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A short note on the development of WCPFC seabird bycatch estimates for Project 68

WCPFC-SC14-2018/ EB-WP-03

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1 Introduction

The Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (Convention) entered into force in June 2004 creating one of the first regional fisheries management organizations to be established since the 1995 adoption of the United Nations Fish Stocks Agreement.

The objective of the Convention is to ensure, through effective management, the long-term conservation and sustainable use of highly migratory fish stocks in the western and central Pacific Ocean (WCPO) in accordance with the 1982 United Nations Convention on the Law of the Sea (UNCLOS) and the Agreement. The Convention applies to all species of highly migratory fish stocks (defined as all fish stocks of the species listed in Annex I of UNCLOS occurring in the Convention Area and such other species of fish as the Commission may determine) within the Convention Area, except sauries. Conservation and management measures under the Convention are to be applied throughout the range of the stocks, or to specific areas within the Convention Area, as determined by the Commission.

The Commission adopted CMM 2015-03, which requests the Scientific Committee to estimate seabird mortality in all fisheries where the Convention applies. The Twelfth Scientific Committee (SC12) developed terms of reference (scope of work) for the estimation of seabird mortality across the WCPO Convention area, Project 68.

1.1 Project History

The Twelfth Scientific Committee (SC12) developed terms of reference (scope of work) for the estimation of seabird mortality across the WCPO Convention area, which was endorsed and approved by the Commission in December 2016, on the basis that the ABNJ Tuna Project may be able to provide co-funding. In 2017 OFP-SPC developed a paper for the Thirteenth Scientific Committee (SC13) providing a project outline, a summary of seabird bycatch data held by SPC and a proposed methodology for estimation (Peatman et al, 2017a). In 2017, SC13 reiterated the scope of the project and increased its rank from medium to high priority. WCPFC 14 approved the scope and proposed budgets. FAO signed a Letter of Agreement with WCPFC in February 2018 to provide the co-funding. The Scientific Service Provider was contracted to undertake Project 68 in late April 2018.

1.2 Project Scope

The scope of work for this project will include, but not be limited to, the following:

a) Fulfil the requirement under the WCPFC seabird CMMs to estimate the total number of seabirds being killed per year in WCPFC fisheries
b) Assess mortality per year over the ten years since the first WCPFC seabird CMM, as requested under CMM 2006-02, CMM 2007-04 and CMM 2012-07, and assess whether there is any detectable trend
c) Describe the methods used to estimate total mortality, including treatment of data gaps

d) Identify the limitations in the data available, allowing the SC to generate advice to the Commission on what improvements are needed to enable better analyses to be made, and
e) Generate advice on what further level of seabird assessment at species or species-group level can be conducted, given the amount and quality of data currently available.

1.3 Project Schedule and Reporting

The project commenced in late April 2018. This report provides a summary of work undertaken to date. A final report will be prepared for SC15 in 2019. Subject to funding, additional updates with methodological improvements and additional years of data will be provided in 2020.

2 Summary of SPC data holdings relevant to seabird bycatch

In the context of this work, we define 'seabird' as any species of bird that are covered by the following families (grouped by order): Procellariiformes – Diomedeidae, Procellariidae, Pelacanoididae and Hydrobatidae; Suliformes – Sulidae, Phalacrocoracidae and Fregatidae; Phaethontiformes – Phaethontidae; Charadriiformes - Stercorariidae, Laridae, Sternida, Rhynchopidae and Alcidae.

The majority of seabird bycatch data held by SPC relates to observed bycatch on longline fishing vessels. At the time of preparing the most recent summary report of purse seine bycatch (Peatman et al., 2018b), there were 11 purse seine sets in SPC's observer data holdings with observed catch events of seabirds, 7 of which were catches of one individual. As such, we focus on longline fisheries in this report, noting that estimates of seabird mortalities in the purse seine fishery will also be required, and prepared, for Project 68.

