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Estimated capture of seabirds in New Zealand trawl and longline fisheries, 2002–03 to 2015–16

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Interactions with commercial fisheries can lead to the incidental capture of non-target species, such as seabirds and marine mammals. In New Zealand waters, captures of seabirds and other protected species are recorded by government observers when they are on-board commercial fishing vessels. These data are used in bycatch assessments to estimate the number of seabirds that would be reported caught if every commercial vessel fishing within New Zealand's Exclusive Economic Zone carried an observer.

This study presents the most recent bycatch assessment, including the 2015–16 fishing year. The assessment was based on statistical models that were used to obtain estimates of total seabird captures across all commercial trawl and longline fisheries. The time periods covered in this estimation were the 2002–03 to 2015–16 fishing years for trawl fisheries, and the 1998–99 to 2015–16 fishing years for longline fisheries.

The present assessment used a unified modelling framework to estimate incidental captures of seabirds for ten species and species groups: New Zealand white-capped albatross (*Thalassarche steadi*), Salvin's albatross (*Thalassarche salvini*), Buller's albatross (*Thalassarche bulleri*, combining both southern *T. b. bulleri* and northern *T. b. platei* subspecies), white-chinned petrel (*Procellaria aequinoctialis*), black petrel (*Procellaria parkinsoni*), grey petrel (*Procellaria cinerea*), sooty shearwater (*Puffinus griseus*), and flesh-footed shearwater (*Puffinus carneipes*). Estimates were also derived for seabirds grouped as either "other albatrosses" or "other birds".

The estimation revealed a total of 4517 (95% c.i.: 3760–5825) seabird captures in trawl and longline fisheries (c.i., credible interval, the 95th quantile range of the posterior distribution) in 2015–16. The total estimate included 1695 (95% c.i.: 1462–1998) seabird captures in trawl fisheries, 1982 (95% c.i.: 1343–3196) captures in bottom-longline fisheries, and 839 (95% c.i.: 632–1157) captures in surface-longline fisheries.

For individual seabird species included in the modelling, white-chinned petrel had the highest number of total estimated captures in 2015–16, with 1041 (95% c.i.: 577–2156) captures of this species. The second highest estimate was 496 (95% c.i.: 393–633) captures of New Zealand white-capped albatross, followed by 469 (95% c.i.: 299–751) captures of flesh-footed shearwater. Capture estimates for other species included 435 (95% c.i.: 291–679) captures of Salvin's albatross, 360 (95% c.i.: 194–733) captures of black petrel, 358 (95% c.i.: 274–480) captures of Buller's albatrosses, 266 (95% c.i.: 169–450) captures of sooty shearwater and 197 (95% c.i.: 72–517) captures of grey petrel. In addition to estimates for individual species, capture estimates for species groupings were 585 (95% c.i.: 404–866) captures of other birds and 306 (95% c.i.: 195–500) captures of other albatrosses.

There was a decrease in the total number of estimated captures for seven of the ten modelled species groups between 2002–03 and 2015–16. For three species, Salvin's albatross, white-chinned petrel and grey petrel, there was no distinct decrease in total captures over the assessment period; only white-chinned petrel had higher mean estimated captures in 2015–16 than in 2002–03. Across all trawl and longline fisheries, the mean number of seabird captures was lower in 2015–16 than in any year in the series. This decrease largely corresponded with decreases in fishing effort over the reporting period.

Large-vessel fisheries had sufficient captures to allow time-trends in capture rates to be estimated In large-vessel squid trawl fisheries, there was an initial decrease in albatross captures after the introduction of mandatory warp mitigation before the 2006–07 fishing year, but capture rates showed an increase between 2013–14 and 2015–16. Capture rates of petrels in large-vessel squid trawl fisheries showed a distinct pattern of higher captures in alternate years. The reasons for this distinct fluctuation are unknown.

This analysis depends on observer coverage. Observer coverage remains low in small-vessel inshore fisheries where many seabird captures are estimated to occur. Increasing observer coverage in small-

vessel fisheries would reduce uncertainty in bycatch estimates.

1. INTRODUCTION

Interactions with commercial fisheries can lead to the incidental capture of protected species, including seabirds. In New Zealand waters, fisheries observers on-board commercial fishing vessels document the incidental captures of seabirds (and other non-target species), including their number and identification. These observer data provide an independent and systematic record, which can be used in bycatch assessments that estimate the total number of incidental seabird captures in commercial fisheries within New Zealand's Exclusive Economic Zone.

These bycatch assessments are regularly carried out for fisheries with sufficient observer coverage, including trawl, surface-longline and bottom-longline fisheries (most recently 2014–15). Owing to limited observer coverage in small-vessel fisheries, the assessments are generally focused on large-vessel fisheries, although increases in observer effort in the former fisheries has led to their inclusion in recent bycatch assessments.

The most recent analysis of incidental seabird captures included data up to the 2014–15 fishing year (Abraham & Richard 2018). The current assessment provides an update of this analysis by including observer records of seabird captures from the 2015–16 fishing year. The time periods covered in the present estimation were from 2002–03 to 2015–16 for trawl fisheries, and from 1998–99 to 2015–16 for longline fisheries.

This analysis followed the same approach as recent bycatch assessments, using a unified modelling framework, allowing direct comparisons across species (Abraham & Richard 2017, 2018). The modelling is based on a hierarchical mixed-effects generalised linear model (GLM) that is fitted using Bayesian methods. Specifically, the current study assessed how many seabirds would be reported caught if every trawl and longline vessel had an observer onboard. The impact of these captures on seabird populations was not considered. Seabird mortalities that would not be reported by observers were also excluded from the assessment. For example, birds may get hooked but fall off the line before they are brought onboard the vessel, and seabird captures may occur while the observer is not on duty. These additional fatalities were not considered in this analysis.

2. METHODS

The current estimation of seabird captures in New Zealand fisheries followed methods used in previous bycatch assessments, based on a unified modelling framework (Abraham & Richard 2017, 2018). The current assessment extended the range of data included in the modelling to the 2015–16 fishing year, with the data preparation and statistical modelling following the previous estimation methods.

2.1 Data preparation

Government fisheries observers on commercial fishing vessels record captures of protected species, including seabirds and marine mammals. The capture events are recorded on paper forms by the observers, and subsequently entered into a database maintained by the National Institute of Water and Atmospheric Research (NIWA) on behalf of Fisheries New Zealand (previously Ministry for Primary Industries). Currently, data are housed in the Centralised Observer Database (COD; Sanders & Fisher 2010). This information of protected species captures in COD was used in the current analysis (a detailed summary of the preparation of observed protected species capture data is provided by Thompson et al. 2017, with a detailed update in Appendix A).

During preparation of the capture data in the preceding assessment by Abraham & Richard (2018), three inconsistencies were detected in the observer records of protected species captures that were used previously by Abraham & Richard (2017) to estimate seabird captures to the end of the 2013–14 fishing year. First, missing observer trip records were identified and located by Fisheries New Zealand. These additional records improved the coverage of observer data, and reduced the number of unlinked records. Second, all deck captures (seabirds that strike the vessel or land on it) were excluded from the data, as they are not considered to be fishing-related captures. Previously, some deck captures had not been excluded. Third, the current data preparation found that some birds had been erroneously treated as having their identity confirmed by photographs. These three inconsistencies were corrected, resulting in a number of changes compared with data used in previous seabird capture assessments.

In addition to the protected species capture data, fishing effort data were required to allow for the observed captures to be appropriately scaled. Commercial fishing vessels complete a record of all fishing effort on each trip, and these records are provided to Fisheries New Zealand. Skippers complete either a Trawl Catch Effort Processing Return (TCEPR), Trawl Catch Effort Return (TCER), Tuna Longline Catch Effort Return (TLCER), Catch Effort Landing Return (CELR), Lining Catch Effort Return (LCER), Lining Trip Catch Effort Return (LTCER), or Netting Catch Effort Landing Return (NCELR). During the 2007–08 fishing year, inshore trawl fisheries changed from reporting fishing effort on CELR forms to TCER forms. The TCER form requires the recording of the latitude and longitude of fishing effort, instead of only the statistical area. This recording of greater spatial detail has allowed a more accurate understanding of where inshore fishing is occurring. Data from these forms are stored in databases administered by Fisheries New Zealand (Ministry for Primary Industries 2012). In this report, information on station date, position, and effort (either number of trawls, number of hooks, or total net length) was used.

Before carrying out the estimation, the observer data were linked to the effort data reported by the fishers. The linking was carried out by searching for fishing events recorded by the fisher from the same vessel at a similar place and time as recorded by the observer, using the same fishing method and targeting the same species. The criteria for matching the records were progressively relaxed to allow most of the observed fishing events to be associated with fisher-reported effort. In each of the years used in the estimation, over 99% of observed bottom-longline fishing events, 97.5% of observed surface-longline sets, and over 98.5% of observed trawl tows were able to be linked to effort reported by the fisher. A small number of captures occurred during observations, but could not be linked to fishing effort. These unlinked captures were not included in the modelling. For the period from 2002–03 onwards, these unlinked captures were of Salvin's albatross (4 captures), sooty shearwater (3), white-chinned petrel (3), Chatham Island albatross (2), flesh-footed shearwater (2), Campbell black-browed albatross (1), Gibson's albatross (1), and New Zealand white-capped albatross (1).

2.2 Observed seabird captures

There was a total of 281 observed fishing trips that started during the 2015–16 fishing year (Table A-1). Of these trips, there were 243 observer trips that had either longline or trawl fishing reported from them by observers during the 2015–16 fishing year (and within the New Zealand Exclusive Economic Zone). The trips that were excluded from the analysis were mostly extra-territorial trips, i.e., they were entirely outside New Zealand's Exclusive Economic Zone. Captures from these trips are reported through the relevant Regional Fisheries Management Organisations (RFMOs). Of the remaining trips that were excluded, two trips were cancelled, three trips had no fishing activity, two trips had no fishing activity within the 2015–16 fishing year, and eleven trips were by fishing methods (set net, purse seine, or Danish seine) that were not included in this analysis.

The summary based on the observer trip record (Table A-1) contained some errors at the time of the data extract; for example, one fishing trip in 2016 was listed with a start date of 2006. These types of errors result in differences in the number of trips in this year's reporting compared with previous reporting. Nevertheless, the observer trip record is only used for reconciliation purposes, and the modelling estimates in the current assessment were based on observer- and fisher-reported catch effort records.

Seabird captures that occurred on these trips were recorded in COD. During preparation of the data used in this analysis, records from COD were merged with seabird necropsy and photo-identification records provided by Wildlife Management International (WMIL). For the entire assessment period, a total of 167 seabird captures were added to the protected species captures dataset (Table A-2). These captures included records that were in load tables within COD, records where the observer comment indicated that a multiple capture had occurred (even though they only reported a single capture on the form), and birds identified through necropsy or in photographs that had no corresponding record in COD.

There were a number of seabird captures that were excluded from the dataset (Table A-3). During the 2015–16 fishing year, there were 342 deck strikes, i.e., records of birds striking or landing on the vessel that were not associated with fishing activity. Of these deck strikes, 284 records were from a single trip (including 273 common diving petrel, nine broad-billed prion, one white-chinned petrel, and one Gibson's albatross), made by a small bottom-longline vessel fishing for ling and school shark in the Fiordland and Stewart-Snares shelf areas. All of the reported deck captures from this trip were of birds that were released alive. During the 2015–16 fishing year, there was one deck capture that was reported as killed; it was a royal albatross that hit the vessel bridge.

After excluding deck captures, decomposed birds, records that could not be linked to fishing effort, and records that were not bycatch, there remained 697 seabird captures that were reported by observers across trawl and longline fisheries during the 2015–16 fishing year.

Information provided by WMIL, from necropsies and from photographs, was used to identify the species captured (to the species or subspecies level, where possible). During 2015–16, a total of 567 seabird captures were identified by WMIL (Table A-4). Of these identified captures, only 160 records had the identifications applied in the data extract obtained from COD. This discrepancy may cause differences reported here compared with extracts obtained directly from COD.

After applying the WMIL identifications, there were 45 remaining records of birds that were only identified to a generic level (e.g., "albatrosses"). For all seabird captures that had not been identified by necropsy or photograph, an imputation process was used to infer the identification (Thompson et al. 2017). This imputation resulted in changes to the observer-reported identification of 42 captures in the 2015–16 fishing year (Table A-5). After the imputation was applied, there only remained seven seabird captures in 2015–16 that could only be identified to a generic level (Table A-6). The imputation may change the identification each time that it is applied. There were differences between seabird captures by species during 2014–15 and those reported for the same fishing year by Thompson et al. (2017) (Table A-7), however these differences were generally small.

Observers also record information of how birds were caught in the fishing gear. In trawl fisheries, most (399 of 508 captures) of the observed seabird captures during the 2015–16 fishing year were reported as having occurred in the net (Table A-8). In comparison, 52 captures were reported from the warps or doors. Seabird captures were also recorded from the paravane cable (3). In addition, there were 37 birds recorded as deck captures or deck landings in trawl fisheries during 2015–16. These records were not directly associated with fishing gear, and were not included in the estimation.

2.2.1 Seabird bycatch estimation dataset

During the 2015–16 fishing year, there were 697 observed seabird captures in trawl and longline fisheries that were included in the model dataset (Table 1). Observed captures in these fisheries were of a wide range of seabird taxa, with 26 different species (or subspecies) being reported. Of all the seabird captures, 542 captures were seabirds that were dead when they were brought onboard the vessel (or that died before being released). The other captured birds were released alive, but their post-capture survival was unknown. Around three-quarters (76.3%) of the captured birds had their identity confirmed, either from necropsy or from a photograph.

