strata with detailed observer data. To substantially improve on these estimates a larger proportion of sets observed and fleet coverage across the entire fishing footprint as well as more detailed information on species-specific bird distribution would be desirable. Other approaches that consider the effect of spatial and overall observer coverage on the model datasets that include the analysis of simulated data could show what biases are to be expected.

## Acknowledgements

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## Tables

**Table 1**: Estimates of seabird bycatch based on BPUE observed by vessels in different CPCs (BZ for Brazil, ZAF for South Africa, JPN for Japan, KOR for Korea, Avg. for average and SD for the standard deviation of the estimates) using stratified ratio-based estimates.

| Year | BZ | ZAF | JPN | KOR | Avg. | SD |
|---|---|---|---|---|---|---|
| 2012 | 32319 | 8779 | 10427 | 7596 | 14780 | 11750 |
| 2013 | 36077 | 9657 | 11447 | 8397 | 16395 | 13181 |
| 2014 | 28178 | 7134 | 8641 | 6234 | 12547 | 10468 |
| 2015 | 25847 | 6854 | 8142 | 5949 | 11698 | 9476 |

**Table 2**: Annual estimates of seabird bycatch (live and dead captures) for the study region for the years 2010-2015. Esitmates are based on the predicted BPUE from the GAM model and publically available data on longline effort.

| Year | Seabird Bycatch |
|---|---|
| 2010 | 16,324 |
| 2011 | 17,265 |
| 2012 | 12,989 |
| 2013 | 14,903 |
| 2014 | 12,396 |
| 2015 | 11,534 |

**Table 3**: Comparison of final model selction based on spatial structur and diagnostics. Model dianostics are the Watanabe-Akaike information criterion (WAIC), Conditional Predictive Ordinates (CPO), and convergence failure (FAIL).

| Spatial Structure | Likelihood | WAIC | CPO | FAIL |
|---|---|---|---|---|
| iCAR between seasons | Poisson | 4541.31 | 0.3 | 0 |
| iCAR between month | Poisson | 8299.49 | 0.3 | 0 |
| iCAR between years | Poisson | 8017.67 | 0.3 | 0 |

**Table 4:** Annual (2012-2015) estimates of seabirds caught and 95% confidence intervals (based on the 2.5% and 97.5% quantiles using the INLA model.

| Year | Birds Caught | 2.5% | 97.5% |
|---|---|---|---|
| 2012 | 32,368 | 372 | 67,220 |
| 2013 | 9,915 | 53 | 20,108 |
| 2014 | 21,519 | 85 | 40,610 |
| 2015 | 53,744 | 198 | 98,959 |

## Figures

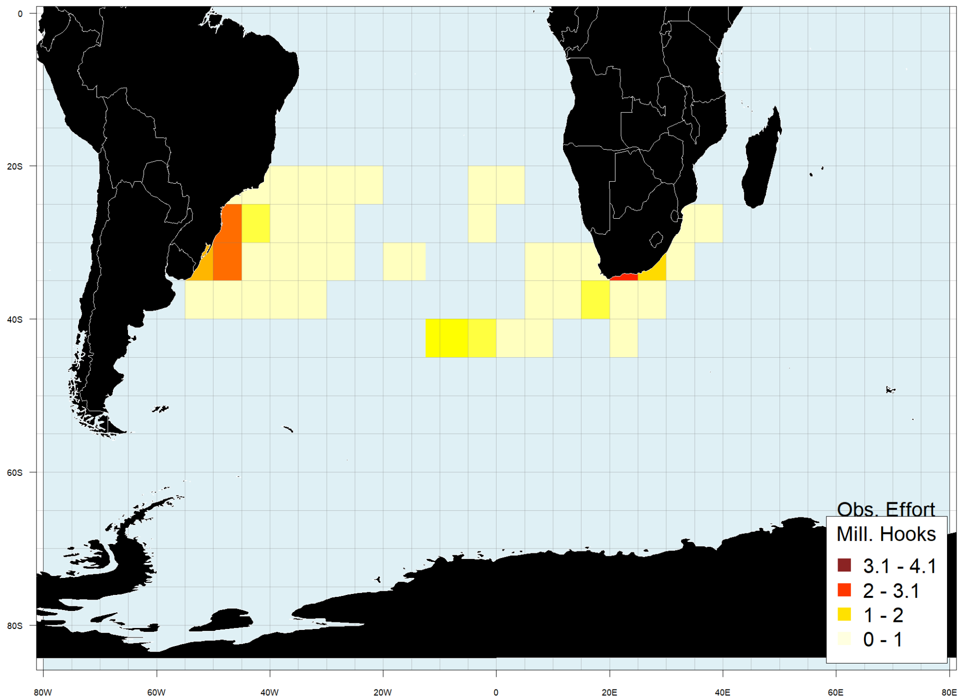


Figure 1. Distribution of total fishing effort observed in pelagic longline fleets operating in the Atlantic and south-west Indian oceans. Data were from observer programmes of Brazil (2000-2017), South Africa (2002-2016) and the Republic of Korea (2012-2016). Observer data from South Africa include foreign charter vessels

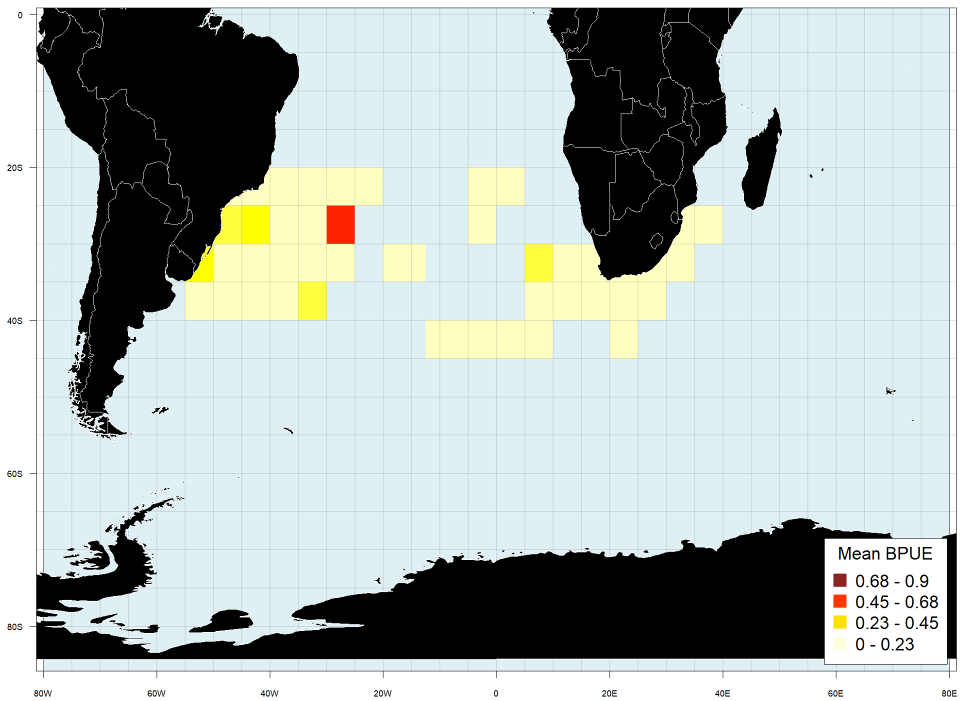


Figure 2. Distribution of the observed BPUE from tuna longline fleets of Brazil, South Africa and Korea, combined. Data represent combined averages of BPUE over individual 5° cells.