2.1 Longline aggregate catch and effort data

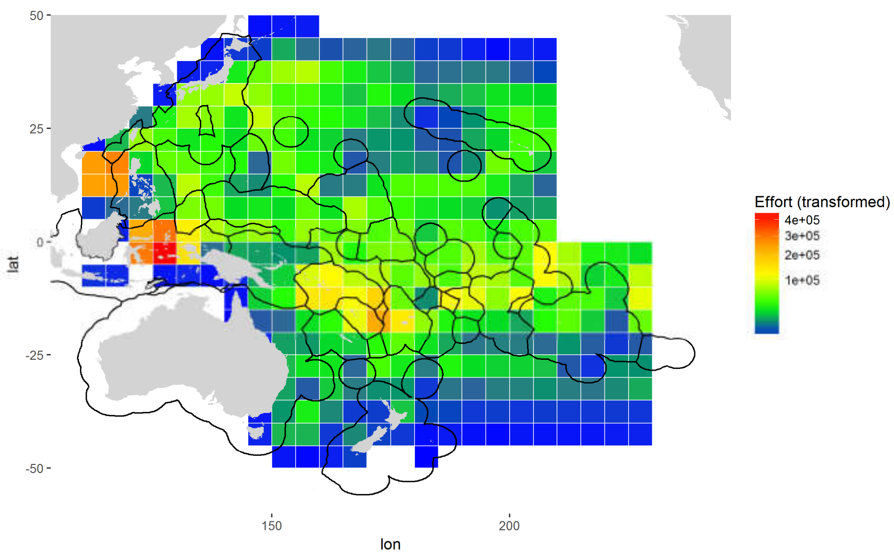

Figure 1 Aggregate longline catch and effort data for the WCPFC Convention Area, 2007 to 2017 (square root transformed).

SPC holds longline aggregate catch and effort data, referred to as L_BEST, and longline catch and effort data disaggregated by hooks between floats (HBF), referred to as L_BEST_HBF. The spatial distribution of longline effort from 2007 to 2017 is provided in Figure 1. Of particular relevance to Project 68 is the extensive longline effort north of 25°N, a region with mandated seabird bycatch mitigation through CMM 2017-06 and its predecessors. Mitigation is required for fishing north of 23°N but aggregate data are stratified by 5° cells. HBF-specific aggregate data held by SPC does not provide full coverage of aggregate effort for all fleets, increasing from 50 % in 2007, to approximately 90 % in 2016 (e.g. see Peatman et al., 2018a).

2.2 Longline observer data

Available longline observer data in SPC data holdings represented annual coverage of between 1.5 and 4.5 % from 2007 to 2017 (e.g. see Peatman et al., 2018a). However observer coverage is quite patchy both spatially and temporally (Figure 2). Observer coverage is generally higher in EEZs, and lower in high seas regions. We note the low observer coverage north of 25°N and west of 180°, an area with substantial longline effort (see Figure 1). There are also regions south of 30°S with limited observer coverage, mainly in the high seas, though total effort in these areas is relatively low.

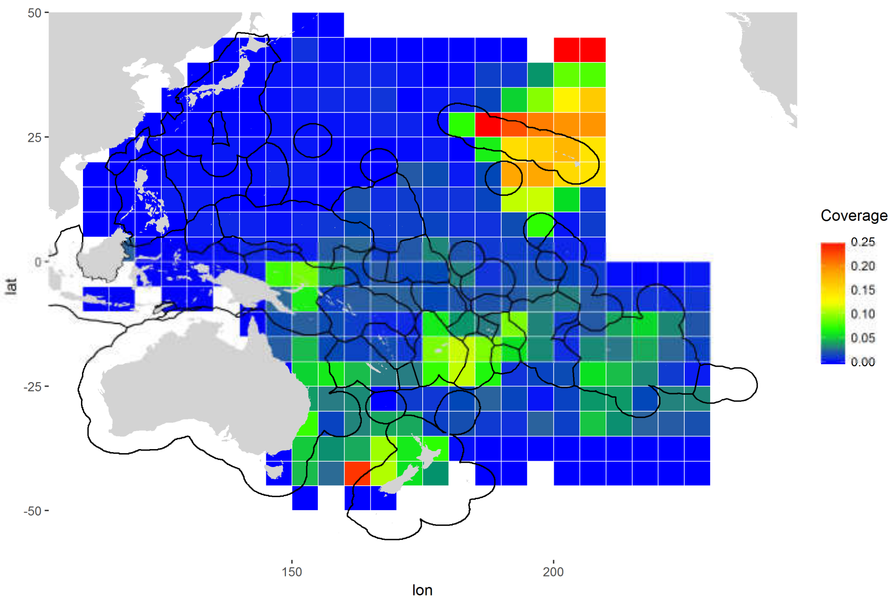

Figure 2 Longline observer coverage (percentage of hooks with observer onboard) for the WCPFC Convention Area, 2007 to 2017. Data extracted from SPC's master observer database 10th July 2018.