The species that was most frequently observed caught was white-chinned petrel with 239 recorded captures, 34.3% of all observed seabird captures. Of all observed captures of this species, 140 captures were in squid trawl fisheries, and 79 captures were in ling bottom-longline fisheries. Other species with more than ten observed captures were New Zealand white-capped albatross, Southern Buller's albatross, sooty shearwater, Salvin's albatross, flesh-footed shearwater, and black petrel (Table 1).

Observed captures of modelled species groups are summarised by fishing method and vessel class in Appendix B, for the fishing methods and vessel classes that had a mean of over 50 estimated captures over the time period. Detailed data on observed protected species captures, including the location and identification of each capture, are available from the protected species capture website (https://data.dragonfly.co.nz/psc/).

During 2015–16, seabird captures in trawl and longline fisheries occurred throughout the New Zealand region, with clear patterns in the distribution of species (Figure 1). Among the albatrosses, white-capped albatross and Buller's albatross were mainly observed caught in the west and to the south of South Island, whereas Salvin's albatross was mainly observed caught on Chatham Rise, to the east of South Island. There were captures of white-capped albatross reported from the far north of New Zealand; however, the identity of these captures was not confirmed. Captures of larger wandering albatross type species were to the north-east of North Island. Among the shearwaters, there were captures of sooty shearwater in the western Chatham Rise area and to the south of South Island. Captures of flesh-footed shearwaters were on the north-eastern coast of North Island, with some observed captures also in the Taranaki region. The capture of *Procellaria* petrels reflected their breeding locations, with capture records of white-chinned petrel largely to the south and east of South Island, of black petrel on the north-eastern coast of North Island, and observed captures of Westland petrel from the west of South Island. With the exception of a cluster of captures close to New Plymouth, there were few seabird captures during observed fishing on the west coast of North Island. The map of observed captures reflected both seabird distributions and the distribution of observer coverage. In general, observer coverage was concentrated on offshore fisheries, with little observer coverage in trawl or longline fisheries around the coast of South Island or lower North Island (Figure 1).

2.3 Statistical modelling

The methods used for the estimation of total captures followed methods used by Abraham & Richard (2017), with the exception that the data range was extended to cover the periods 1998–99 to 2015–16 for longline fisheries and 2002–03 to 2015–16 for trawl fisheries. Earlier observer records of seabird captures in trawl fisheries were not included in the estimation as they were considered incomplete, due to observers on trawl vessels not focusing on seabird captures during that period. While the model retained the same structure as in the previous estimation, it was reimplemented in the software Stan (Carpenter et al. 2015). This software uses a different algorithm for sampling the posterior distribution, and achieved faster convergence than the JAGS software used previously. Changes were also made to the priors and to the formulation of the overdispersion during the shift of the model from JAGS to Stan.

Generalised linear models (GLMs) were fitted to the observed fishing effort and capture data, and then used to estimate the observable captures on unobserved fishing effort. Bayesian methods were used to fit the models. These methods have the advantage of allowing the complex structures that are appropriate for species that have been frequently observed caught, and they also allow for samples of the estimated quantities. By using the samples, uncertainty in any derived quantities may be obtained, allowing for estimates to be combined or to be reported for different fisheries or for the area breakdowns that were used in the modelling.

Models were fitted for ten species and species groups: New Zealand white-capped albatross (*Thalassarche steadi*), Salvin's albatross (*Thalassarche salvini*), Buller's albatross (*Thalassarche bulleri*, combining both southern *T. b. bulleri* and northern *T. b. platei* subspecies), white-chinned petrel (*Procellaria aequinoctialis*), black petrel (*Procellaria parkinsoni*), grey petrel (*Procellaria cinerea*), sooty shearwater (*Puffinus griseus*), and flesh-footed shearwater (*Puffinus carneipes*). Estimates were also derived for seabirds grouped as either "other albatrosses" or "other birds".

For each model, data were grouped by fishing method, target fishery, vessel size class, spatial area,

Table 1: Number of observed seabird captures during the 2015–16 fishing year, in trawl and longline fisheries, that were included in the model dataset to estimate the capture of seabirds in New Zealand fisheries. Shown for each species group are the total number of captures, the number of captures with a confirmed identification by experts (either through necropsy or photograph), and the number of captures that were dead when brought onboard the vessel.

Common name	Scientific name	Captures	Confirmed	Dead
White-chinned petrel	*Procellaria aequinoctialis*	239	189	198
New Zealand white-capped albatross	*Thalassarche cauta steadi*	147	102	105
Southern Buller's albatross	*Thalassarche bulleri bulleri*	115	100	102
Sooty shearwater	*Puffinus griseus*	62	48	51
Salvin's albatross	*Thalassarche salvini*	40	28	32
Black petrel	*Procellaria parkinsoni*	20	13	10
Flesh-footed shearwater	*Puffinus carneipes*	14	10	8
Westland petrel	*Procellaria westlandica*	13	10	10
Common diving petrel	*Pelecanoides urinatrix*	7	6	2
Antipodean albatross	*Diomedea antipodensis antipodensis*	4	3	3
Campbell black-browed albatross	*Thalassarche impavida*	4	4	4
Grey petrel	*Procellaria cinerea*	3	2	2
Gibson's albatross	*Diomedea antipodensis gibsoni*	3	2	2
Wandering albatross	*Diomedea exulans*	3	2	2
Southern royal albatross	*Diomedea epomophora*	3	3	1
Cape petrel	*Daption capense*	2	1	1
Buller's shearwater	*Puffinus bulleri*	2	1	1
Shearwaters	*Puffinus* spp.	2	0	0
Mid-sized petrels & shearwaters	*Pterodroma*, *Procellaria*, and *Puffinus* spp.	2	0	0
Northern giant petrel	*Macronectes halli*	2	2	2
Snares Cape petrel	*Daption capense australe*	1	1	1
Grey-faced petrel	*Pterodroma macroptera gouldi*	1	1	0
New Zealand white-faced storm petrel	*Pelagodroma marina maoriana*	1	0	0
Great albatrosses	*Diomedea* spp.	1	0	0
Broad-billed prion	*Pachyptila vittata*	1	1	1
Petrels, prions, and shearwaters	*Hydrobatidae*, *Procellariidae*, and *Pelecanoididae*	1	0	1
Chatham Island albatross	*Thalassarche eremita*	1	1	1
Black-browed albatross	*Thalassarche melanophris*	1	1	1
Australasian gannet	*Morus serrator*	1	0	0
Grey-headed albatross	*Thalassarche chrysostoma*	1	1	1
Total		697	532	542

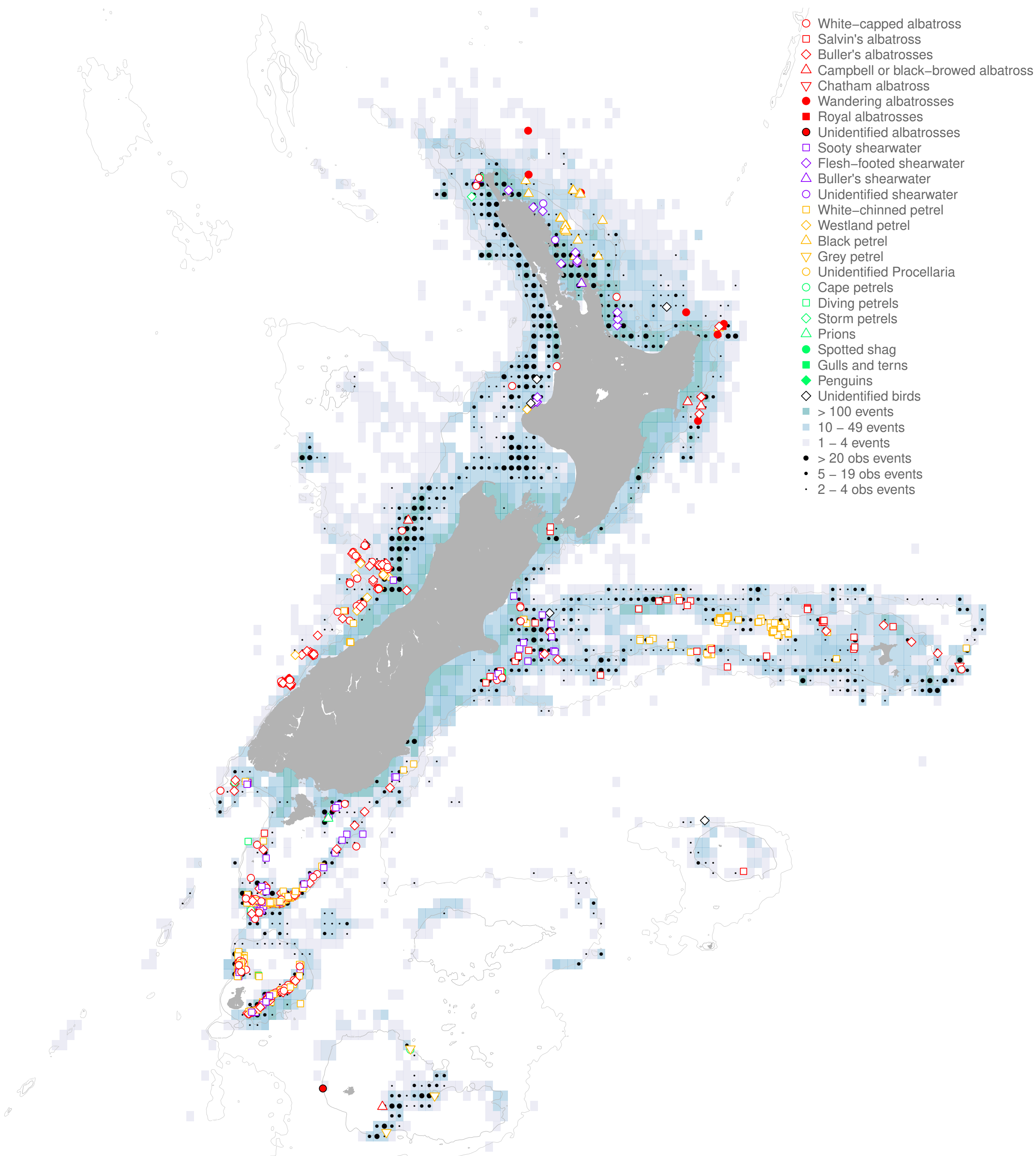


Figure 1: Captures of seabirds recorded during the 2015–16 fishing year in trawl, surface-longline and bottom-longline fisheries. Total fishing effort and the amount of effort observed (as number of fishing events) are also shown.

fishing year, and quarter of the year. Data on mitigation measures (i.e., use of integrated weight line) were also included in the modelling. The capture rate (number of captures per unit fishing effort) was estimated within each of these strata from the observed captures. The capture rate was then applied to unobserved fishing effort to estimate the number of total captures.

To standardise the models across species, a single model structure was used for all species and species groupings, combining all trawl, surface-longline, and bottom-longline fisheries. Observed captures were assumed to follow a negative binomial distribution, similar to the approach taken in other assessments (Baird & Smith 2008, Abraham & Thompson 2011). This distribution provides an adequate representation of capture data, characterised by many zeros and occasional large values. The negative binomial distribution is parametrised by a mean, μ, and an overdispersion, ϕ. The variance is given by $\mu + \mu^2/\phi$. As the overdispersion increases to infinity, the variance nears the mean, and the negative binomial distribution converges to a Poisson distribution. As ϕ gets small relative to the mean, the negative binomial distribution becomes increasingly peaked at zero and becomes right-skewed (i.e., it develops a long right-hand tail). The negative binomial distribution has the convenient property that the sum of n samples drawn from a negative binomial distribution is also negative-binomially distributed, with mean $n\mu$ and overdispersion $n\phi$. This characteristic of the negative binomial distribution allowed the model to be applied to grouped event-level data (multiple fishing events reported as a single record). The Stan parameterisation of the negative binomial was used ('neg_binomial_2').

The mean catch rate for a single fishing event was assumed to vary with:

- $M_{m,v}$: combination of fishing method (m; either trawl, surface-longline, or bottom-longline), and vessel class (v; "large" for vessels with a length over 45 m, 34 m, or 28 m, for surface-longline, bottom-longline, and trawl fishing, respectively, "small" otherwise),
- F: target fishery,
- A: area (see Figure 2),
- R: region ("north" or "south", with "north" being the region including Kermadec Islands, west coast North Island, east of North Island, and north-east areas),
- S: season (period of four months, starting with January–April considered to be summer),
- $Y_{m,v,y}$: year.

The mean catch rate for a single fishing event in the group i of events was assumed to be the product of the effects:

$$\mu_i = \alpha M_{m,v,i} F_i A_i R_i S_i Y_{m,v,y,i}, \tag{1}$$

where α is the intercept, with a log-normal prior, defined with a mean of -3 and a standard deviation of 5 on the log scale.

The area, region, and season effects were assumed to apply to all fisheries, irrespective of the fishing method, fishery, or vessel class. Under this assumption, spatial and temporal effects are primarily determined by the ecology of the species, not by the fishing practices. In contrast, the year effect was estimated independently for each combination of method and vessel class, recognising that inter-annual variations may occur not only due to the ecology of species, but also due to changes in fishing practices.

The main effects of the combination of fishing method and vessel class, and the season and region effects, were modelled as fixed effects, relative to the base case, taken as the combination of method, vessel class, region, and season with the highest number of observed captures, different for each species (see Table 2 for the base levels of these factors for each species). The prior of these fixed effects was a log-normal distribution, having a mean of 0 and a standard deviation of 5 on the log scale. This approach was the same as the previous BUGS model.