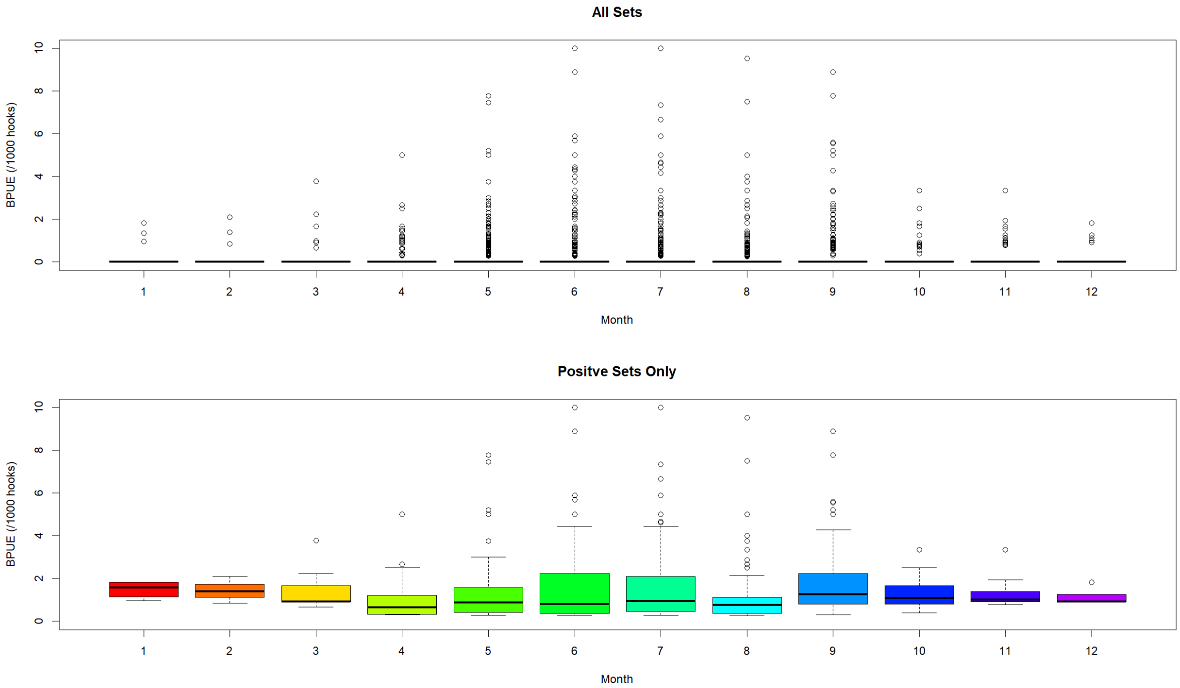


Figure 3. Distribution of BPUE by month for all sets (top panel) and only those with seabirds caught (a positive catch rate, bottom panel)

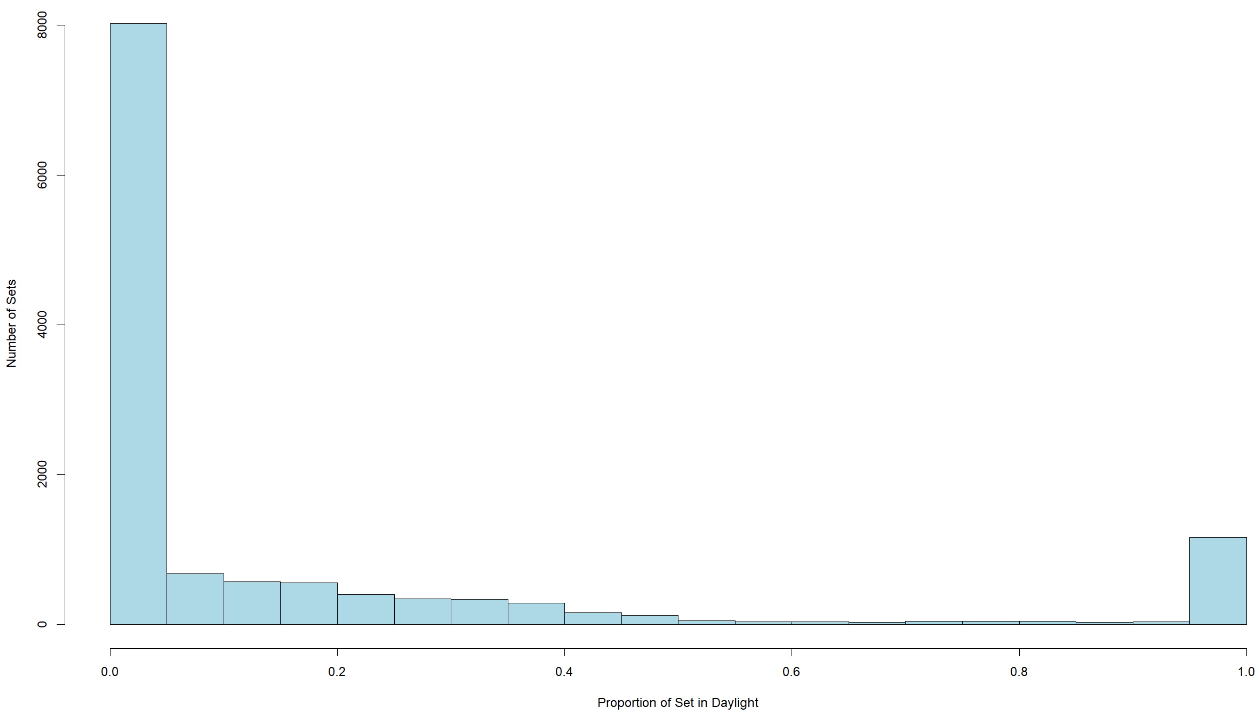


Figure 4. Proportion of observed sets from tuna longline fleets of Brazil, South Africa and Korea, conducted in daylight

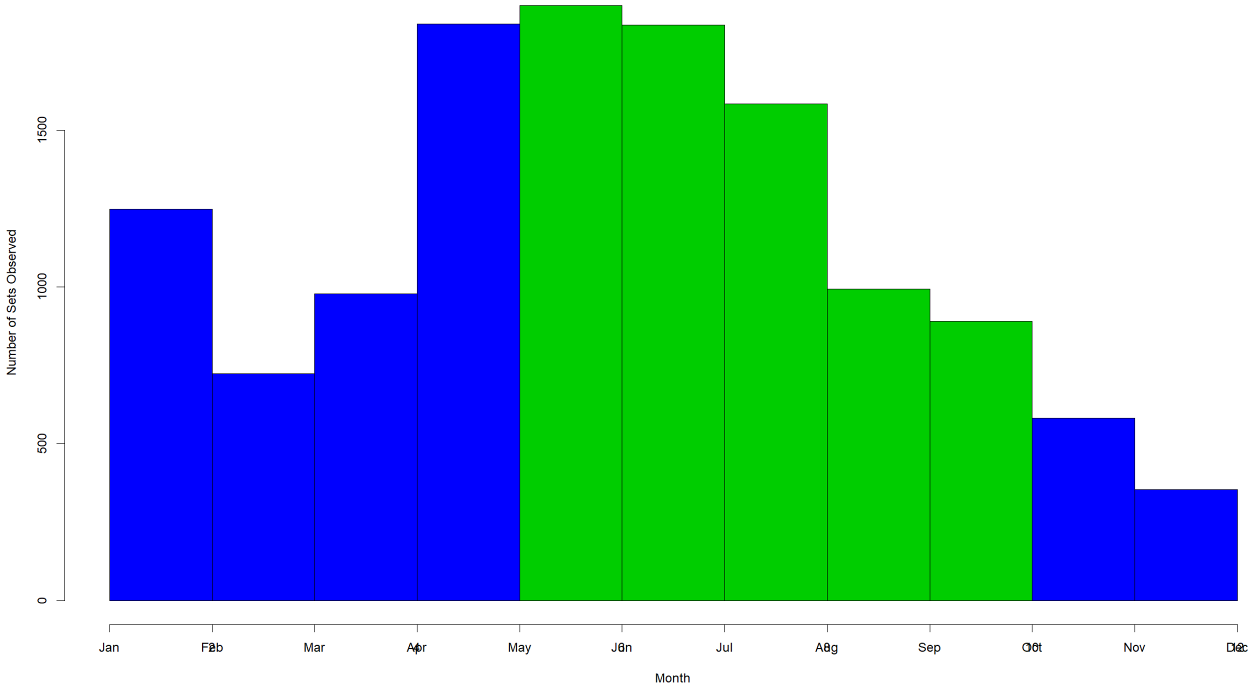


Figure 5. Number of observed sets from tuna longline fleets of Brazil, South Africa and Korea, by month, 2010-2015 combined, coloured by seabird breeding (October-April, blue) and non-breeding (May-September, green) season