As of 10th July 2018, there were 4,100 individual seabirds recorded in longline observer catch observations from 2003 to 2017 (Figure 3). 1,950 of these were north of 23°N, 1,700 were south of 30°S, and 400 were between 23°N and 30°S. Note we include the time period from 2003 onwards as seabird bycatch data before the introduction of WCPFC CMM 2006-02 may be useful for the Project. Over 80% of caught individuals were albatrosses, with 15 % petrels and puffins combined.

Approximately 70 % of albatrosses were dead at-vessel, with the remainder alive or with no corresponding condition information, with 80% of petrels and puffins dead at-vessel (Figure 3).

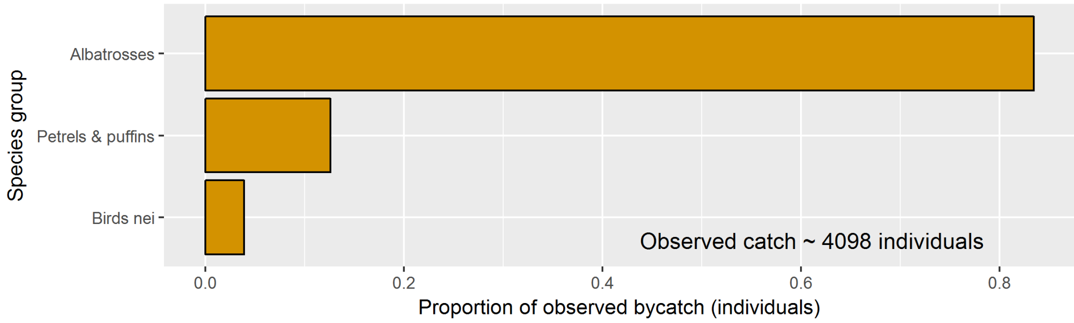

Figure 3 Observer seabird bycatch for albatrosses, petrels & puffins and seabirds nei (not elsewhere included).

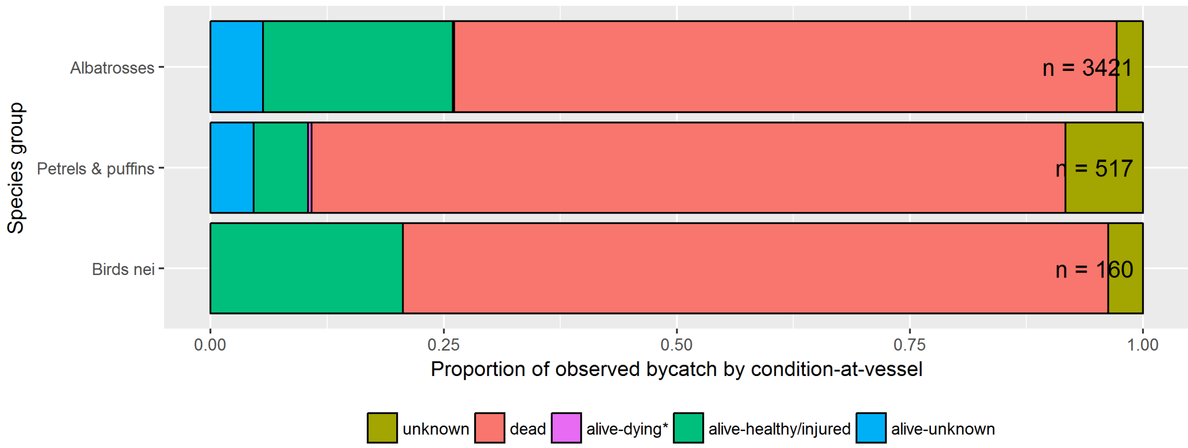

Figure 4 Condition at-vessel for seabird bycatch.