The effects of area, fishery, and year were modelled as random effects, with the prior being a gamma distribution. The year effect was only applied to large vessels, because the number of observations in the small-vessel fleet was insufficient to fit a random variable. For each random effect, the shape and rate of the gamma distribution were set to be the same, so that the mean was 1 for each random effect, and set so that the standard deviation of the random effect was drawn from a log-normal distribution (the standard deviation of a gamma-distributed random variable with mean 1 is the inverse of the square-root of the shape). The prior of the standard deviation was a log-normal distribution (with a mean of 0 and a standard deviation of 1, on the log scale), and was truncated to be between 10^{-8} and 5. The random effects were truncated to between 10^{-8} and 10. This truncation assumed that large deviations from the mean (a multiplier over 10) would not be plausible, preventing limitations caused by occasional samples with exceedingly high values affecting the capture estimates; the quantiles of the posterior distributions were assessed to ensure they remained different from this limit.

The overdispersion parameter ϕ had a log-normal prior (with mean 0 and standard deviation 1 on the log scale), truncated to be within the range $1/400$ to 400.

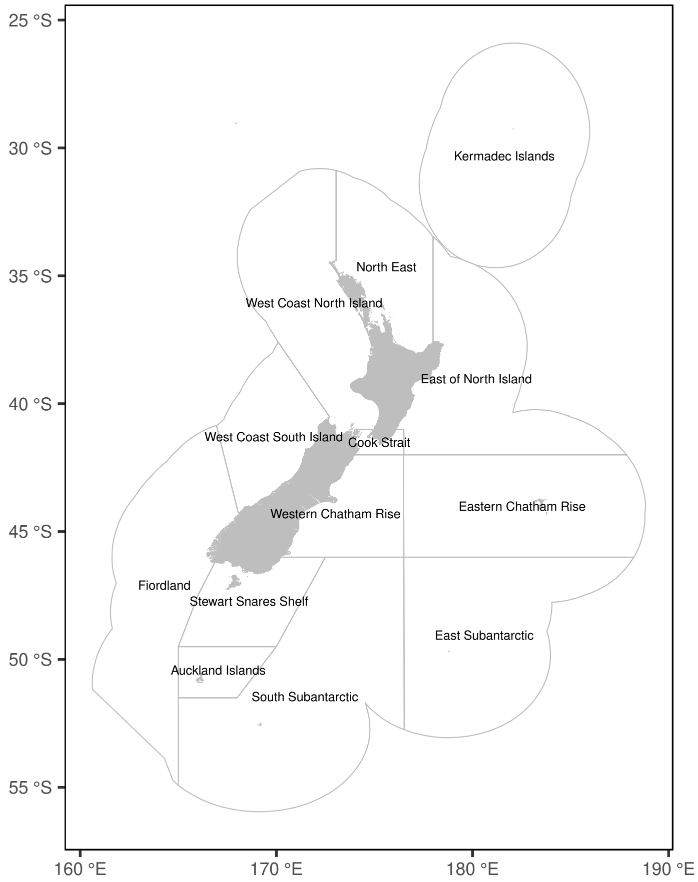


Figure 2: Areas used for the estimation of the number of incidental captures of seabirds in commercial fisheries in New Zealand's Exclusive Economic Zone.

Target fisheries were the same as those used previously by Abraham & Richard (2017, 2018) (see Table 3). They included the split of bottom-longline fisheries targeting ling into three different target fisheries, including small vessels, large vessels using integrated weight lines, and large vessels not using integrated weight lines. This split was prompted by a proportion of large-vessel bottom-longline fisheries using integrated weight lines as a mitigation measure to reduce the capture rate of seabirds. This weighting of lines has been shown to be effective in minimising the time baited hooks are available to seabirds, and was previously found to significantly reduce capture rates in models used for estimating seabird captures (Abraham et al. 2016).

Each model was fitted with the software package Stan (Carpenter et al. 2015), using Markov chain Monte Carlo (MCMC) methods (see Appendix C for the model code). Three chains were fitted to each model, with the output including samples of the posterior distribution from each chain. Model convergence was assessed with diagnostics provided by the CODA package for the R statistical system (Plummer et al. 2006), including the criteria of Heidelberger & Welch (1983) and Geweke (1992). The models were run for 2000 updates during burn-in, and then run for up to a further 40 000 updates, with every 30th sample retained for analysis (i.e., 1334 samples were saved from each chain).

Traces from the posterior chains for the model parameters provide a visual assessment of the performance of the Bayesian model, and indicate parameters that had limited convergence, possibly resulting in unreliable estimates. For each parameter, diagnostics also included testing the number of chains that failed half-width (Heidelberger & Welch 1983) and their convergence (Geweke 1992). In addition, the sample size adjusted for autocorrelation was calculated, and the percentage of samples lost due to autocorrelation in the chains was included in the diagnostics.

To shorten the computing time for fitting the Bayesian models, the data were aggregated by summing the number of fishing events and the number of observed captures by fishing method, target fishery, vessel class, region, area, fishing year, and season.

Table 2: Base levels for fishing method, vessel class, region, and season, for which the number of observed seabirds captures was highest, for the ten models used to estimate the number of incidental captures of ten species groups in commercial trawl, bottom-longline (BLL), and surface-longline (SLL) fisheries. For each model, the effects were estimated relative to these base levels. Cut-off lengths for the large-vessel size class were 45 m, 34 m, and 28 m, for surface-longline, bottom-longline, and trawl fishing, respectively.

Model	Method - vessel class	Region	Season
White-capped albatross	Trawl - Large vessels	South	Summer
Salvin's albatross	Trawl - Large vessels	South	Spring
Buller's albatrosses	SLL - Large vessels	South	Autumn
Other albatrosses	SLL - Small vessels	North	Spring
White-chinned petrel	Trawl - Large vessels	South	Summer
Black petrel	BLL - Small vessels	North	Summer
Grey petrel	BLL - Large vessels	South	Winter
Sooty shearwater	Trawl - Large vessels	South	Autumn
Flesh-footed shearwater	SLL - Small vessels	North	Summer
Other birds	Trawl - Large vessels	South	Summer

Table 3: Summary of total effort, observed effort, proportion of effort observed by modelled fishery, which consisted of a combination of fishing method, vessel class, and target fishery. Also shown are the fishing years during which the fisheries were active, between 2002–03 and 2014–15 for trawl, and between 1998–99 and 2014–15 for bottom-longline (BLL) and surface-longline (SLL) fisheries. Cut-off lengths for the large-vessel size class were 45 m, 34 m, and 28 m, for surface-longline, bottom-longline, and trawl fishing, respectively. IWL: integrated weight line.

Method	Vessel class	Target fishery	Fishing years		Fishing events		
			First	Last	Total	Observed	Proportion (%)
Trawl	Large vessels	Deepwater	2003	2016	76 165	20 391	26.8
		Flatfish	2003	2016	144	0	0.0
		Hake	2003	2016	15 039	4 745	31.6
		Hoki	2003	2016	169 037	35 240	20.8
		Inshore	2003	2016	32 167	1 411	4.4
		Ling	2003	2016	10 738	1 862	17.3
		Mackerel	2003	2016	32 468	14 097	43.4
		Middle depths	2003	2016	42 829	10 011	23.4
		S. blue whiting	2003	2016	11 460	6 120	53.4
		Scampi	2003	2016	9 161	974	10.6
		Squid	2003	2016	66 300	22 748	34.3
	Small vessels	Deepwater	2003	2016	5 955	180	3.0
		Flatfish	2003	2016	277 743	2 047	0.7
		Hake	2003	2016	730	0	0.0
		Hoki	2003	2016	17 469	888	5.1
		Inshore	2003	2016	451 494	8 652	1.9
		Ling	2003	2016	5 862	129	2.2
		Mackerel	2003	2016	93	1	1.1
		Middle depths	2003	2016	63 941	856	1.3
		Scampi	2003	2016	54 972	4 059	7.4
		Squid	2003	2016	4 567	8	0.2
SLL	Large vessels	Albacore	2003	2003	231	224	97.0
		Bigeye	1999	2013	138	113	81.9
		Bluefin	1999	2015	4 357	3 827	87.8
	Small vessels	Albacore	1999	2016	4 039	32	0.8
		Bigeye	1999	2016	43 575	960	2.2
		Bluefin	1999	2016	18 308	1 147	6.3
		Minor species	1999	2016	1 586	42	2.6
		Swordfish	1999	2016	2 913	215	7.4
BLL	Large vessels	Minor species	1999	2016	424	140	33.0
		Bluenose	1999	2006	383	40	10.4
		Hāpuku	1999	2004	14	0	0.0
		Ling, with IWL	2003	2016	9 971	2 551	25.6
		Ling, no IWL	1999	2016	33 538	4 977	14.8
	Small vessels	Ling	1999	2016	52 096	878	1.7
		Minor species	1999	2016	29 977	477	1.6
		Bluenose	1999	2016	50 663	278	0.5
		Hāpuku	1999	2016	35 189	148	0.4
		Snapper	1999	2016	149 193	2 109	1.4

3. RESULTS

3.1 Estimation model fitting

All model parameters, across all ten models, passed convergence and half-width tests for most chains (there were six cases where one of the three chains failed the convergence test). There were no chains where autocorrelation led to a significant reduction in the effective length of the chains (see Appendix D for diagnostics for each of the ten models, and details of each model by region, fishery, vessel size, area, and season strata). The performance of the models written in Stan was better than the performance of the models written in JAGS (Abraham & Richard 2018), particularly for the overdispersion parameter, which previously had autocorrelated chains. In the previous models, some parameters failed half-width tests.

The models were used to estimate captures on the observed fishing, and the comparison of these estimates with the observed captures provided a model diagnostic. For example, in the model of white-capped albatross, the ten strata (where the strata are defined by region, fishery, vessel size, area, and season) with the highest estimated captures on observed fishing all included the observed captures within the 95% credible interval (see Appendix D, Figure D-32). Overall, there were eight strata where the observed captures were outside the 95% credible interval of the estimates, but these strata all had relatively low numbers of captures (Appendix D, Table D-42).

Nevertheless, not all models performed well. For example, the model of other albatrosses indicated there were an estimated 8.82 (95% c.i.: 0–44) captures in observed fishing in the Kermadec Islands area (small-vessel surface longline, spring stratum), but a total of 56 captures were observed (Appendix D, Figure D-35, Table D-51). These captures occurred during only 21 observed fishing events, and were outside of the credible interval predicted by the model when all data were taken into account. Across all the models, white-chinned petrel had the highest number of strata (twelve) where the observed captures were outside the credible interval of the estimated captures on observed fishing (Table D-54).

Considering the model covariates (summarised in Appendix D, e.g., see Table D-41 for the estimated parameters of the white-capped albatross model) showed that in all models, the region, season, fishery, and area parameters had well-constrained values (for example, mean values of these multiplicative effects were less than five). In many cases, the relative values of the parameters appeared qualitatively reasonable. For example, the winter season effect for flesh-footed shearwater had a mean of 0.028 (95% c.i.: 0.001–0.110), indicating a low capture rate when these birds are largely in the Northern Hemisphere (Appendix D, Table D-65).

The models included a fishing-method and vessel-size fixed effect. This inclusion allowed for variation in the base catch rates between hook-based methods (such as surface longline) and trawl to be accounted for. In five of the models, the values of these parameters were occasionally large (i.e.,with mean values exceeding ten), indicating a considerable difference in the capture rates per set between trawl and longline methods. The most pronounced example for large values was the effect for small ($<$43 m length) surface-longline vessels relative to $\geq$28 m trawl vessels in the model of white-chinned petrel captures—this parameter had a mean value of 255 (95% c.i.: 16–1372) (Appendix D, Table D-53). Despite the high value of this parameter, the strata with the highest number of estimated captures were in trawl and bottom-longline fisheries (Appendix D, Table D-52).

3.2 Estimated seabird captures

There was an estimated total of 4517 (95% c.i.: 3760–5825) seabirds captured during the 2015–16 fishing year, including 1695 (95% c.i.: 1462–1998) seabirds in trawl fisheries, 1982 (95% c.i.: 1343–3196) seabirds in bottom-longline fisheries, and 839 (95% c.i.: 632–1157) seabirds in surface-longline fisheries (Table 4, and see Appendix B for detailed estimates for each modelled species group, for the fishing method and vessel classes that had a mean of over 50 estimated captures between 2002–03 and 2015–16).

White-chinned petrel had 1041 (95% c.i.: 577–2156) estimated captures during the 2015–16 fishing year,

Table 4: Number of estimated captures (mean and 95% credible interval, c.i.) for each seabird species group in trawl, bottom-longline (BLL), and surface-longline (SLL) fisheries for the 2015–16 fishing year.

Species grouping	Trawl		SLL		BLL		Total	
	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.
White-capped albatross	329	256–425	143	84–244	24	5–56	496	393–633
Salvin's albatross	290	202–409	6	1–14	138	44–363	435	291–679
Buller's albatrosses	135	99–185	186	120–302	37	15–73	358	274–480
Other albatrosses	30	14–55	141	87–233	134	53–309	306	195–500
White-chinned petrel	252	211–315	46	9–156	742	294–1 822	1 041	577–2 156
Black petrel	43	26–66	101	36–262	215	83–539	360	194–733
Grey petrel	6	3–15	20	8–41	170	47–488	197	72–517
Sooty shearwater	250	156–433	1	0–6	14	1–44	266	169–450
Flesh-footed shearwater	89	45–167	142	46–348	237	134–439	469	299–751
Other birds	267	154–466	48	30–80	268	153–464	585	404–866
All birds	1 695	1 462–1 998	839	632–1 157	1 982	1 343–3 196	4 517	3 760–5 825

the highest estimate of any of the modelled species groups. These captures were estimated to have mainly occurred in trawl and bottom-longline fisheries (Table 4). Other species groups with mean estimated captures of over 400 birds during the 2015–16 fishing year were white-capped albatross, flesh-footed shearwater, Salvin's albatross, and the "other birds" group.