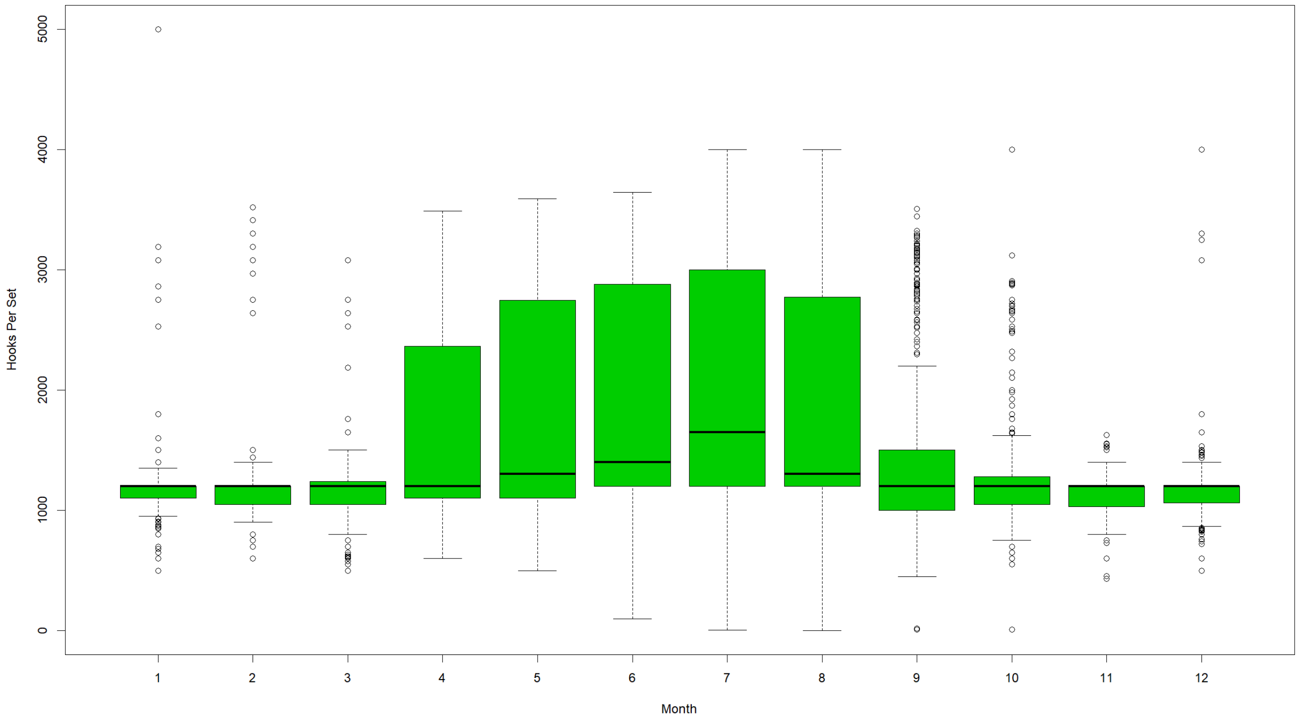


Figure 6. Number of hooks per set, by month, from tuna longline fleets of Brazil, South Africa and Korea, by month, 2010-2015 combined.

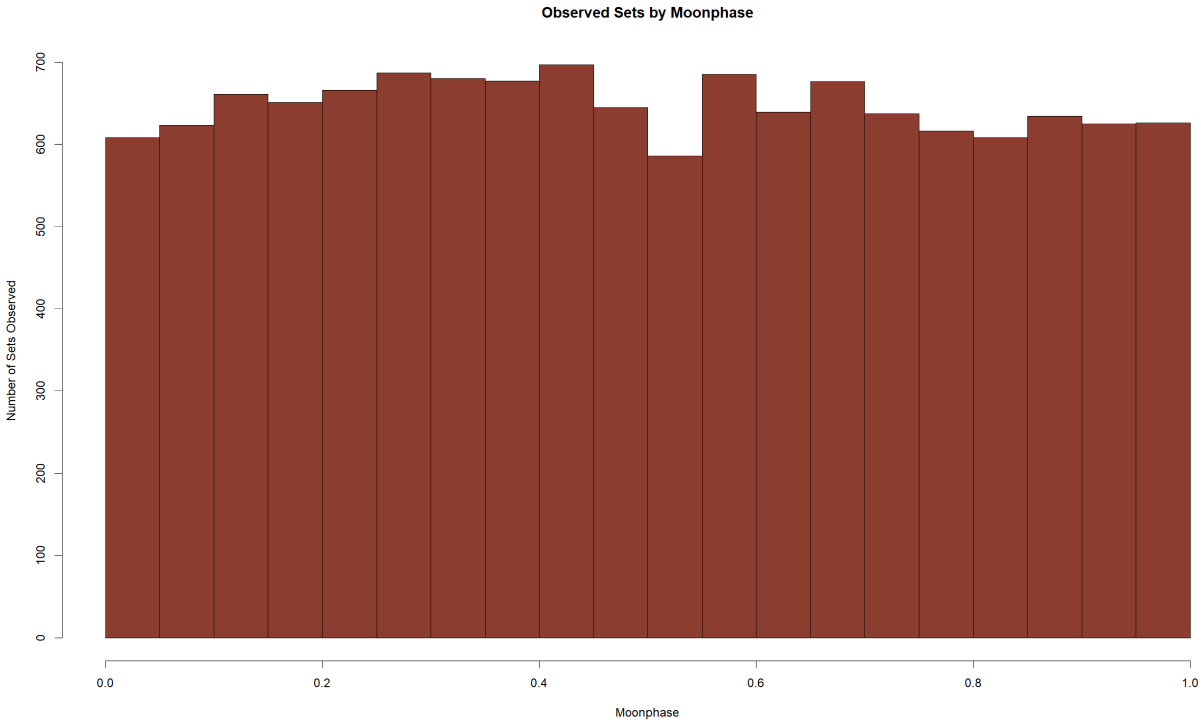


Figure 7. Sets from tuna longline fleets of Brazil, South Africa and Korea, 2010-2015 combined by moon phase, where 0.5 represents a full moon, and 0 represents a new moon and 1 represents the waning crescent

Figure 8. Seabird bycatch estimates for non-breeding season and for observed strata for 2012. Lower panel indicates effort coverage (circles), and observations squares. Estimates for unsampled strata for the year where other years' observations were available are shown in the top panel

Figure 9. Seabird bycatch estimates for breeding season in observed strata for 2012. Lower panel indicates effort coverage (circles), and observations squares. Estimates for unsampled strata for the year where other years' observations were available are shown in the top panel

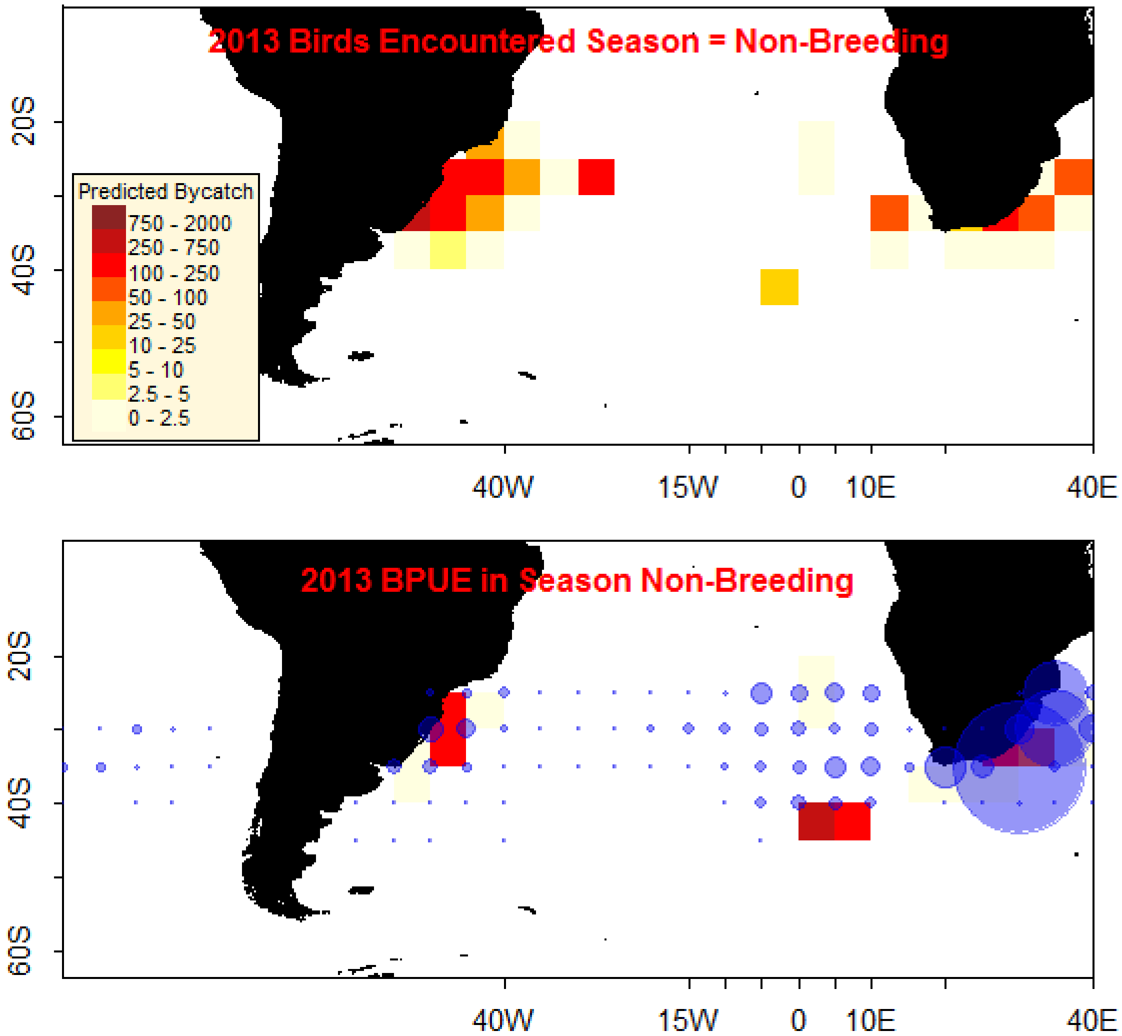


Figure 10: Seabird bycatch estimates for non-breeding season in observed strata for 2013. Lower panel indicates effort coverage (circles), and observations squares. Estimates for unsampled strata for the year where other years' observations were available are shown in the top panel