3 Preliminary bycatch rate models of seabird bycatch in WCPO longline fisheries

3.1 Methods

We have fitted preliminary catch rate models to observer data from 2003 to 2017 using the models developed by Peatman et al. (2018a). Separate models were fitted to albatrosses, petrels and puffins, and 'seabirds nei' (nei = not elsewhere included – a combination of other species, and general species codes that can't be attributed at a finer level). We used Generalised Estimating Equations (GEEs) to account for correlation between observations within observer trips, fitted using the R package 'geepack' (Højsgaard et al., 2006). An 'exchangeable' working correlation structure was used, where residuals from observations from the same observer trip are correlated, with a shared correlation parameter for all observer trips. A poisson-like error structure was used to model petrel & puffins, and seabirds nei. A delta-lognormal model was used for albatrosses, to account for zero-inflation. Explanatory variables included in the models were: year, sea-surface temperature (SST) and HBF, included as cubic splines; and, a categorical variable for the species composition cluster for the 'L_BEST' strata. The year effect was modelled as a spline rather than a categorical variable to prevent over-fitting to temporal variation in catch rates and allow for a relationship between subsequent year effects. SST and HBF were included as splines to account for potential non-linearity in effects on catch rates. Species composition cluster was included to account for the effects of fishing strategy and targeting on seabird catch. All explanatory variables were retained in catch rate models regardless of statistical significance. We did not include, or test for, interactions between explanatory variables.

The specification of the Poisson-like models for petrel & puffins and seabirds nei was

$$E[Y_{ij}] = \mu_{ij} \qquad\qquad Var[Y_{ij}] = \phi\, \mu_{ij}$$

$$\ln \mu_{ij} = \ln(thooks_{ij}) + \beta_0 + \beta_1 cluster_{ij} + f_1(year_{ij}) + f_2(HBF_{ij}) + f_3(SST_{ij})$$

where Y_{ij} denotes observed catch rate (individuals per thousand hooks), subscripts i and j refer to observer trip and set number respectively, f_n represent natural cubic splines and ϕ is a variance inflation parameter.

The specification of the delta-lognormal models for albatrosses was:

(presence-absence component)

$$E[P_{ij}] = \gamma_{ij} \qquad\qquad Var[P_{ij}] = \phi\, \gamma_{ij}(1 - \gamma_{ij})$$

$$\ln\left(\frac{\gamma_{ij}}{1-\gamma_{ij}}\right) = \beta_0 + \beta_1 cluster_{ij} + f_1(year_{ij}) + f_2(HBF_{ij}) + f_3(SST_{ij})$$

(positives component i.e. catch rate when present)

$$E[N_{ij}] = \eta_{ij} \qquad\qquad Var[N_{ij}] = \sigma^2$$

$$\ln(\eta_{ij}) = \beta_0 + \beta_1 cluster_{ij} + f_1(year_{ij}) + f_2(HBF_{ij}) + f_3(SST_{ij})$$

where P_{ij} denotes whether individuals (of the species concerned) were caught, N_{ij} denotes the observed catch rate (numbers per '000 hooks), and the overall estimated mean catch rate ζ_{ij} is given by $\zeta_{ij} = \gamma_{ij}\, \eta_{ij}$.

3.2 (Preliminary) Results

The effects of the fitted models are presented in Annex I (Figure 5 to Figure 7). Examination of residuals did not provide evidence of lack of fit for the albatross presence-absence model or the petrels and puffins catch rate model. However, the log-normal model for positive albatross catch did not fit particularly well to the observations. We note that estimated correlation was low, with the exception of the log-normal albatross model.

We summarise here the effects of the presence-absence component of the albatross model (Figure 5) and the catch rate model for puffins and petrels (Figure 7).

There was strong variation in estimated albatross presence/absence between catch clusters. The probability of albatross presence decreased with increasing hooks between floats and sea surface temperature. The probability of albatross catch displayed a generally weak increasing trend from 2006 onwards, with a strong increase from 2014 to 2016 and a subsequent decline from in 2017.

There was strong variation in estimated petrel & puffin catch rates between catch clusters. Catch rates were highest for 10 hooks between floats. Catch rates were highest for sea surface temperatures of 20°C. Petrel & puffin catch rates displayed a generally weak decreasing trend from 2003 to 2012, before increasing through to 2017.

3.3 Brief discussion of results

Despite the preliminary nature of the models, there are a number of aspects that are worth some discussion. The models are fitted to seabird bycatch observations at haul-back. As such the catch estimates, and derived estimates of mortalities, will represent underestimates. Cryptic mortality could be accounted for by taking available estimates from elsewhere (e.g. Brothers et al., 2010). We note that it appears unnecessary to use GEEs to model the seabird bycatch dataset here given the weak estimated within-trip correlation. More flexibility in model specification would be available using other modelling frameworks, e.g. generalised additive models (GAMs).