During the 2015–16 fishing year, seabird captures occurred in a wide range of fisheries—there was a mean of over 100 seabird captures for 18 different seabird group and fishing method combinations (Table 4), demonstrating the breadth of seabird captures across species and across fisheries. When grouped by target fishery, there was an estimated mean of more than 100 seabird captures in 14 of the 20 defined target fisheries (Table 5). The target fisheries within each method that had the highest estimated mean seabird captures during this fishing year were trawl fisheries targeting inshore species, with 370 (95% c.i.: 271–495) estimated seabird captures; ling bottom-longline fisheries, with 924 (95% c.i.: 513–1680) estimated seabird captures; and southern bluefin tuna surface-longline fisheries, with 371 (95% c.i.: 285–495) estimated seabird captures.

For seven of the ten modelled species groups, the total number of estimated captures decreased between 2002–03 and 2015–16 (where the decrease was sufficient for the upper credible interval in 2015–16 to be lower than the mean in 2002–03) (Figure 3). Only Salvin's albatross, white-chinned petrel and grey petrel did not show a clear decrease in total captures over this time period, but only white-chinned petrel had higher mean estimated captures in 2015–16 than in 2002–03. When captures in 2015–16 were compared with captures in 2006–07, the changes were considerably less clear, with only black petrel and sooty shearwater showing decreases in total estimated captures over this ten-year period. When all species were combined, the total estimated number of seabird captures showed a clear decrease over the assessment period, with the mean number of seabird captures in 2015–16 at about half the value of the estimated seabird captures in 2002–03.

In the small-vessel fisheries, the models had no year effect, and so changes in the estimated number of captures in small-vessel fisheries corresponded with changes in fishing effort. In large-vessel fisheries, changes in the estimated number of seabird captures also corresponded with changes in fishing effort.

There were marked declines in fishing effort in New Zealand trawl and surface-longline fisheries over the reporting period, and the declines in estimated captures largely corresponded with changes in fishing effort (see Appendix B.1 for time series of total seabird captures and of fishing effort in each of the six vessel-class fishing-method groups, excepting large-vessel surface-longline fisheries data which are restricted by confidentiality requirements). The number of tows in trawl fisheries in 2015–16 was 70% and 46% of the effort in 2002–03, for small-vessel and large-vessel trawl fisheries, respectively.

Large surface-longline vessels stopped fishing in 2015–16, due to changes in the regulation of foreign vessels in New Zealand waters. The number of hooks set in small-vessel surface-longline fisheries in

Table 5: Number of estimated seabird captures in different trawl, bottom-longline (BLL), and surface-longline (SLL) target fisheries for the 2015–16 fishing year. Mean and 95% credible interval (c.i.) of the posterior distribution of total seabird captures, summed over all modelled species groups.

Method	Target fishery	Mean	95% c.i.
Trawl	Inshore	370	271–495
	Squid	361	324–440
	Hoki	237	184–310
	Middle depths	228	158–352
	Flatfish	216	109–406
	Scampi	195	132–283
	Ling	48	24–92
	Deepwater	12	6–20
	Hake	11	9–17
	Mackerel	7	6–12
	S. blue whiting	6	6–6
BLL	Ling	913	524–1 680
	Snapper	339	236–488
	Minor species	260	115–609
	Hāpuku	243	67–824
	Bluenose	225	77–555
SLL	Bluefin	371	285–495
	Bigeye	276	156–500
	Swordfish	160	74–328
	Albacore	17	2–69
	Minor species	12	0–58

2015–16 was 27% of the number of hooks set in 2002–03. Across all surface-longline fishing, the number of hooks set in 2015–16 was 24% of the number of hooks set in 2002–03. In bottom-longline fisheries, the number of hooks set during 2015–16 was 138% and 87% of the number of hooks set during 2002–03, for small- and large-vessel fisheries, respectively.

For the large-vessel fisheries that have had sufficient records of seabird captures, changes in capture rate (birds per unit fishing effort) showed different patterns over time (Figure 4). In large-vessel squid trawl fisheries, a decrease in albatross captures was evident following the introduction of mandatory warp mitigation before the 2006–07 fishing season (i.e., in January 2006). Nevertheless, albatross capture rates increased between 2013–14 and 2015–16.

Capture rates of petrels in the squid trawl fishery showed a distinct pattern of higher captures in alternate years, with a lower capture rate in each of 2009–10, 2011–12, 2013–14, and 2015–16 than in the preceding year. This pattern was evident in observed captures in large-vessel trawl fisheries for both white-chinned petrel (Appendix B, Figure B-17) and sooty shearwater (Appendix B, Figure B-20). The factors determining this variation in capture rates remain unexplored.

In large-vessel hoki trawl fisheries, there was a decrease in albatross capture rates following the introduction of mandatory warp mitigation in January 2006 (Figure 4). Capture rates of albatross then gradually increased between 2007–08 and 2011–12. There were no clear patterns in the capture rate of petrels in large-vessel hoki trawl fisheries. Nevertheless, the capture rates of both petrels and albatrosses were lower in 2015–16 than in 2014–15.

In large-vessel ling bottom-longline fisheries, capture rates peaked in 1999–2000 and 2000–01 for albatrosses and petrels, respectively. Integrated weight line was introduced to ling autoliners in 2002–03. Capture rates have remained relatively stable since then. In 2014–15, all observations were made on vessels without integrated weight line, and in 2015–16, 94% of observed sets were without integrated weight line. There was an increase in the observed capture rates in both of those years (e.g., see Appendix B, Figure B-18).

In large-vessel surface-longline fisheries targeting bluefin tuna, the highest capture rates were of al-

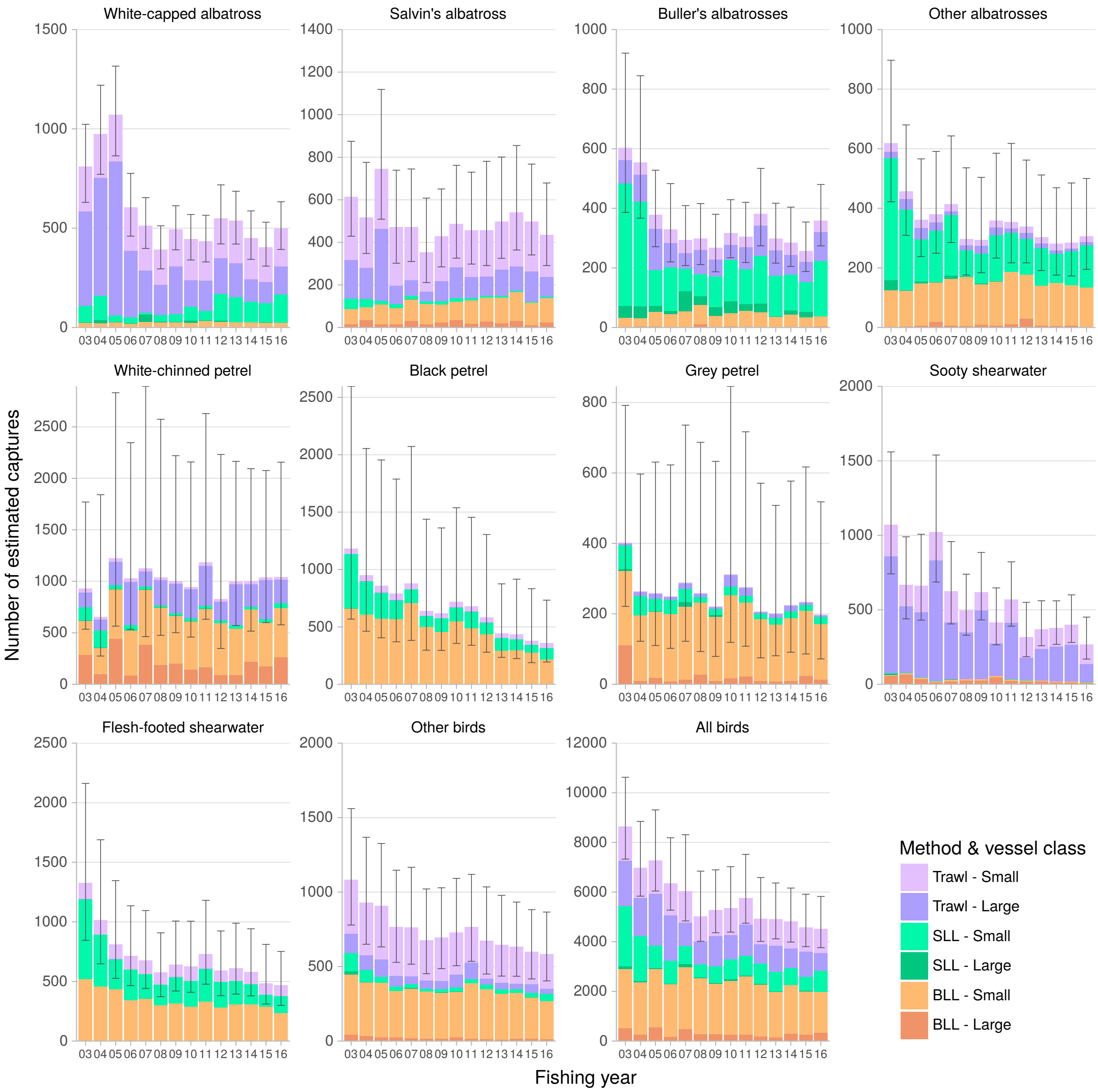


Figure 3: Time series of the number of estimated captures for the seabird species groups and for all birds for the 2002–03 to 2015–16 fishing years. Estimates are shown by fishing method and vessel size class. Cut-off lengths for small and large vessel size classes were 45 m, 34 m, and 28 m, for surface-longline (SLL), bottom-longline (BLL), and trawl fishing, respectively. Coloured bars indicate the mean number of captures, error bars are the 95% credible interval in the total number of estimated captures within each fishing year. (Note different y-axis scales.)

batrosses. Capture rates varied widely. The capture rates often had no or low uncertainty, due to high observer coverage in this fishery, which was frequently 100%. There were no large vessels in this fishery during 2015–16, and so the time series does not continue.

Capture rates in the middle-depths and scampi trawl fisheries did not show consistent trends over time.

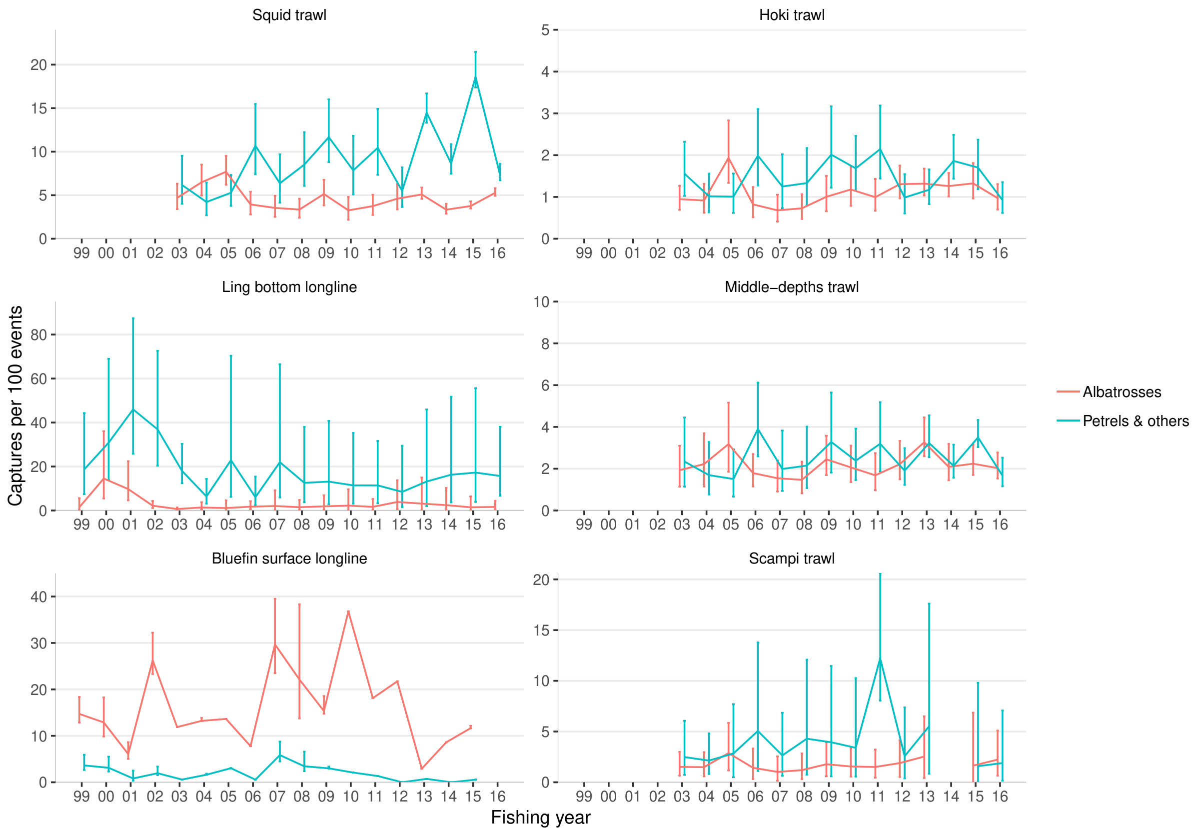


Figure 4: Capture rates (captures per 100 fishing events) of two seabird groupings in selected large-vessel fisheries, for fishing years between 2002–03 and 2015–16 for trawling, and between 1998–99 and 2015–16 for bottom and surface longlining. Cut-off lengths for the large -vessel size class were 45 m, 34 m, and 28 m, for surface-longline, bottom-longline, and trawl fishing, respectively. Lines show the mean estimated capture rate per fishing year; error bars indicate the 95% credible interval of the estimates. (Note different y-axis scales.)