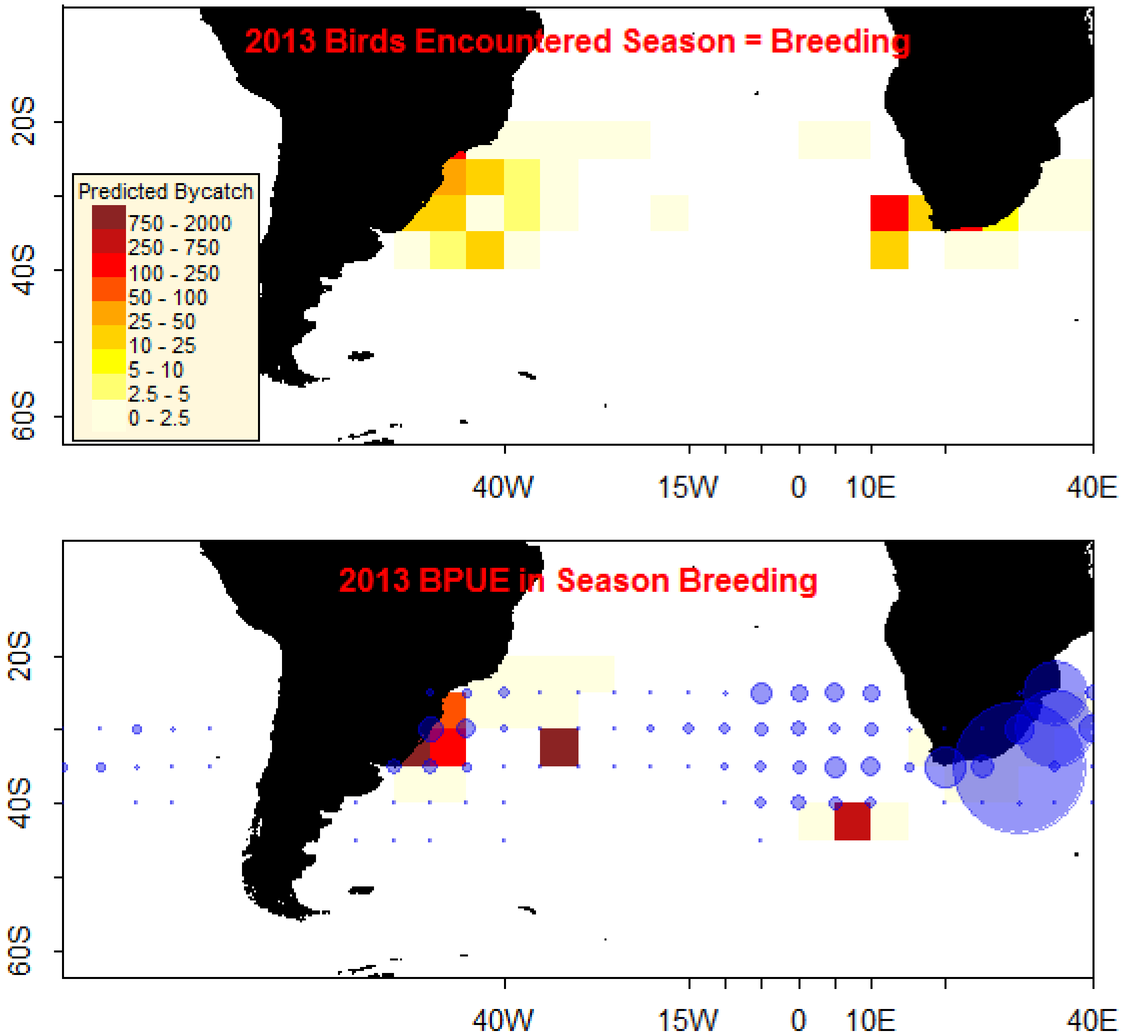


Figure 11. Seabird bycatch estimates for breeding season in observed strata for 2013. Lower panel indicates effort coverage (circles), and observations squares. Estimates for unsampled strata for the year where other years' observations were available are shown in the top panel

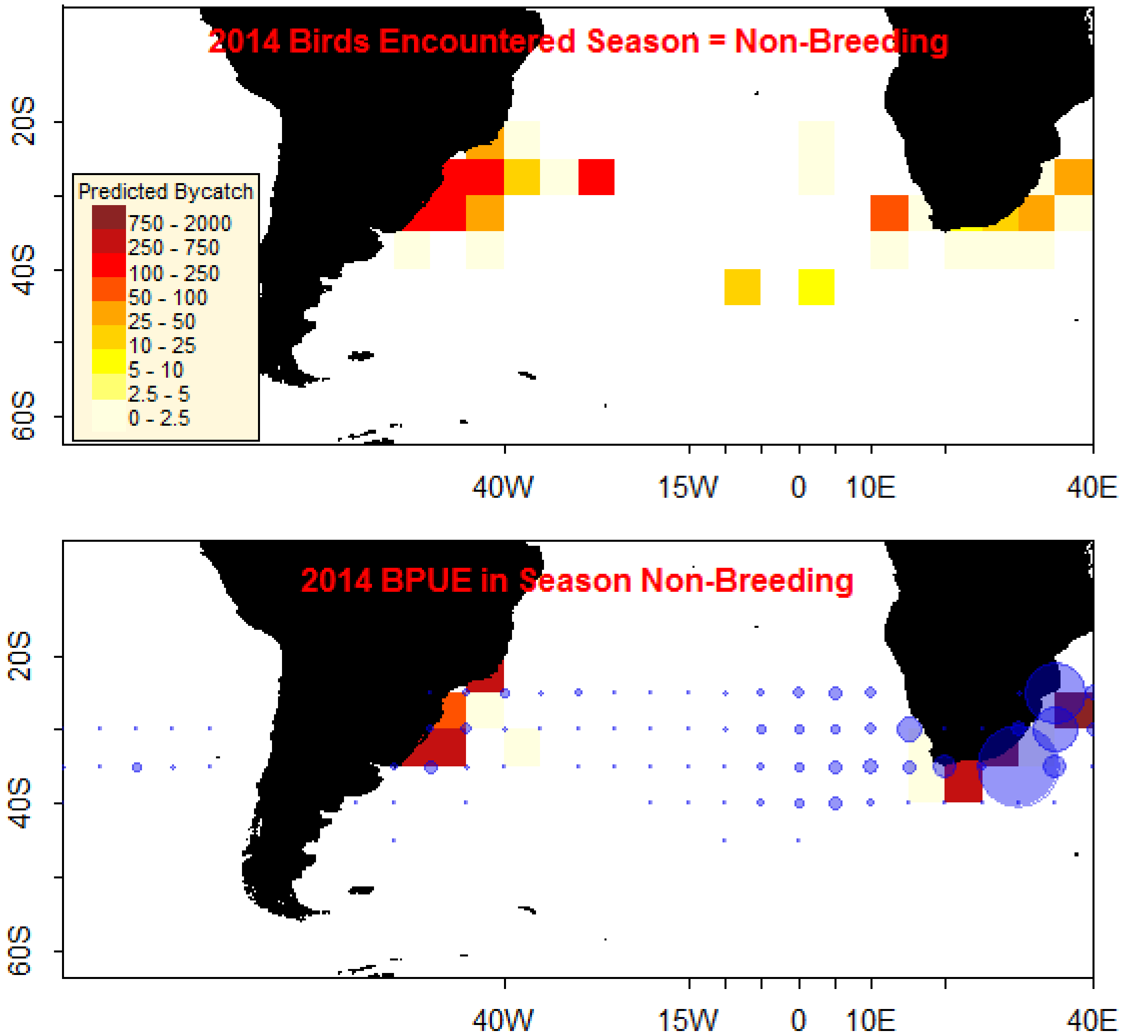


Figure 12. Seabird bycatch estimates for non-breeding season in observed strata for 2014. Lower panel indicates effort coverage (circles), and observations squares. Estimates for unsampled strata for the year where other years' observations were available are shown in the top panel