The estimates of bycatch rates from the models were quite imprecise. An exploration of predicted catch rates for different combinations of explanatory variables present in the observer data suggested that CVs in the region of 30 to 60 % were common for the albatross and petrel & puffin catch rate models. The catch rate models presented here can readily be improved, but it appears unlikely that any alternative approach to catch rate estimation would result in substantial reductions in CVs given the generally low levels of observer coverage and rare-event nature of seabird interactions (e.g. Lawson, 2006; Debski et al., 2016).

Estimated catch rates of petrel & puffins, and presence of albatrosses, were higher for longline sets with < 10 hooks between floats. The apparent effect of HBF may at least partially be driven by other un-modelled variables that are correlated with HBF. Regardless, we note that coverage of HBF-specific aggregate was comparatively low in, and before, 2007. This will also result in uncertainty in bycatch rates.

Finally, the year effects of the models raise some interesting questions. The year effects are likely to be affected by a range of factors, including changes in catchability, changes in the underlying abundance of the seabird species, and may be overfitting to random noise in the data. There is of course the possibility that the estimated year effects are an artefact of the modelling approach. We note that both the albatross presence/absence model and the petrels & puffin model display strong increases in catch rates from 2012 onwards.

4 General discussion and implications on future work

As described earlier, the coverage of SPC's observer data holdings varies in time and space. In particular there is limited observer data in large regions of the WCPFC Convention Area north of 23°N. It appears unlikely that robust estimates for this region could be obtained through extrapolation of available observer data from other regions. Part I reports of appropriate members will be reviewed, along with other available literature, to ensure that all relevant information can inform the estimation approach. We also note that there are non-standard observer data submissions for 2017 for some fleets operating in the region that have not been processed and consolidated with SPC's observer database (Williams et al., 2018).

There is the question of how best to incorporate available information on seabird distributions. The preliminary models have been fit to seabird bycatch aggregated to groups of species, one model for albatross species, one model for puffin & petrel species, and one model for all other seabirds. It would be easier to incorporate information on seabird distributions if catch rates were estimated at a species level, though it remains to be seen if sufficient data are available for analyses at that resolution. Regardless, we are planning on holding a small technical workshop attended by experts working in the field to compare methodologies and review the approach.

As noted in Section 2, the scope of Project 68 extends to all WCPFC fisheries. As described in Peatman et al (2017a), we anticipate using stratified ratio estimators to estimate seabird bycatch in purse seine fisheries given the low levels of observed catch events. Qualitative estimates of seabird bycatch for other fisheries falling under the WCFPC convention will be based on available information. We note that there will be components for both longline and purse seine fisheries for which SPC holds no observer data, and no observer data that are likely to provide representative seabird bycatch rates, namely domestic purse seine and longline fisheries in the most western equatorial sector of the WPCFC Convention Area and high latitude purse seine fisheries (see Peatman et al., 2017b; Peatman et al., 2018a). We will not attempt to estimate bird bycatch for these fisheries. There are a range of estimates of seabird bycatch longline fleets operating in the WCPFC-CA (e.g. Abraham & Richard, 2017; Pacific Islands Regional Office, 2018). We plan to compare our derived estimates for relevant fleets against existing estimates, to the extent possible.

Finally, review of data summaries prepared for the 2018 BMIS workshop (Common Oceans (ABNJ) Tuna Project, 2018) suggested that there may be additional seabird bycatch related data, e.g. related to mitigation, that had not been successfully migrated to SPC's master observer database from 'non-standard' observer data submissions, i.e. data that was not collected on SPC/FFA forms. Work is ongoing to ensure that all relevant data are incorporated in SPC's observer database.

5 Recommendations

We recommend that the Scientific Committee:

- Consider the work undertaken to date.
- Take note of high latitude areas with substantial fishing effort and limited levels of available observer coverage.
- Take note of fleets for which SPC holds no observer data (and no observer data that is likely to be representative of seabird bycatch for the fleets concerned), and for which seabird bycatch estimation is thus unlikely to be achievable.
- Consider the work plan for Project 68 in the context of work undertaken to date.

Acknowledgements

The funding for Project 68 comes from the WCPFC Commission and the GEF-FAO Common Oceans project.