Seabirds were caught across a wide range of fisheries, and many fisheries caught a range of seabird species or species groups (Figure 5). During 2015–16, white-chinned petrel was the species with the highest mean estimated captures in ling bottom-longline, squid trawl, minor-species bottom-longline, and hāpuka bottom-longline fisheries. In bluefin surface-longline fisheries, the highest mean estimated captures were of Buller's albatross and of white-capped albatrosses. In inshore trawl fisheries, the highest estimated mean captures were of white-capped and Salvin's albatrosses. In snapper bottom-longline fisheries, the highest mean estimated captures were of flesh-footed shearwater, the other birds group, grey petrel, and black petrel. In bigeye tuna surface-longline fisheries, the highest mean estimated captures were of flesh-footed shearwater and black petrel.

As in previous years, the spatial distribution of estimated captures in 2015–16 showed distinct patterns for each seabird species group across the different model areas (Figure 6). For most species groups, capture estimates were high in one or two specific areas, with fewer estimated captures in other areas, reflecting the distribution of the species. Estimated captures of black petrel and flesh-footed shearwater primarily occurred in northern areas. Among the three albatross groups, estimated mean captures of white-capped albatrosses were highest on the South Island west coast, and to the south of New Zealand;

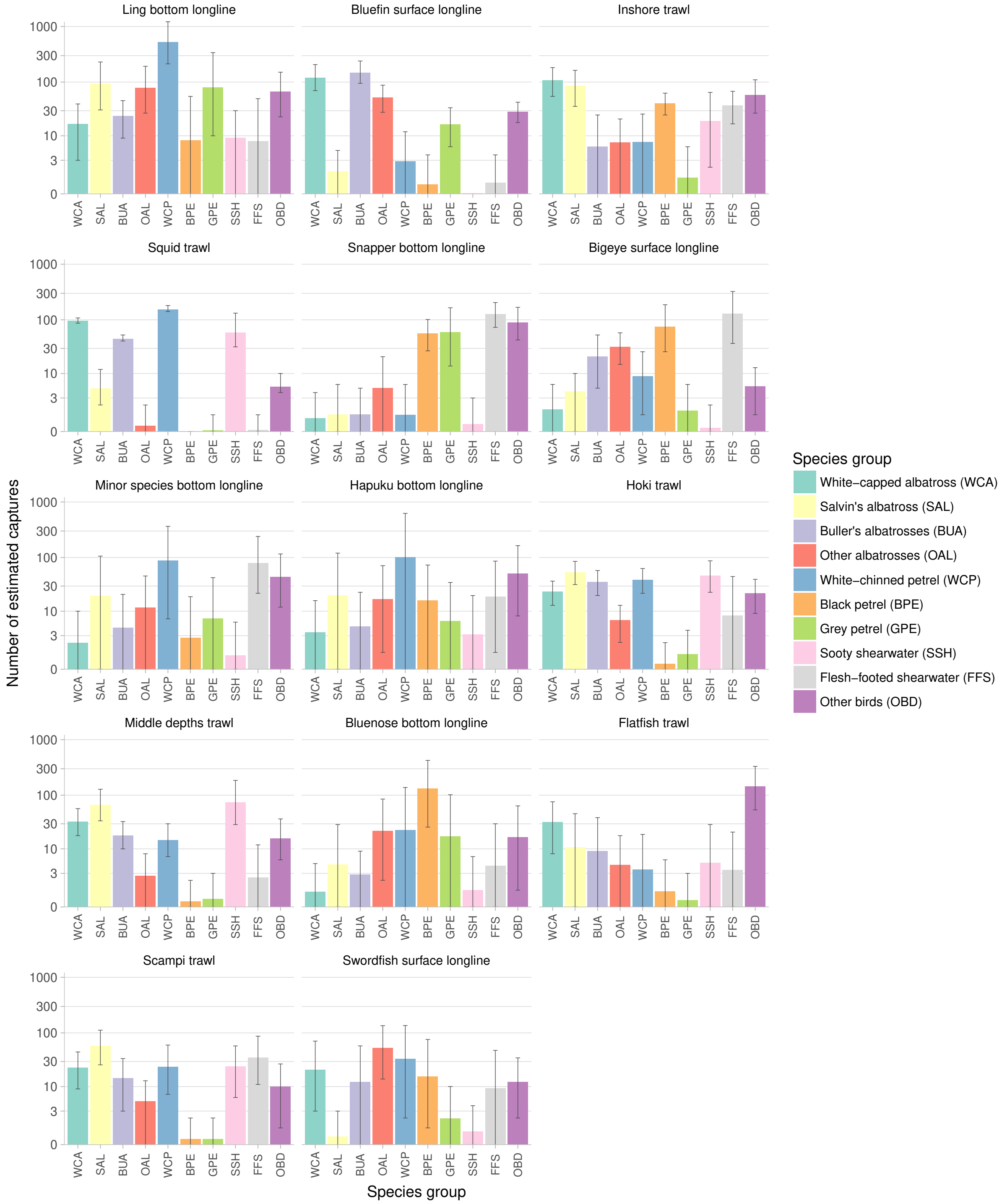


Figure 5: Number of estimated captures for the modelled seabird species groups for the 2015–16 fishing year. For each species group and fishery, the bars show mean captures and the 95% credible interval. The y-axis is on the log plus one scale. Shown are only fisheries that were estimated to have caught a mean of more than 50 birds.

estimated mean captures of Salvin's albatross were higher on the South Island east coast and on Chatham Rise.

Across all species, estimated seabird captures were highest in the north-eastern, Chatham Rise and West Coast areas (Table 6). Captures in the north-eastern area were primarily in bottom-longline fisheries, while captures in the eastern and western Chatham Rise areas were primarily in bottom-longline and trawl fisheries, respectively. During the 2014–15 fishing year, the area with the highest seabird captures was also the north-eastern area (1073 captures; 95% c.i.: 791–1504), while the Stewart-Snares shelf had the second highest number of captures (714 captures; 95% c.i.: 617–889). In 2015–16, estimated mean captures on the Stewart-Snares shelf decreased, and the Stewart-Snares shelf was the area with the sixth highest mean estimated captures (423 captures; 95% c.i.: 342–555).

Figure 6: Estimated captures of seabird species groups by model area in the 2015–16 fishing year. For each of the modelled species groups, the size of the circles is proportional to the mean number of estimated captures in each of the model areas (mean estimated captures of less than one bird are not shown).

Table 6: Number of estimated seabird captures by model area and fishing method in the 2015–16 fishing year (SLL, surface longline; BLL, bottom longline). Mean and 95% credible interval (c.i.) of the posterior distribution of total estimated seabird captures, summed across all modelled species groups. Areas are sorted in decreasing order of the mean number of estimated captures.

Area	Trawl		SLL		BLL		Total	
	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.
North East	106	71–161	262	148–485	536	354–838	905	663–1 306
Eastern Chatham Rise	172	124–236	0	0	633	326–1 344	805	486–1 515
Western Chatham Rise	406	294–580	0	0	212	71–549	619	409–995
West Coast South Island	157	102–242	337	233–510	70	35–137	565	423–763
East of North Island	98	58–162	180	113–296	235	107–527	514	336–839
Stewart-Snares Shelf	400	330–499	0	0	23	1–122	423	342–555
Auckland Islands	210	178–257	0	0	1	0–13	212	179–260
Cook Strait	73	39–120	0	0	93	27–272	166	80–355
West Coast North Island	43	23–78	23	7–56	71	34–141	138	83–226
Fiordland	18	11–32	35	31–59	40	8–153	94	56–212
South Subantarctic	6	6–8	0	0	52	6–218	58	12–224
East Subantarctic	2	2–2	0	0	10	0–62	12	2–64
Kermadec Islands	0	0	0	0–1	0	0	0	0–1

4. DISCUSSION

4.1 Captures of seabird species and species groups

4.1.1 White-capped albatross

White-capped albatross breed on islands in the Auckland Islands and Antipodes Islands groups, with 95% of the population breeding on Disappointment Island. There are around 100 000 annual breeding pairs, with no clear trend in the population over nine years of monitoring (Baker et al. 2015).

Estimated captures of white-capped albatross in large-vessel trawl fisheries showed a decrease from a peak in 2004–05 of 777 captures (95% c.i.: 604–990) to 140 captures (95% c.i.: 123–162) in 2015–16 (Appendix B, Table B-15). The decrease in estimated captures corresponded with a decrease in observed captures, and followed the introduction of mandatory warp mitigation in January 2006 for trawl vessels that are 28 m length or longer (Department of Internal Affairs 2006). The capture rate of white-capped albatross (i.e., captures per one hundred tows) has stayed relatively constant since then.

In small-vessel trawl fisheries, the estimated mean captures of white-capped albatross were higher in 2015–16 than in 2014–15, although the uncertainty was high (Table B-16). Observer coverage in small-vessel trawl fisheries remained low, particularly in southern and west coast South Island areas, where white-capped albatross captures are expected to occur. Reducing the uncertainty in estimated captures of this species requires increased observer coverage in small-vessel trawl fisheries.

4.1.2 Salvin's albatross

Salvin's albatross breed on Bounty Islands, with a recent population estimate of around 40 000 annual breeding pairs (Baker et al. 2014a). A smaller population of around 1500 breeding pairs also breeds on Snares Islands/Tini Heke (Baker et al. 2014b). Salvin's albatross is classified as "nationally critical" by Department of Conservation, due to a very high ongoing or predicted decline (Robertson et al. 2017). Of all New Zealand seabirds, Salvin's albatross are estimated to have the second highest risk of population impacts as a result of fisheries captures (Richard & Abraham 2017).

Observed captures of Salvin's albatross have been reported on the North Island east coast (extending north to offshore Great Barrier Island), and a single Salvin's albatross has been confirmed caught in observed fishing on the South Island west coast (see PSC website, https://data.dragonfly.co.nz/psc/). Salvin's albatross were estimated to be mainly caught in trawl fisheries, on the South Island east coast and Chatham Rise, and most estimated captures were in small-vessel (less than 28 m) trawl fisheries (Table B-19). Salvin's albatross are also caught in bottom-longline fisheries operating on Chatham Rise.

Low observer coverage in small-vessel trawl fisheries on the South Island east coast makes it difficult to assess trends in the capture rate. There have been no Salvin's albatross observed caught in inshore trawl fisheries in the South Island east coast area since the 2010–11 fishing year. In large-vessel trawl fisheries, there has been no clear trend in the estimated number of captures of this species since the introduction of mandatory warp mitigation in January 2007.

4.1.3 Buller's albatrosses

There are two subspecies of Buller's albatross, northern Buller's albatross, which mainly breed on islands in the Chatham Island's group, with a total population of around 16 000 annual breeding pairs (Baker et al. 2017); and southern Buller's albatross, which mainly breed on Snares Islands/Tini Heke, with a total population of around 14 000 annual breeding pairs (Sagar et al. 2017). Trends in the population of northern Buller's albatross are not well known, although the population is considered to be stable, with the current population estimate similar to that in 1991 (Roberstons 1991). The population of southern Buller's albatross increased to a peak in 2005–06, and has remaining stable since then. Adult survival decreased from 0.95 before 2005–06, to around 0.91 subsequently (Sagar et al. 2017).

In the current assessment, the two subspecies were combined owing to some uncertainty in their identification. Only eight Buller's albatross have been necropsied and identified as northern Buller's albatross, compared with 590 individuals that have been identified as southern Buller's albatross (data from the PSC database). It is unknown whether this disparity reflects difficulty in separating the two subspecies, or if there is a marked difference in the interactions between the two subspecies and fisheries.

Buller's albatrosses were caught in a range of fisheries, including trawl fisheries to the south and east of South Island, and in surface-longline fisheries operating on the South Island west coast. In 2015–16, the large-vessel Japanese surface-longline fishery left New Zealand, and was replaced by a smaller domestic fleet. This fleet operated closer inshore and further north than the Japanese fishery. During the 2015–16 fishing year, there was a high number of observed captures of southern Buller's albatross recorded from this domestic fishery (a total of 43 captures, based on 13% observer coverage); the observed capture rate was also high (Table B-22). The captures were not evenly distributed across the eight observed vessels, but one vessel caught 26 southern Buller's albatross.

The model of captures in small-vessel fisheries did not have a year effect, and there was a moderate increase in the total estimated captures of Buller's albatross in small-vessel longline fisheries, from 99 (95% c.i.: 47–189) estimated captures in 2014–15 to 167 (95% c.i.: 104–278) estimated captures in 2015–16. Some of these estimated captures were in the small-vessel surface-longline fishery on the east coast of North Island.

4.1.4 Other albatrosses

A range of other albatross species were caught in fisheries during 2015–16, including Antipodean albatross, Gibson's albatross, wandering albatross, southern royal albatross, Chatham Island albatross, black-browed albatross, and grey-headed albatross (see Table 1). In the estimation carried out here, these species were grouped together. Most of the estimated captures of this group occurred in surface- and bottom-longline fisheries (Appendix B, subsection B.5).

4.1.5 White-chinned petrel

White-chinned petrel breed at eight different subantarctic island groups, with New Zealand waters supporting about a third of the global population (Rexer-Huber 2017). The estimated population size in New Zealand is 204 725 to 368 125 breeding pairs, with the largest population at Antipodes Islands (Sommer et al. 2010, Sommer et al. 2011, Rexer-Huber et al. 2016).

White-chinned petrel are frequently caught in trawl and longline fisheries. In 2015–16, the highest number of estimated captures was in large-vessel bottom-longline fisheries (Appendix B, subsection B.6), on vessels targeting ling, particularly on the Stewart-Snares shelf and on eastern Chatham Rise.