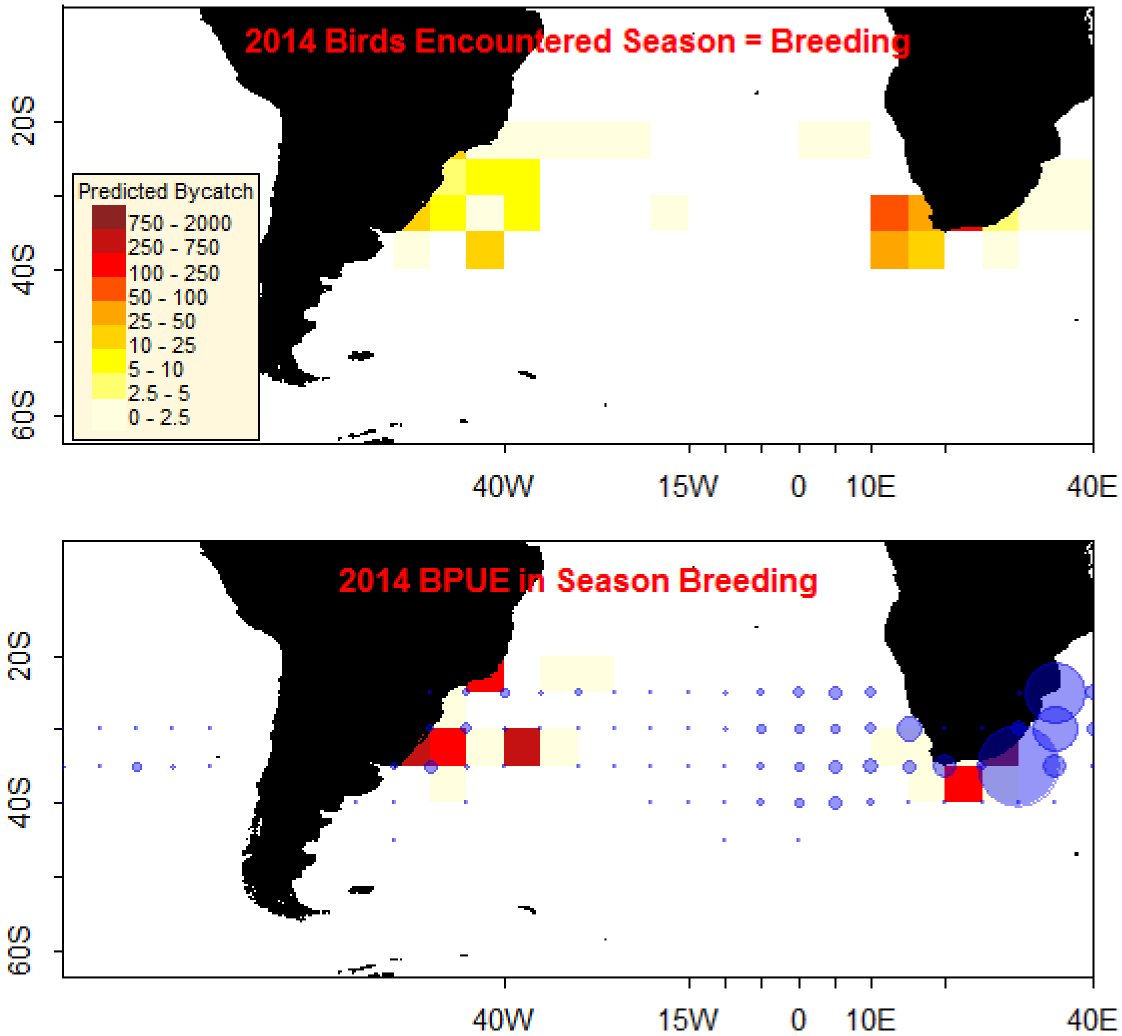


Figure 13. Seabird bycatch estimates for breeding season in observed strata for 2014. Lower panel indicates effort coverage (circles), and observations squares. Estimates for unsampled strata for the year where other years' observations were available are shown in the top panel

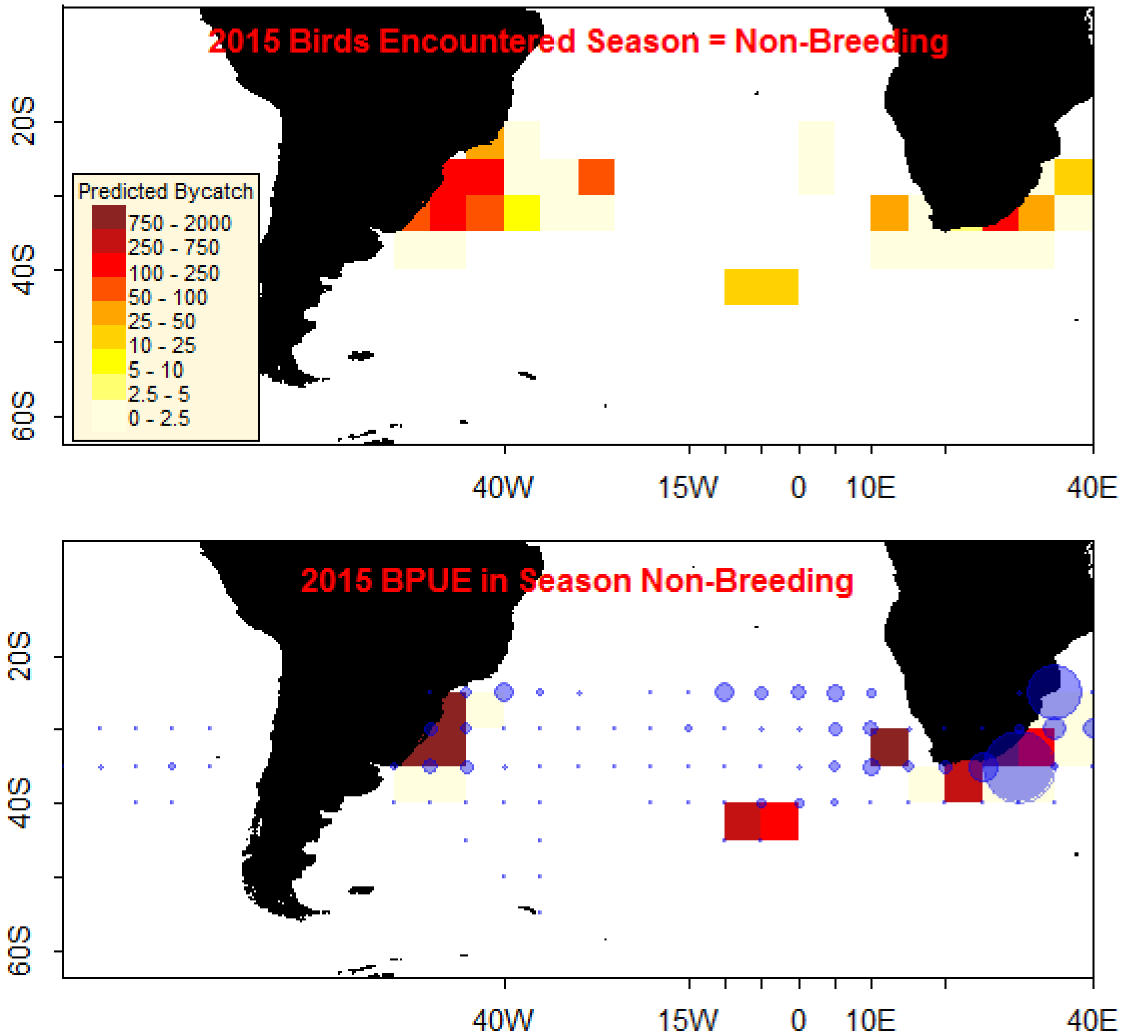


Figure 14. Seabird bycatch estimates for non-breeding season in observed strata for 2014. Lower panel indicates effort coverage (circles), and observations squares. Estimates for unsampled strata for the year where other years' observations were available are shown in the top panel