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Annex I – Effect plots of preliminary bycatch rate models

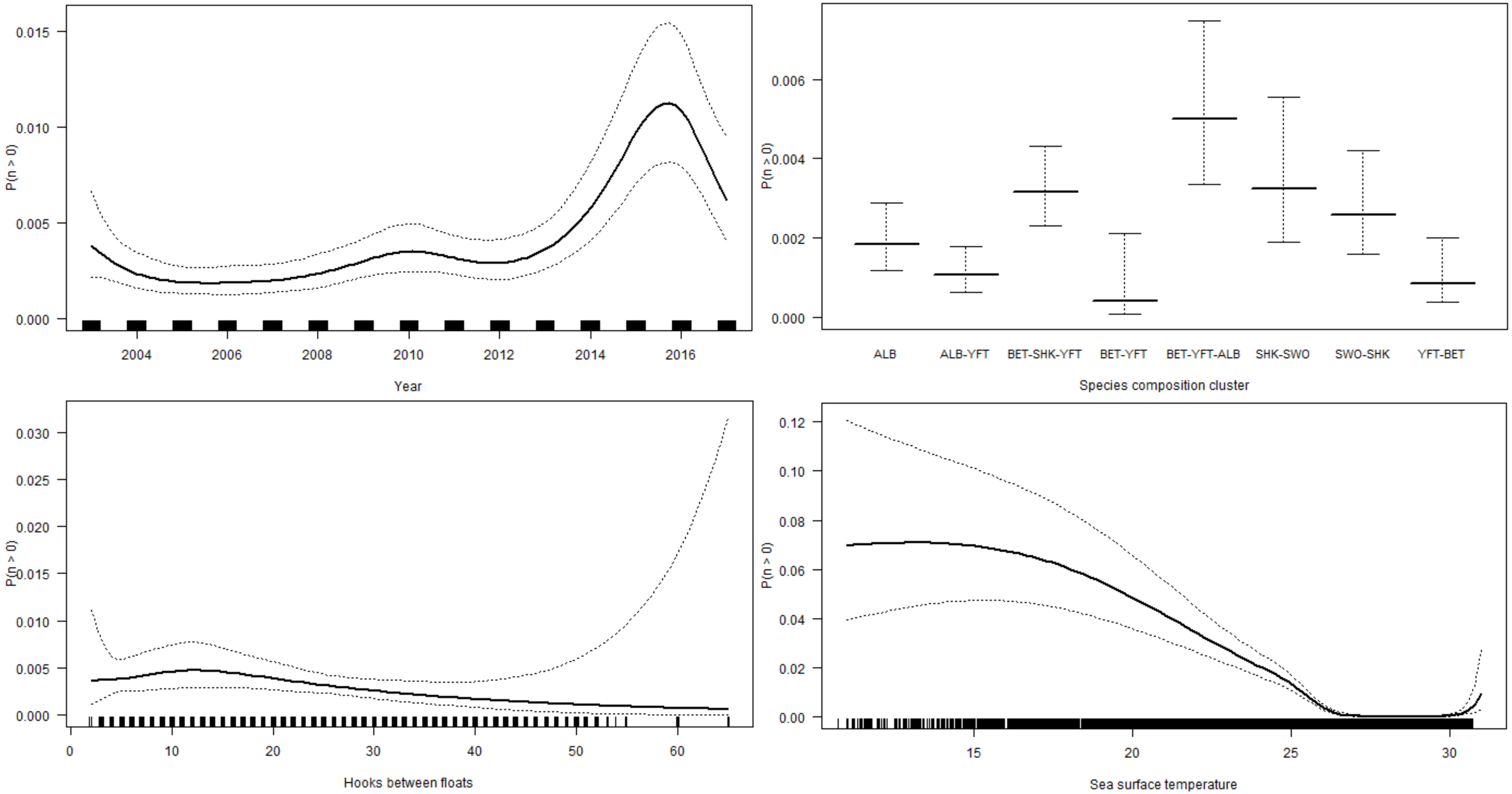

Figure 5 Effects plots for the delta component of the albatross model: year (top left), aggregate catch composition cluster (top right), HBF (bottom left) and sea surface temperature (bottom right). Reference levels for explanatory variables were: year = 2011, cluster = 'BET-SHK-YFT', hbf = 25, sst = 26.1°C. Note that the uncertainty in mean response incorporates uncertainty from all model parameters.