Integrated weight line was introduced in large-vessel bottom-longline fisheries in 2002–03. Since then, around half of the fishing effort by large bottom-longline vessels has been with integrated weight line (Figure 7). Between 2006–07 and 2013–14, observer effort was low for fishing without integrated weight line. In 2014–15 and 2015–16, however, all the observed effort was on vessels using integrated weight line. Throughout the reporting period, observed captures of white-chinned petrel occurred predominantly when no integrated weight line was used, with a rise in observed captures during 2015–16. This bias of observer coverage towards vessels not using integrated weight line is the reason that estimated capture rates of white-chinned petrel in large-vessel bottom-longline fisheries did not follow the observed capture rate (Appendix B, Table B-26). The high uncertainty in the estimated captures was largely associated with fishing by vessels without integrated weight line.

Observed capture rates of white-chinned petrel in large-vessel trawl fisheries fluctuated, with distinct peaks in alternate years (Appendix B,). Similar fluctuations were evident in the captures of sooty shearwater, although they were less distinct in recent years. The fluctuations are evident in both the observer data and the estimated captures. The reason for these fluctuations is unknown. Exploration of the variation in either the spatial distribution or the timing of the observed captures may help to understand the cause of these fluctuations.

4.1.6 Black petrel

Black petrel breed in Hauraki Gulf, on Great Barrier Island/Aotea Island and Te Hauturu-o-Toi/Little Barrier Island, with an estimated population size of 1400 to 1600 breeding pairs (Bell et al. 2016a, Bell et al. 2016b). The conservation status of this species is “nationally vulnerable” owing to the small population size and predicted decline of 10 to 50% (Robertson et al. 2017). Black petrel was identified in the seabird risk assessment as the species with the highest risk ranking in relation to New Zealand commercial fisheries, particularly in surface-longline fisheries targeting bigeye tuna, bottom-longline fisheries targeting snapper and bluenose, and inshore trawl fisheries (Richard & Abraham 2017).

Estimated captures of black petrel were highest in small-vessel bottom-longline fisheries, particularly bluenose and snapper target fisheries in the north-eastern area. Observer coverage in these fisheries was consistently low, reaching 4.6% in 2015–16. The low observer coverage led to high uncertainty in the estimated captures, with a 95% credible interval of 83 to 539 captures during 2015–16 (Appendix B, Table B-30). Increasing observer coverage in the fisheries where black petrel are likely to be caught is crucial for reducing uncertainty in the estimated captures of this species.

There has been a marked decline in the estimated total captures of black petrel, associated with a decrease in fishing effort Figure 3 in the fisheries where black petrel are caught. Mean estimated captures decreased by around two-thirds between 2002–03 and 2015–16. The capture rate per fishing event may not have changed (there has been insufficient observer coverage in fisheries that target black petrel for changes in capture rate to be assessed), however, this decline in the total captures will have benefits for the black petrel population.

4.1.7 Grey petrel

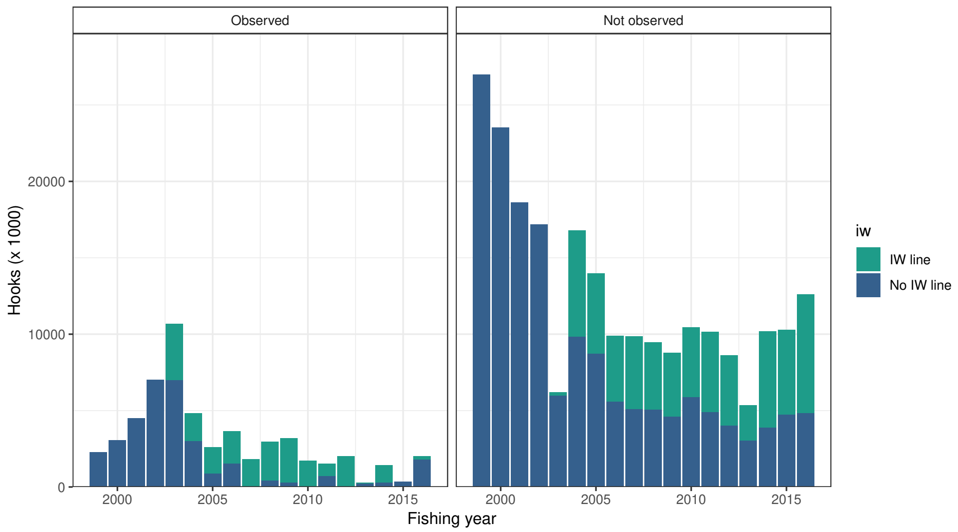
Grey petrel has a circumpolar distribution, with breeding in New Zealand restricted to Campbell and Antipodes islands (Parker et al. 2017); there are 32 000 to 73 000 breeding pairs in New Zealand (Bell et al. 2013). Grey petrel breed over winter, from April through to November.

The highest estimated captures of grey petrel were in small-vessel bottom-longline fisheries targeting snapper in north-eastern North Island during winter (Appendix D.7). However, during the period covered by the estimation (1998–99 to 2015–16), there was no observer coverage of snapper bottom-longline fisheries during the winter. The lack of observer coverage in this fishery during the middle of the grey petrel breeding season results in a fundamental uncertainty about grey petrel bycatch.

4.1.8 Sooty shearwater

Sooty shearwater has a high population abundance in New Zealand, with an estimated 5 million breeding pairs in this country (Waugh et al. 2013). Captures of sooty shearwater occurred mostly in large-vessel trawl fisheries, with some fluctuations in the number of observed captures in recent fishing years (Appendix B, subsection B.7). Overall, estimated captures of this species have shown a decrease since 2007, including a marked decline in the most recent fishing year to 121 (95% c.i.: 87–178) estimated captures, compared with 246 (95% c.i.: 188–334) estimated captures in large-vessel trawl fisheries in 2014–15 (with similar observer coverage at around 45%). These captures are low, relative to the population size, and so the sooty shearwater population is not thought to be at risk from fisheries impacts (Richard & Abraham 2017).

(a)



(b)

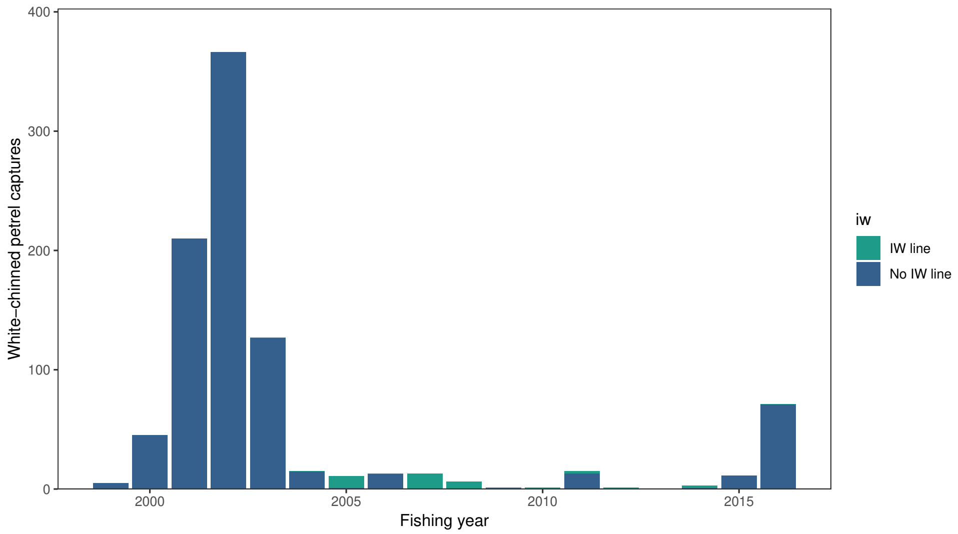


Figure 7: Usage of integrated weight (IW) line in large-vessel bottom-longline fisheries (vessels over 34 m length), distinguished by the use of IW line in New Zealand waters between 1998–1999 and 2015–16. Data are (a) usage of IW line in unobserved and observed fishing, (b) captures of weight-chinned petrel in observed fishing.

4.1.9 Flesh-footed shearwater

Flesh-footed shearwater is a species that is at high risk of population impacts as a result of fisheries bycatch (Richard & Abraham 2017). Flesh-footed shearwater breed at around 20 colonies in northern New Zealand and Marlborough Sounds, with current indications that the populations are declining (Waugh et al. 2013). In addition to captures in commercial fisheries, there is evidence that flesh-footed shearwater are caught in recreational fisheries (Miskelly et al. 2012).

Flesh-footed shearwater were mainly estimated to be caught in small-vessel bottom-longline, surface-longline, and trawl fisheries (Appendix B, subsection B.10), with observed captures being reported from the Northland-Hauraki and Bay of Plenty areas. Because no inter-annual variation was included in the small-vessel models, changes in the captures of flesh-footed shearwater are associated with changes in fishing effort.

Since 2012–13, there have been observations of small-vessel bottom-longline vessels in the Taranaki region, mainly in the gurnard fishery that operates along the northern coast of Taranaki Peninsula (see PSC website, https://data.dragonfly.co.nz/psc/). In 2014–15, there were eight captures of flesh-footed shearwater in this fishery, with three captures in 2015–16. These captures coincided with increases in observer coverage, illustrating that the increases in the latter from previously low observer coverage (or unobserved fisheries) may reveal capture patterns that were previously unknown.

4.1.10 Other birds

Seabird species with the highest observed captures within the other birds grouping were Westland petrel and common diving petrel (see Table 1).

Westland petrel breed exclusively on the South Island west coast, and their population includes 2954 to 5137 annual breeding pairs (Wood & Otley 2013). Owing to its restricted distribution, Westland petrel is considered naturally uncommon (Robertson et al. 2017). It was estimated to be at high risk from commercial fishing impacts in New Zealand waters in the recent risk assessment (Richard & Abraham 2017).

Westland petrel were most frequently caught in surface-longline fisheries targeting southern bluefin tuna, particularly in small-vessel fisheries. Observer coverage in these fisheries has been consistently low at less than 10%, although it was 13% in 2015–16, when ten captures were observed in these fisheries. The domestic fleet that replaced the Japanese southen-bluefin longline fleet in 2015–16 fishes further to the north, closer to the Westland petrel breeding colony.

4.2 Model framework

4.3 Reimplementation in Stan

The modelling approach in the present study followed the framework developed by Abraham & Richard (2017). This framework used a consistent model structure to estimate the captures of ten different species groups across all trawl and longline fisheries. The current modelling approach simplified previous bycatch assessments, which had different model structures and covariates for each seabird species and fishing method (Abraham et al. 2013, Abraham et al. 2016). In this assessment, the model was reimplemented in the software Stan, and this implementation resolved some limitations of the previous modelling associated with convergence of some of the model parameters.

There was close agreement in both the mean and uncertainty in estimated seabird captures from this model and from the previous model (Figure 8). This finding indicated that reimplementing the model in the Stan framework did not greatly affect the results. In small-vessel trawl fisheries, the results from the current model revealed lower estimates than estimates from the previous model (although the credible intervals overlapped the means). Similarly, in small-vessel bottom-longline fisheries, the mean estimated captures from the current model were higher in all years than they were when estimated using the previous model. In small-vessel fisheries, the model had no year effect, and there was a change in the mean captures that influenced the estimates in all years. This change may partly have been due to new data from the 2015–16 fishing year. For example, in small-vessel trawl fisheries, around 15% of the observed fishing effort included in the current model was during the 2015–16 fishing year.

4.4 Comparison with the seabird risk assessment

The estimated captures from the current analysis also allowed a comparison with results from the seabird risk assessment (SRA; Richard & Abraham 2017). The seabird risk assessment estimates captures for each species, with annual average captures estimated over the three fishing years between 2012–13 and 2015–16. In most cases, the uncertainty from the risk assessment was considerably smaller than the uncertainty from the generalised linear model (Figure 8). In part, this difference was due to differences in the estimation methods; the total estimates from the SRA were obtained by combining many different independent estimates (the SRA produces estimates for 71 different seabird species). Correlation in captures between different species was not considered in either framework. The smaller uncertainty in the estimates from the SRA was also associated with a simpler model structure, which assumed that the captures were directly related to the seabird distribution.

In one case, large-vessel surface longline, the uncertainties in the SRA were higher than in the present study. This difference was also related to the different methods, as the SRA is used to estimate captures across all fishing effort, whereas the generalised linear model was used to estimate captures across the unobserved fishing effort. For large-vessel surface longline, close to 100% of the fishing effort in recent years was observed, so that the uncertainty in the generalised linear model was low.

In general, the mean estimates from the SRA were lower than they were from the generalised linear model, based on a comparison for each of three fishing years used in the SRA, across the three fishing methods and vessel size-class groupings. In 14 of the 18 cases, the mean estimate of total seabird captures from the SRA was lower than from the generalised linear model. This discrepancy was most obvious in bottom-longline fisheries. One source of differences is the different time period used in the two modelling approaches. In the generalised linear model, the data period started in 1998–99 for longline fisheries, and in 2002–03 for trawl fisheries. In contrast, the data used in the seabird risk assessment went back to 2006–07. In addition, in large-vessel bottom-longline fisheries, there were sporadic records of very high captures of seabirds on sets that did not use integrated weight line. These captures were in fishing years before the period included in the risk assessment. As some large-vessel fishing without integrated weight line is ongoing, it is possible that large capture events may still occur.

The risk assessment was intended for estimating captures for species where few captures have been observed. It is possible that for species with many observed captures, the generalised linear model provides more accurate estimates.

4.5 Limitations and possible developments

The model framework used here was designed for consistent application across all species and fisheries. This framework is adequate for the estimation of total seabird bycatch. One option for improving the model structure would be the inclusion of correlations between the effects. For example, in the current model, the spatial structure was represented as discrete areas. Using a smaller grid, and then allowing for spatial correlations, would allow for the seabird distributions to be inferred. Spatio-temporal modelling would allow both spatial and temporal variations to be inferred, replacing both the spatial and seasonal factors. Similarly, auto-correlation in the year effects may allow for annual variation to be included in the small-vessel models.