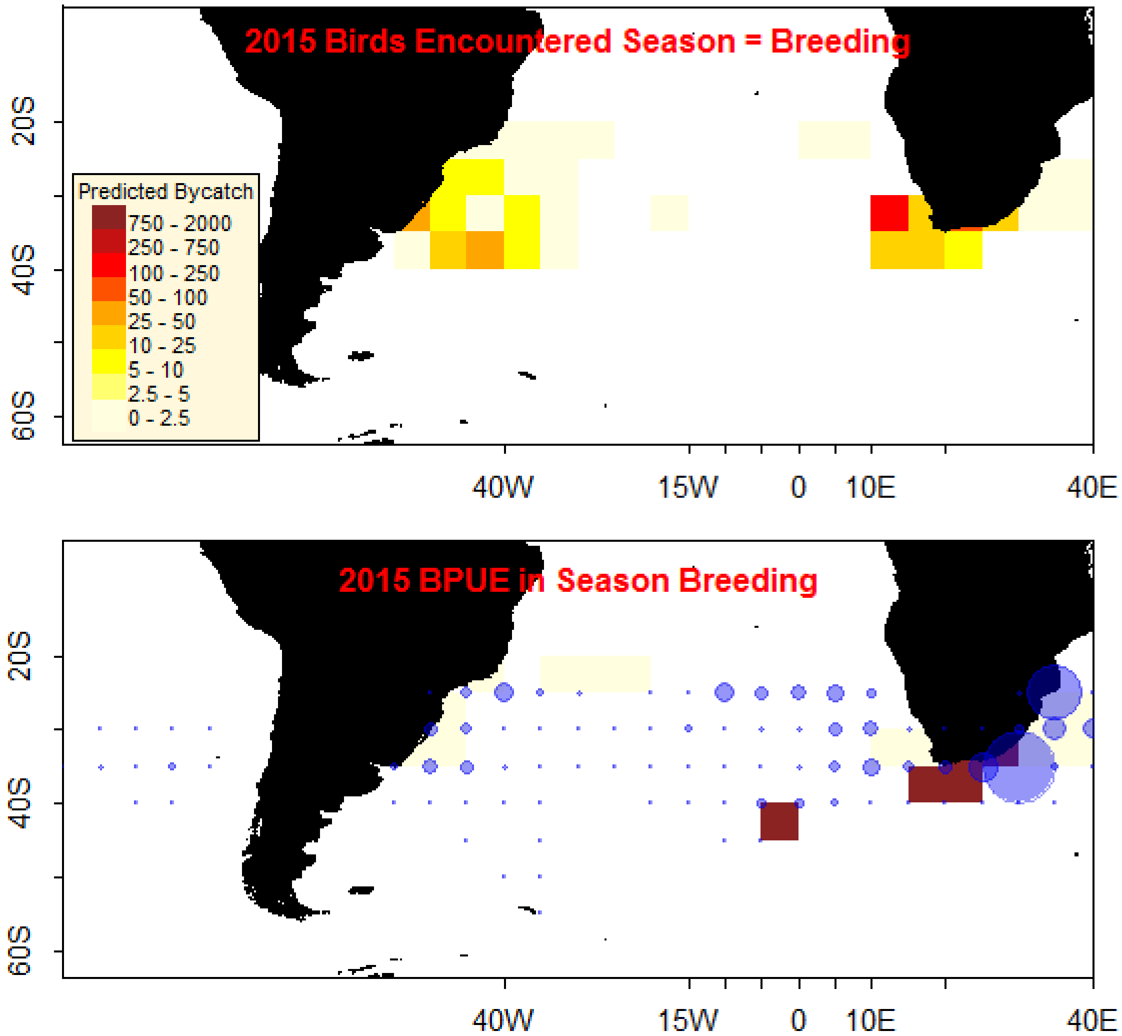


Figure 15. Seabird bycatch estimates for breeding season in observed strata for 2014. Lower panel indicates effort coverage (circles), and observations squares. Estimates for unsampled strata for the year where other years' observations were available are shown in the top panel

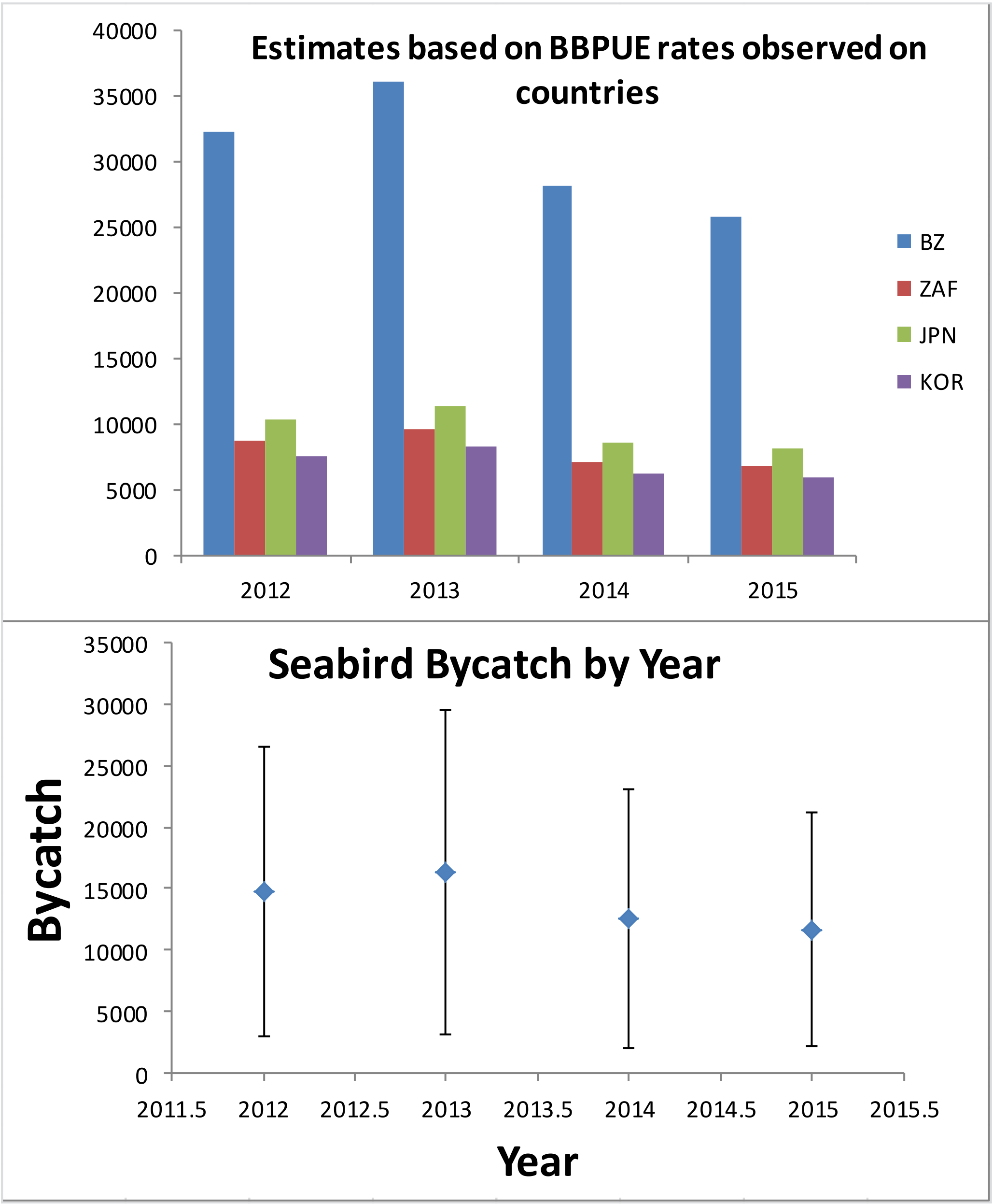


Figure 16. Estimates of total seabird bycatch based on BPUE by flag state (BZ = Brazil, ZAF = South Africa, JPN = Japan, KOR = Korea); or aggregated with variability across BPUE across flag states