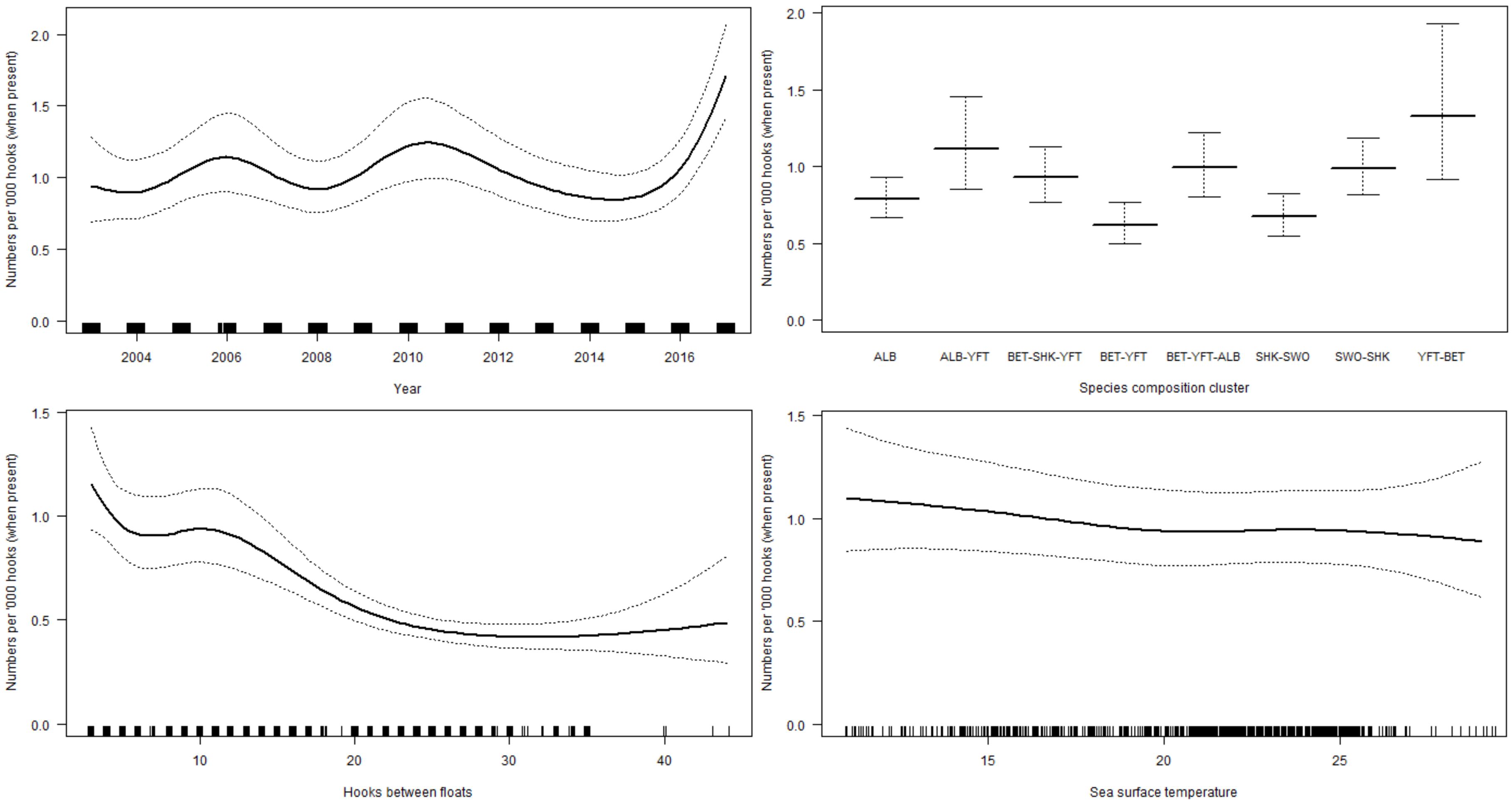

Figure 6 Effects plots for the lognormal component of the albatross model: year (top left), aggregate catch composition cluster (top right), HBF (bottom left) and sea surface temperature (bottom right). Reference levels for explanatory variables were: year = 2013, cluster = 'BET-SHK-YFT', hbf = 11, sst = 20.8°C. Note that the uncertainty in mean response incorporates uncertainty from all model parameters.