Another simplifying assumption in the current assessment was that the models of each species are independent. If variations in capture rate are influenced by annual variation in the timing of migration,

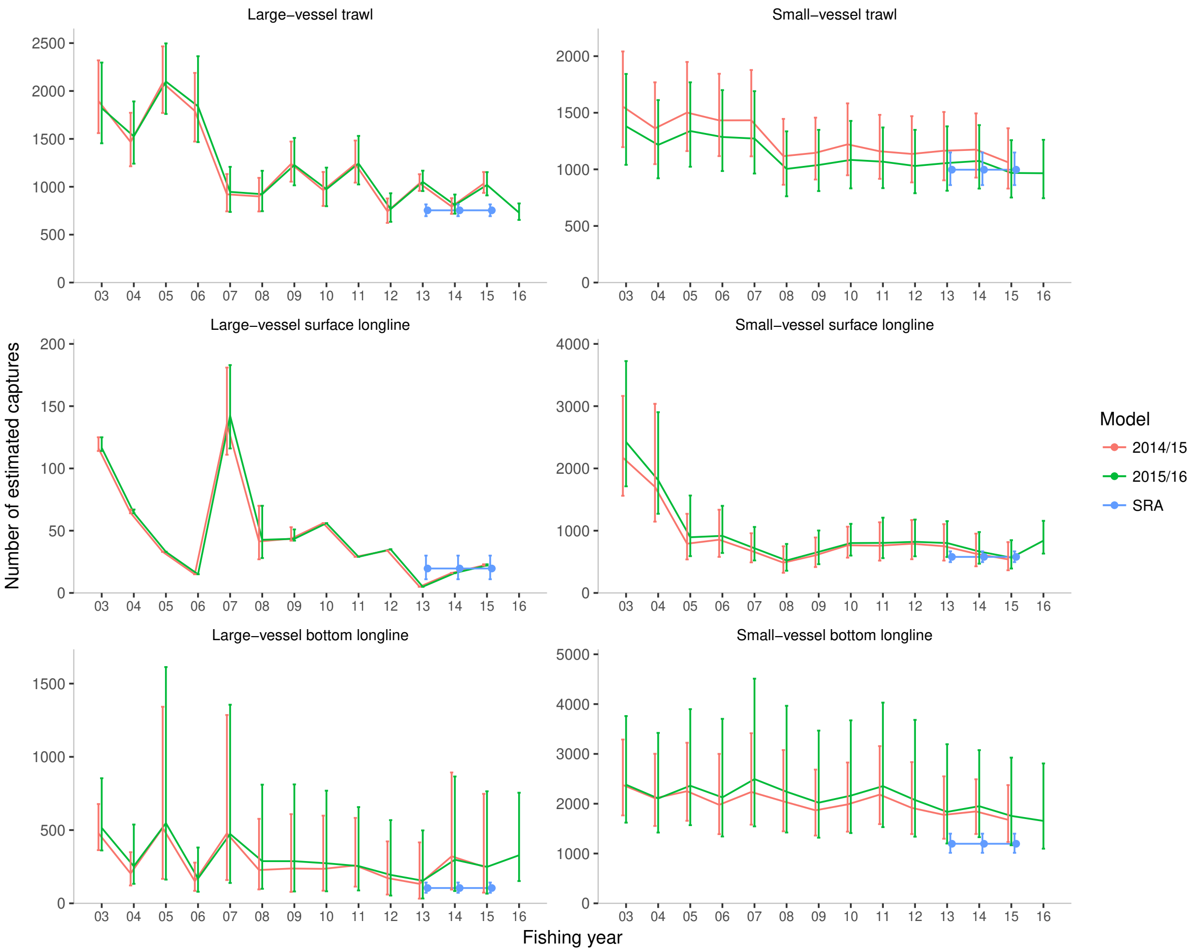


Figure 8: Comparison of the number of seabird captures estimated with three different statistical models. For each fishing method (trawl, surface longline, bottom longline) and vessel class, estimated captures are from the previous assessment of 2014–15 (Abraham & Richard 2018), this study (2015–16), and the seabird risk assessment (SRA; Richard & Abraham 2017). Estimates for the risk assessment were an average over the three fishing years 2012–13 to 2014–15. Cut-off lengths for small- and large-vessel size classes were 45 m, 34 m, and 28 m, for surface-longline (SLL), bottom-longline (BLL), and trawl fishing, respectively. Lines and symbols indicate mean captures, error bars are the 95% credible interval for the total number of estimated captures within each fishing year. (Note different y-axis scales.)

or by variations in seabird distributions, then the different species should not be treated as independent. This aspect was evident in the distinct two-year cycle in the bycatch rates of both sooty shearwater and white-chinned petrel. Similarly, it can be expected that changes in fisher behaviour that affect seabird catch rates (such as increased use of mitigation measures) will affect multiple species. Treating species independently may reduce the power of the models to detect changes in capture rates.

The purpose of this analysis was to estimate total captures, species-by-species event-level modelling could be carried out to investigate the factors associated with seabird bycatch in more detail.

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APPENDIX A: PREPARATION OF PROTECTED SPECIES CAPTURE (PSC) DATA RELATED TO SEABIRDS

Summary of data preparation for the Protected Species Capture database. This appendix updates the tables presented by Thompson et al. (2017) that included information related to seabird captures. In addition to longline and trawl fishing methods that are included in seabird bycatch estimation, these tables include seabird captures in set-net and purse seine fisheries.

Table A-1: Number of trips reconciled from the observer trip record database in the data preparation of protected species captures (PSC). Included are the number of trips with records in the PSC database in the current data extract and in 2016. Trips were classified by reasons for not including them in the estimation and for missing information. Cancelled: observer trip did not occur; extra-territorial: observer trip was entirely outside New Zealand's Exclusive Economic Zone; no sea days: observer was unable to get time onboard the vessel; research trip: observer trips that involved research activities and did not report protected species captures; other method: the fishing method was not included in the PSC database (i.e., there was no trawl, longline, set net, or purse seine on the trip); In COD (Centralised Observer Database): data in loading tables but not in the COD itself; Not in COD: data missing from the database; No vessel assoc.: fishing vessel not known; No catch effort: missing effort data.

				Not included					Missing				
	Observer trip record	PSC	PSC (2016)	Cancelled	Extra-territorial	No sea days	Research trip	Other method	In COD loading	Not in COD	No vessel assoc.	No catch effort	Trip in 2016–17
2002–03	122	107	107		13					2			
2003–04	164	154	154		7		1			2			
2004–05	155	146	146		6			1		1	1		
2005–06	135	125	124		10								
2006–07	181	172	172		6			2				1	
2007–08	176	162	162		11		1	1			1		
2008–09	233	212	212	2	14	1		4					
2009–10	221	197	198	2	16			6					
2010–11	186	162	162	4	16			4					
2011–12	184	167	167	3	11	2		1					
2012–13	274	245	245		14	6	3	6					
2013–14	326	298	298	7	13	4		4					
2014–15	270	252	251	1	13	2	1	1					
2015–16	281	254		2	19	3		1					2

Table A-2: Summary of seabird captures (by species) that were added to captures in the Centralised Observer Database (COD) during the current data preparation. These additional captures resulted from the expanding of multiple capture events that were initially recorded as single captures ("Expanded"), from non-fish bycatch forms that were available in the COD loading tables ("COD load tables"), and from necropsy or photograph identifications that had no corresponding record in COD.

Species	Expanded	COD load tables	Identifications		Total
			Necropsy	Photographs	
Sooty shearwater	10	26	2	5	43
NZ white-capped albatross		5	2	20	27
Antarctic prion				19	19
Fairy prion	3	1		9	13
Southern Buller's albatross		5	3	1	9
White-chinned petrel		2		7	9
Common diving petrel	2			6	8
Buller's shearwater	2	3			5
Salvin's albatross			2	2	4
Southern black-backed gull		3			3
Black petrel		2		1	3
Black-bellied storm petrel		1		2	3
Grey-backed storm petrel		1		2	3
Fulmars, petrels, prions and shearwaters		1	1		2
Broad-billed prion	2				2
Shearwaters		2			2
NZ white-faced storm petrel		1		1	2
White-headed petrel				2	2
Albatrosses		1			1
Wandering albatross				1	1
Cape petrels		1			1
Flesh-footed shearwater			1		1
Cook's Petrel		1			1
Prions				1	1
Spotted shag				1	1
Westland petrel		1			1
All species	19	57	11	80	167

Table A-3: Records of observed seabird captures in New Zealand commercial fisheries that were excluded from the final dataset during data preparation, by fishing year between 2002–03 and 2015–16. Exclusions included records of seabirds landing on the deck or colliding with vessel structures ("Deck"), captures recorded during mitigation research trips ("Research"), animals in a decomposed state at the time of capture ("Decomposed"), seabirds caught on trawl warps but not brought onboard the vessel ("Warp lost"), records that were determined from observer remarks to not be bycatch events ("Not bycatch"), records that could not be linked to fishing effort ("No station"), records of non-seabirds ("Land birds"), and captures in extra-territorial waters ("ET"). For each fishing year, the table also indicates the number of protected species captures remaining in the database.

Fishing year	Exclusions								Final
	Deck	Research	Decomposed	Warp lost	Not bycatch	No station	Land birds	ET	
2002–03	176	0	1	5	37	0	0	1	633
2003–04	58	58	3	8	1	0	1	0	379
2004–05	106	61	6	31	1	0	0	1	505
2005–06	63	73	1	6	3	0	0	0	427
2006–07	41	0	3	3	0	0	0	0	467
2007–08	77	4	8	4	0	0	0	0	317
2008–09	64	0	4	9	4	0	0	0	577
2009–10	229	0	1	1	1	0	0	0	477
2010–11	67	0	12	1	0	3	0	1	459
2011–12	83	0	0	0	2	1	2	0	324
2012–13	104	0	4	0	2	18	1	0	749
2013–14	119	0	1	8	1	6	0	0	631
2014–15	80	0	2	2	1	6	0	1	689
2015–16	342	0	4	0	6	6	0	0	714
All years	1 609	196	50	78	59	40	4	4	7 348

Table A-4: Summary of identifications carried out by Wildlife Management International (WMIL) of seabird captures, by fishing year between 2002–03 and 2015–16. Included are the total number of seabird captures identified by WMIL, the number of seabird captures for which the WMIL identification was included in the extract of the Centralised Observer Database (COD), the total number of WMIL seabird identifications (some captures have multiple identifications), the number of identifications from necropsy and from photographs, and the number of identifications that could not be linked to (or used to create) a capture record.

Year	Identified captures		WMIL identifications			
	WMIL	In COD	Total	Necropsy	Photo	Unlinked
2002–03						
2003–04						
2004–05	3		3		3	
2005–06	18		18		18	
2006–07	100	51	100		100	
2007–08	52	29	53		53	1
2008–09	48	6	48		48	
2009–10						
2010–11	379	314	383	206	177	1
2011–12	292	226	294	196	98	
2012–13	513	474	576	448	128	1
2013–14	411	372	469	346	123	2
2014–15	372	336	382	336	46	
2015–16	567	160	594	324	270	1
All years	2 755	1 968	2 920	1 856	1 064	6

Table A-5: Imputation rules applied by fishing year. The imputation process was applied to seabird capture records that were not assessed by experts. The "best" matches agreed on trip number, fishing year, observer identification, fishery, method, area, and observer-recorded species code. On each pass, the imputation loosens one criterion for matching observer-identified captures with expert-identified captures, in turn.

Fishing year	Match type					Total
	Best	- trip	- year	- observer	-fishery	
2002–03	15	1	1	18	8	43
2003–04	4	1		11	1	17
2004–05	17			17	2	36
2005–06	2		4	8	4	18
2006–07	4		1	5	3	13
2007–08	4			10	5	19
2008–09	48	1	3	13	5	70
2009–10	34		1	22	4	61
2010–11	12		5	9	3	29
2011–12	2	1	1	12	2	18
2012–13	26		2	60	5	93
2013–14	40		3	23	4	70
2014–15	23	16	7	31	6	83
2015–16	20		3	13	6	42
All years	251	20	31	252	58	612

Table A-6: Summary of seabird captures (by fishing year) after imputation of species identifications. The imputation process was applied to capture records that were not assessed by experts. Total number of observed captures, the number of identifications confirmed by experts, the number of captures for which a generic (species groups) or specific (single species or sub-species) code was used for species identifications, and the type of seabird.

Fishing year	Total	Confirmed	Specificity		Species class			Identification changes
			Generic	Specific	Albatross	Other pelagic	Other	
2002–03	633	480	12	621	208	422	3	43
2003–04	379	292	6	373	232	144	3	17
2004–05	505	355	10	495	312	190	3	36
2005–06	427	323	25	402	117	305	5	18
2006–07	467	349	60	407	260	199	8	13
2007–08	317	243	13	304	112	201	4	19
2008–09	577	399	16	561	198	339	40	70
2009–10	477	267	8	469	228	240	9	61
2010–11	459	342	5	454	127	332	0	29
2011–12	324	237	3	321	206	118	0	18
2012–13	749	484	3	746	278	469	2	93
2013–14	631	396	3	628	211	415	5	70
2014–15	689	351	15	674	193	495	1	84
2015–16	714	548	7	707	324	375	15	42
All years	7 348	5 066	186	7 162	3 006	4 244	98	613

Table A-7: Summary of the number of seabird captures by taxon for the 2015–16 and 2014–15 fishing years. Captures for the 2015–16 fishing year are from the current dataset, whereas the captures for 2014–15 include the current dataset and the previous version (prepared in 2016, and used by Ministry for Primary Industries 2015). Also shown is the change in the number of captures of each taxon between the two datasets for 2014–15.