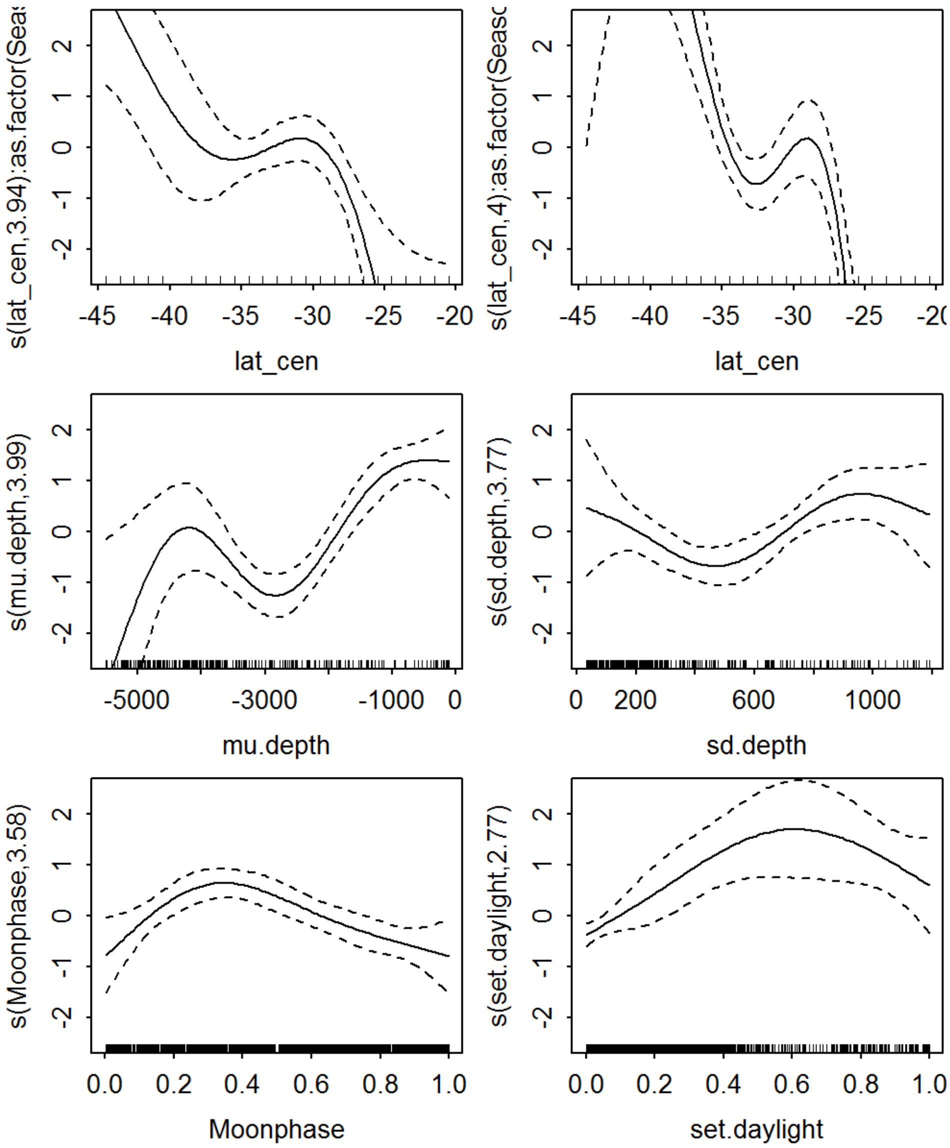


Figure 17. Partial effects plots (the effect of each of the factors individually) of variables affecting seabird bycatch estimates. The top row shows the effect of latitude by season (breeding is on the left), mu.depth represents the average depth of the seabed in the 5° by 5° cell, sd. depth is the standard deviation of the depth in the 5°X5° cell and set.daylight is the proportion of the set in daylight.

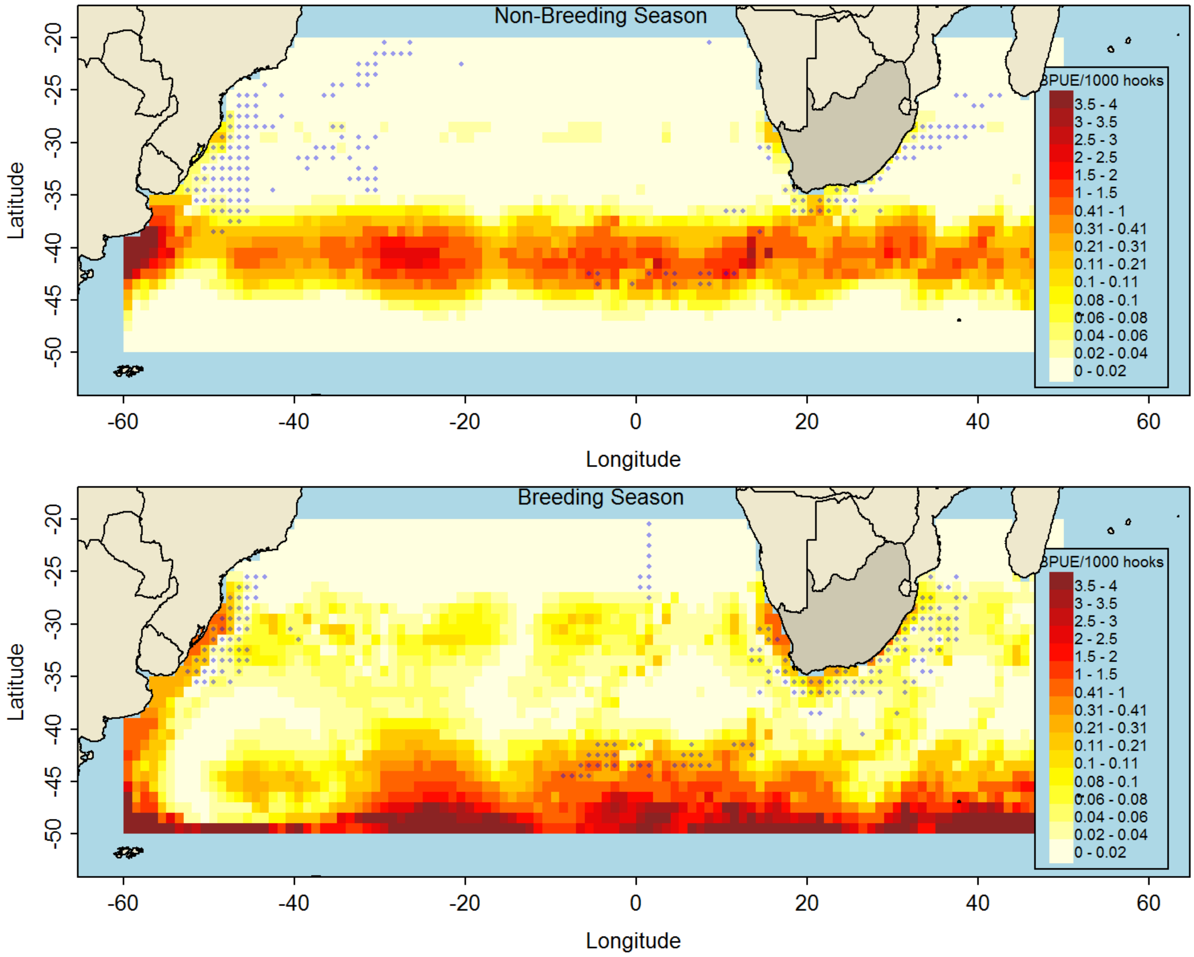


Figure 18. Estimated seabird BPUE from the GAM model. Darker colors represent higher BPUE and blue diamonds represent observed sets. The top panel represents the non-breeding season and the bottom panel represents the breeding season

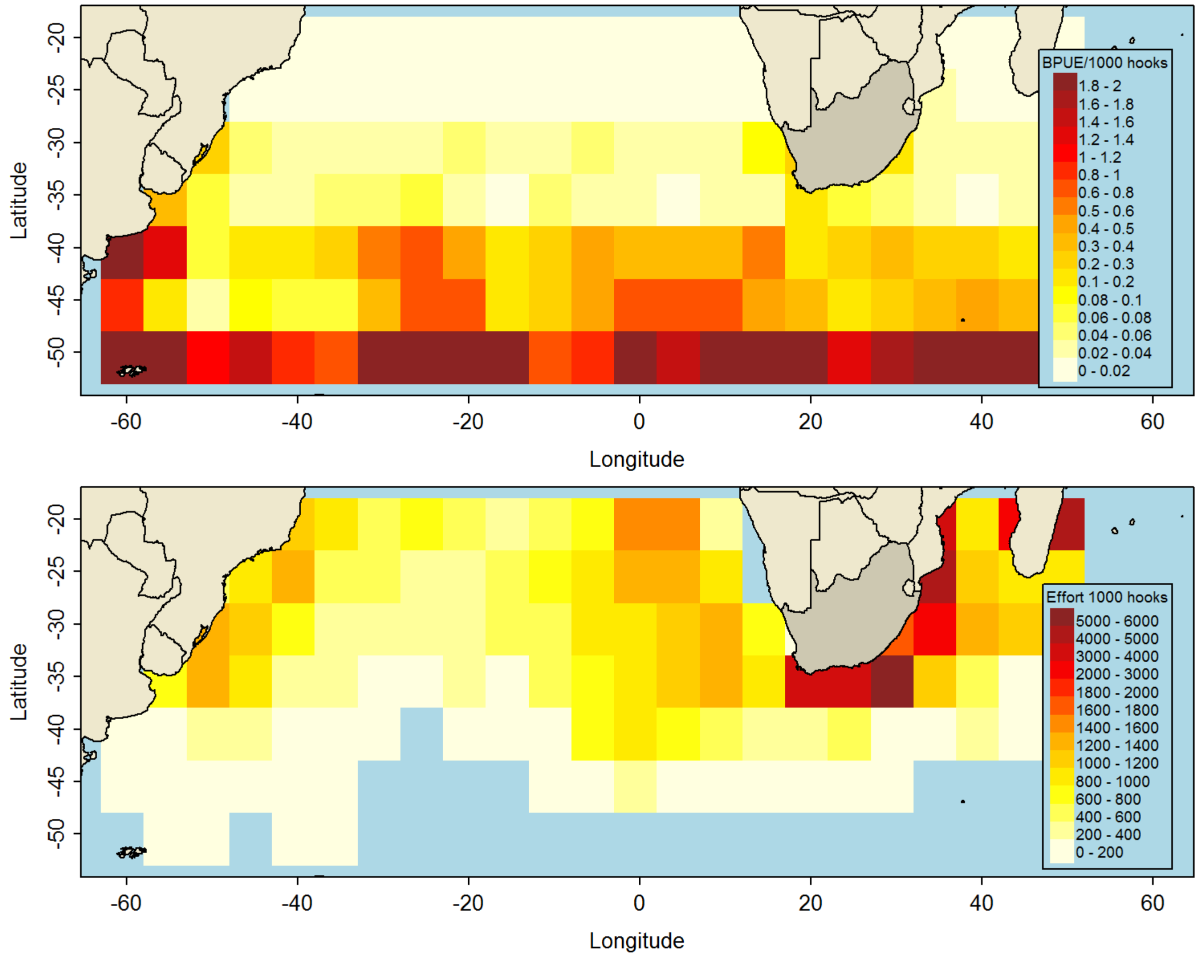


Figure 19. Estimated mean seabird BPUE (on a 5° by 5° basis, top panel) and the mean annual effort in units of 1000 hooks.