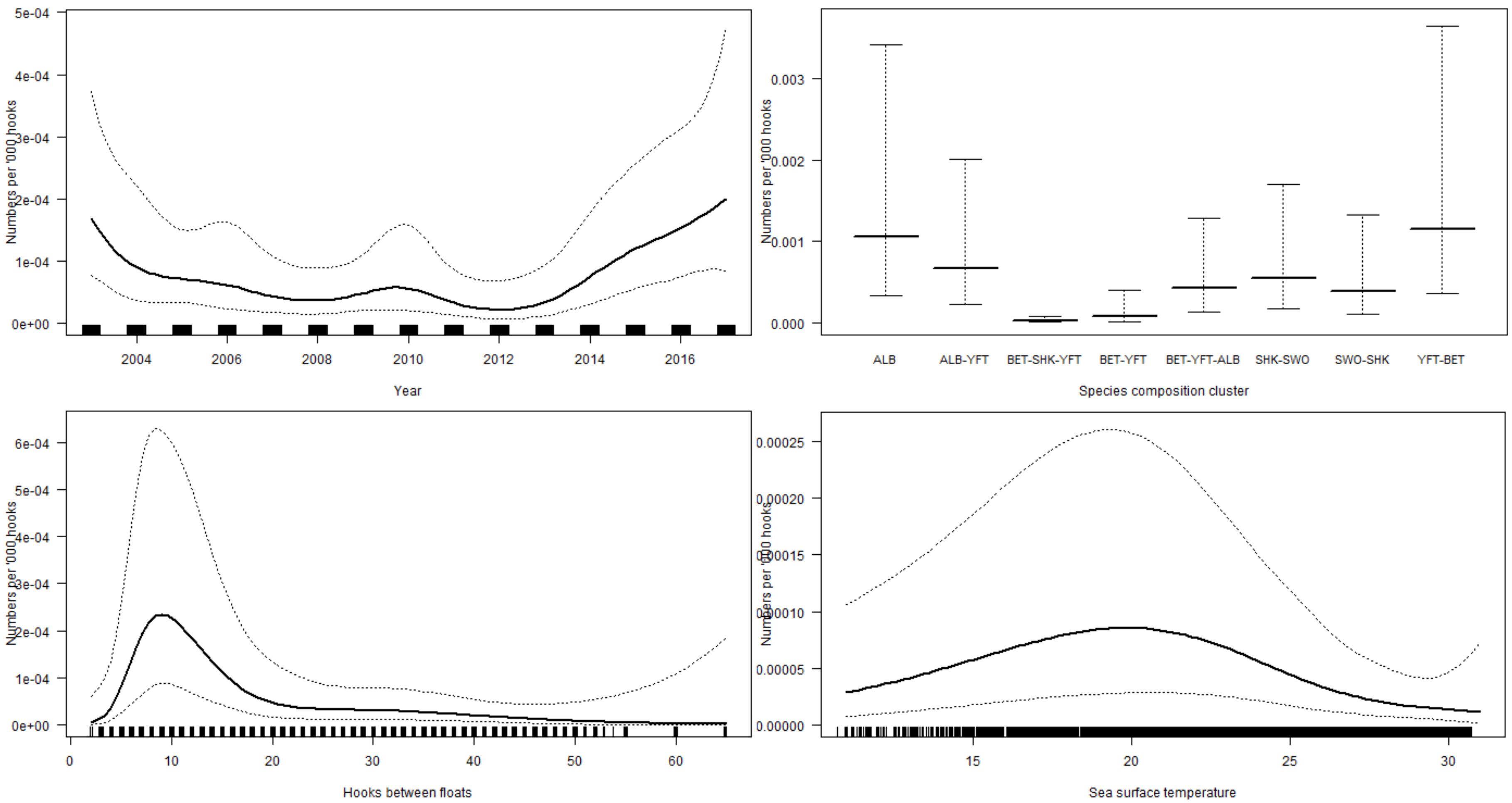

Figure 7 Effects plots for the puffins and petrels model: year (top left), aggregate catch composition cluster (top right), HBF (bottom left) and sea surface temperature (bottom right). Reference levels for explanatory variables were: year = 2011, cluster = 'BET-SHK-YFT', hbf = 25, sst = 26.1°C. Note that the uncertainty in mean response incorporates uncertainty from all model parameters.