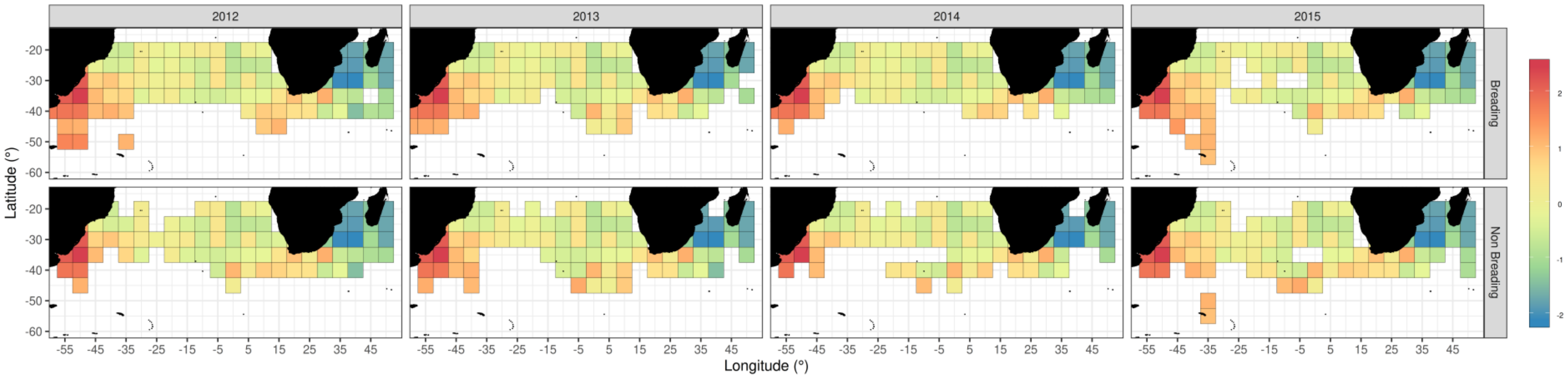


Figure 20. Summary of the spatial random effect (Gaussian random fields) for each year and season (breeding and non-breeding) – mean.

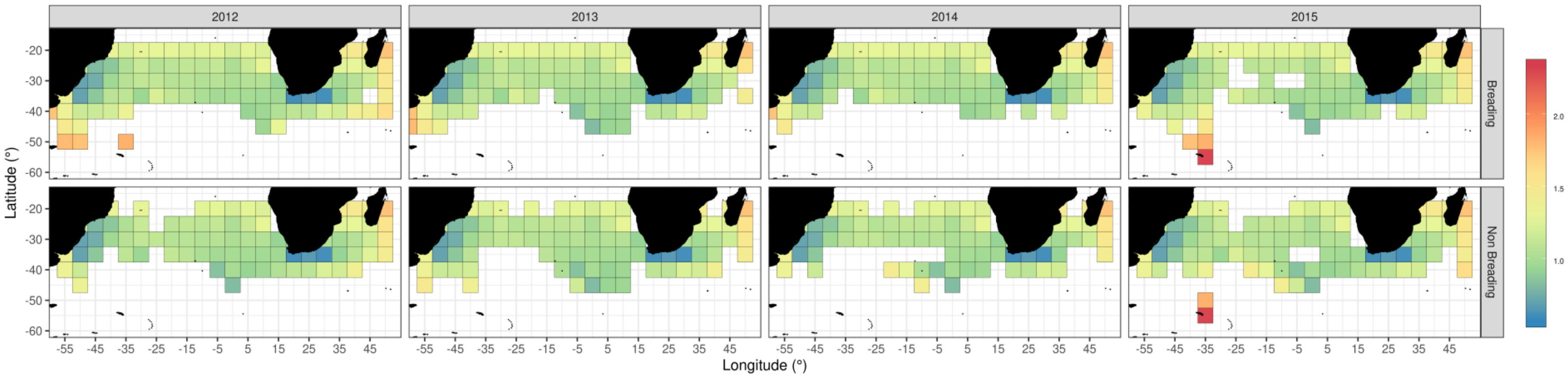


Figure 21. Summary of the spatial random effect (Gaussian random fields) for each year and season (breeding and non-breeding) –standard deviation.

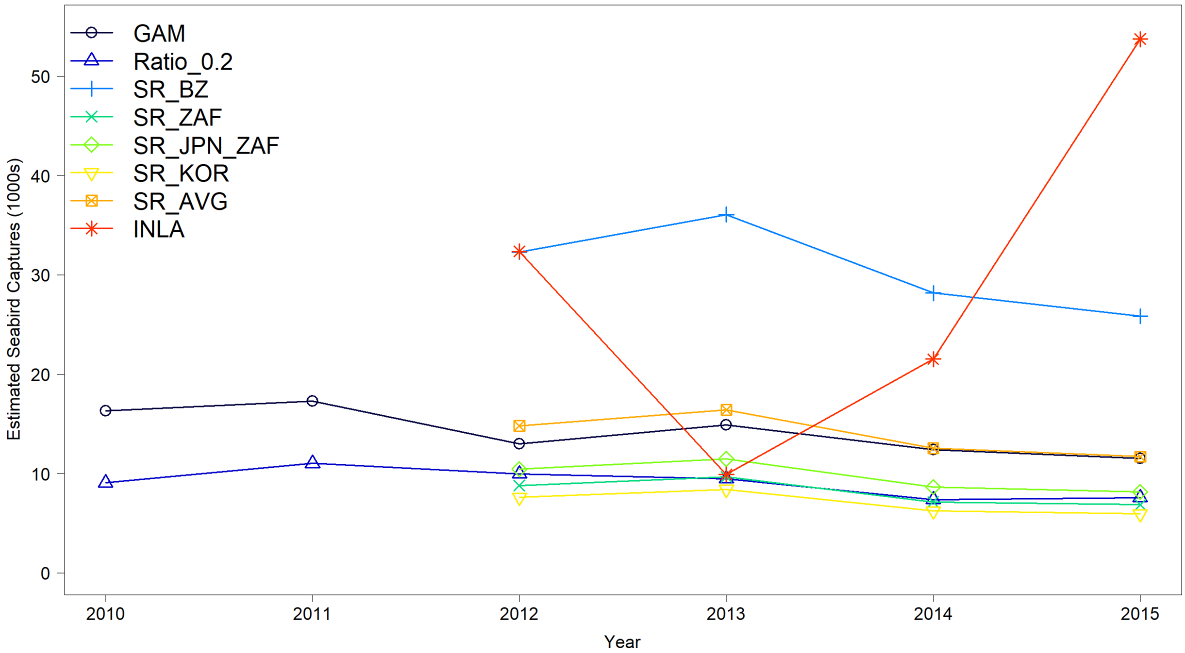


Figure 22. Comparison of estimates of total seabirds caught, abbreviations are as defined above for GAM, and INLA. A comparison to an estimate made based on a direct ratio-based estimate (Ratio_0.2, where 0.2 birds per 1000 hooks is assumed) is included for reference. SR = stratified ratio-based estimates, BZ = Brazil data, ZAF = South Africa data, JPN_ZAF = Japanese effort in South Africa, KOR = Korea data, and AVG as the average of the estimates.

## Annex 1 Background on the CO/ABNJ Seabird Project

In 2017, with the support of the FAO's Common Oceans program, BirdLife commenced supporting national scientists to undertake work towards the evaluation of seabird bycatch from tuna longline fishing in the waters south of 25°S. The purpose of this work is twofold:

1. To estimate the number of seabird bycatch in tuna longline fishing annually, from the most recent and credible set of annual observer and effort data (expected 2012 to 2016).

2. To evaluate the impact of seabird bycatch mitigation measures on BPUE.

The first phase of the project focused on national scientists compiling national bycatch data and producing standardised reports and undertaking basic exploratory analysis. The second phase of the project (occurring concurrently with phase 1) is oriented at national scientists undertaking collaborative, intersessional work to collate datasets and identify factors contributing to the differences in BPUE between fleets (to the extent possible). The third phase of the project is pair of workshops focusing on data preparation (held in February 2018) and analysis (to be held February 2019) to complete the goals of the project.

For more information on this project, please contact: Nini van der Merwe, International Liaison Officer Nini.vdmerwe@birdlife.org.za