Taxon	Scientific name	2015–16	2014–15		
			Curr.	Prev.	Change
White-chinned petrel	*Procellaria aequinoctialis*	239	291	295	-4
New Zealand white-capped albatross	*Thalassarche cauta steadi*	147	83	81	2
Sooty shearwater	*Puffinus griseus*	62	137	136	1
Southern Buller's albatross	*Thalassarche bulleri bulleri*	115	55	55	
Salvin's albatross	*Thalassarche salvini*	40	46	46	
Flesh-footed shearwater	*Puffinus carneipes*	15	18	17	1
Black petrel	*Procellaria parkinsoni*	20	3	3	
Westland petrel	*Procellaria westlandica*	13	5	5	
Common diving petrel	*Pelecanoides urinatrix*	7	6	5	1
Grey petrel	*Procellaria cinerea*	3	8	8	
Little penguin	*Eudyptula minor*	8			
Mid-sized petrels & shearwaters	*Pterodroma*, *Procellaria* & *Puffinus* spp.	2	6	6	
Campbell black-browed albatross	*Thalassarche impavida*	4	2	2	
Gibson's albatross	*Diomedea antipodensis gibsoni*	4	2	2	
Giant petrels	*Macronectes* spp.		5	5	
Northern giant petrel	*Macronectes halli*	2	2	4	-2
Antipodean albatross	*Diomedea antipodensis antipodensis*	4			
Black-browed albatross	*Thalassarche melanophris*	1	3	3	
Grey-faced petrel	*Pterodroma macroptera gouldi*	1	3	3	
Cape petrel	*Daption capense*	2		2	-2
New Zealand white-faced storm petrel	*Pelagodroma marina maoriana*	1	2	2	
Shearwaters	*Puffinus* spp.	2	1	1	
Southern royal albatross	*Diomedea epomophora*	3			
Wandering albatross	*Diomedea exulans*	3			
Yellow-eyed penguin	*Megadyptes antipodes*	3			
Antarctic prion	*Pachyptila desolata*		3	2	1
Buller's shearwater	*Puffinus bulleri*	2			
Fiordland crested penguin	*Eudyptes pachyrhynchus*	2			
Fairy prion	*Pachyptila turtur*		2	2	
Cape petrels	*Daption* spp.	1	1		1
Snares Cape petrel	*Daption capense australe*	1	1		1
Broad-billed prion	*Pachyptila vittata*	1	1		1
Australasian gannet	*Morus serrator*	1			
Buller's albatross	*Thalassarche bulleri*		1	1	
Chatham Island albatross	*Thalassarche eremita*	1			
Stewart Island shag	*Leucocarbo chalconotus*	1			
Cormorants and shags	*Phalacrocoracidae*		1	1	
Great albatrosses	*Diomedea* spp.	1			
Grey-headed albatross	*Thalassarche chrysostoma*	1			
Petrels, prions, and shearwaters	*Hydrobatidae*, *Procellariidae* & *Pelecanoididae*	1			
Royal albatrosses	*Diomedea sanfordi* & *D. epomophora*		1	1	

Table A-8: Number of seabird captures associated with different capture methods in trawl fisheries, by fishing year between 2002–03 and 2015–16. Capture methods are indicated as included or excluded from the current data preparation of protected species captures (note that captures may be excluded for other reasons).

Fishing year	Included						Excluded	
	Net	Warp or door	Paravane	Mitigation	Other	Unknown	Deck	Warp lost
2002–03	131	59	3			69	40	5
2003–04	127	71	1			55	41	8
2004–05	224	131		2		142	89	31
2005–06	251	48	2	4		44	52	6
2006–07	171	18		1		20	35	3
2007–08	195	23	2	5	4	11	75	4
2008–09	391	59		7	2	6	53	9
2009–10	189	47	9	2	1	18	189	1
2010–11	336	16		1	1	40	61	1
2011–12	178	63	1	1	2	5	83	
2012–13	615	67	2	4	1	29	105	
2013–14	416	65	1	1		6	112	8
2014–15	580	24	1	7	1	9	77	2
2015–16	399	52	3		2	15	37	

APPENDIX B: SUMMARIES OF CAPTURES BY SPECIES AND FISHERY

B.1 All birds captures

B.1.1 All birds captures in large-vessel (≥ 28 m length) trawl fisheries

Table B-9: Annual fishing effort and number of tows observed in large-vessel (≥ 28 m length) trawl fisheries, number of observed captures of all birds and observed capture rate (captures per hundred tows), estimated captures and capture rate of all birds (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	54 200	11.9	260	4.03	1 821	1 454–2 297	3.36	2.68–4.24
2003–04	47 339	13.4	248	3.90	1 526	1 241–1 891	3.22	2.62–3.99
2004–05	44 156	17.2	428	5.64	2 099	1 760–2 497	4.75	3.99–5.65
2005–06	39 121	15.8	333	5.39	1 840	1 466–2 363	4.70	3.75–6.04
2006–07	35 193	20.6	176	2.43	947	737–1 208	2.69	2.09–3.43
2007–08	32 767	25.3	221	2.66	923	745–1 167	2.82	2.27–3.56
2008–09	29 976	24.7	373	5.03	1 227	1 015–1 510	4.09	3.39–5.04
2009–10	29 505	26.0	241	3.14	974	797–1 200	3.30	2.70–4.07
2010–11	27 397	22.7	339	5.45	1 243	1 024–1 531	4.54	3.74–5.59
2011–12	25 593	32.8	226	2.69	767	634–932	3.00	2.48–3.64
2012–13	23 970	49.3	704	5.96	1 051	955–1 168	4.38	3.98–4.87
2013–14	25 660	43.7	463	4.13	809	719–919	3.15	2.80–3.58
2014–15	25 623	44.6	597	5.22	1 019	910–1 153	3.98	3.55–4.50
2015–16	25 008	46.1	435	3.77	729	654–826	2.92	2.62–3.30

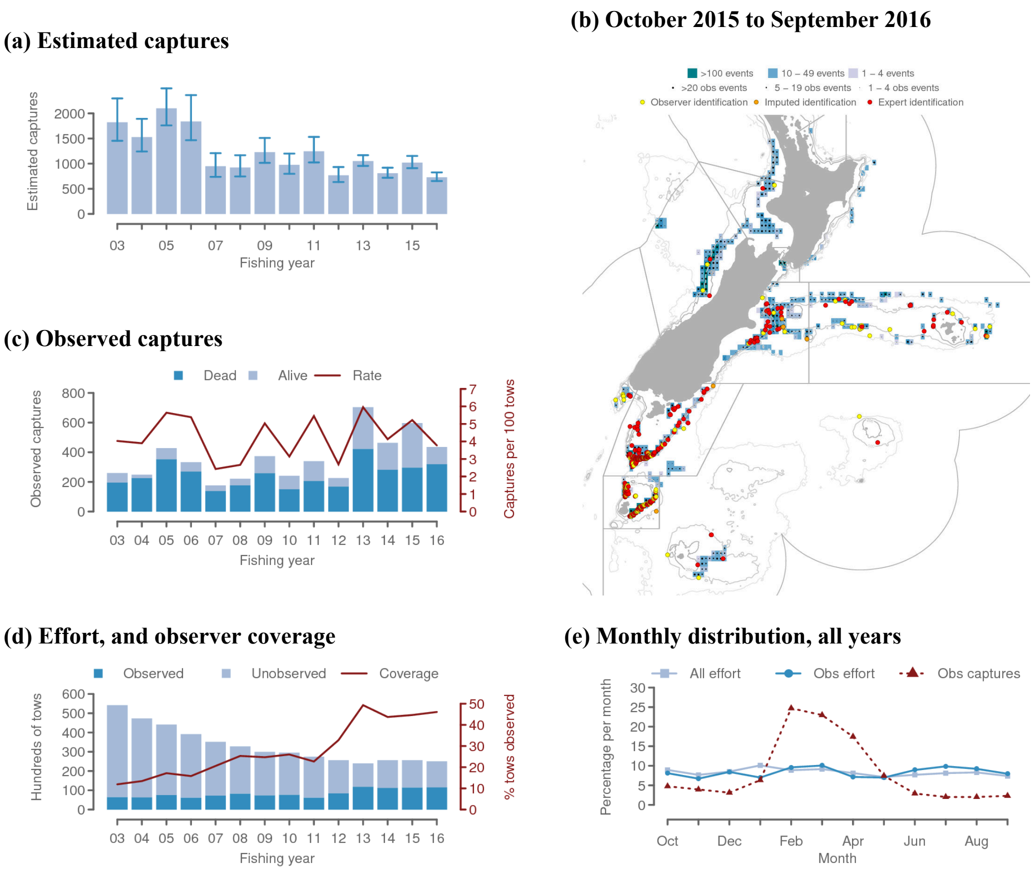


Figure B-1: All birds captures in large-vessel (≥ 28 m length) trawl fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.1.2 All birds captures in small-vessel (< 28 m length) trawl fisheries

Table B-10: Annual fishing effort and number of tows observed in small-vessel (< 28 m length) trawl fisheries, number of observed captures of all birds and observed capture rate (captures per hundred tows), estimated captures and capture rate of all birds (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	75 976	0.5	1	0.26	1 380	1 040–1 843	1.82	1.37–2.43
2003–04	73 511	0.3	3	1.62	1 216	921–1 612	1.65	1.25–2.19
2004–05	76 305	0.2	6	4.76	1 338	1 023–1 769	1.75	1.34–2.32
2005–06	70 830	0.6	12	2.75	1 286	985–1 700	1.82	1.39–2.40
2006–07	68 124	1.0	32	4.66	1 272	963–1 691	1.87	1.41–2.48
2007–08	56 769	1.3	11	1.46	1 004	762–1 336	1.77	1.34–2.35
2008–09	57 574	4.5	87	3.34	1 039	808–1 349	1.80	1.40–2.34
2009–10	63 384	2.9	23	1.24	1 083	832–1 428	1.71	1.31–2.25
2010–11	58 694	2.3	53	3.88	1 068	834–1 370	1.82	1.42–2.33
2011–12	58 831	1.6	22	2.32	1 030	789–1 349	1.75	1.34–2.29
2012–13	59 862	1.0	8	1.37	1 056	811–1 380	1.76	1.35–2.31
2013–14	59 453	3.3	25	1.26	1 074	830–1 391	1.81	1.40–2.34
2014–15	53 131	4.6	23	0.95	968	751–1 258	1.82	1.41–2.37
2015–16	53 032	5.0	27	1.02	966	745–1 261	1.82	1.40–2.38

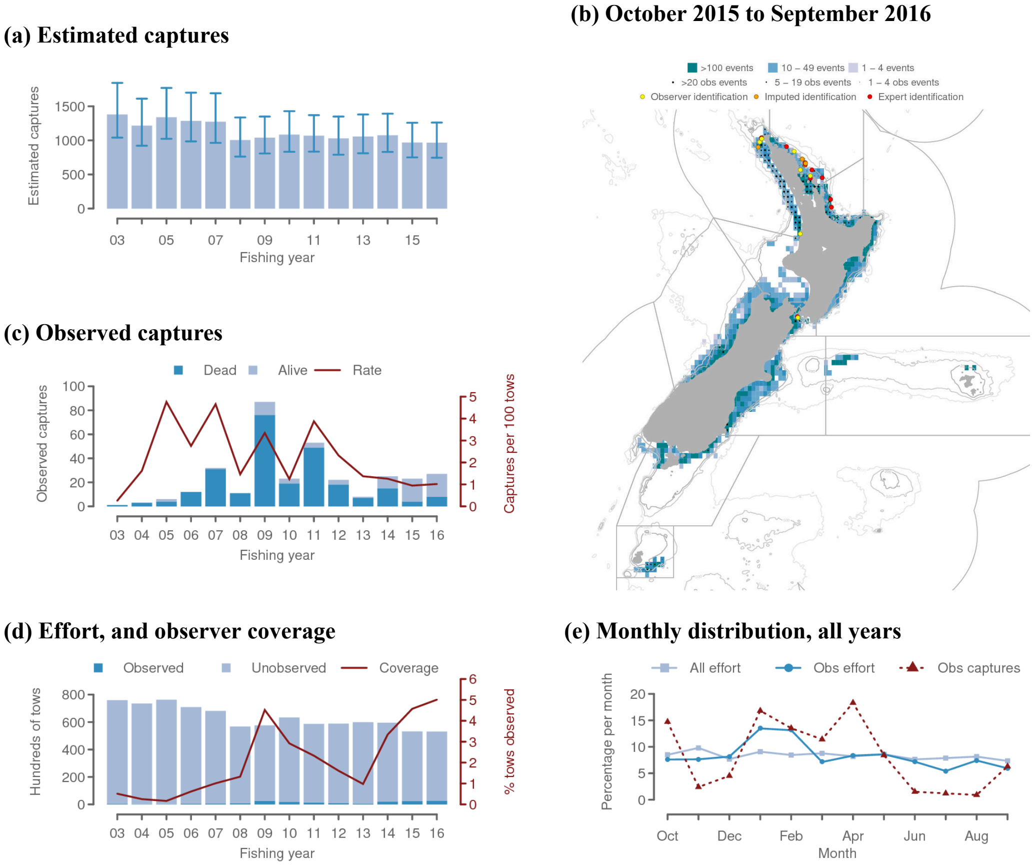


Figure B-2: All birds captures in small-vessel (< 28 m length) trawl fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.1.3 All birds captures in large-vessel (≥ 28 m length) bottom-longline fisheries

Table B-11: Annual fishing effort and number of hooks observed in large-vessel (≥ 28 m length) bottom-longline fisheries, number of observed captures of all birds and observed capture rate (captures per thousand hooks), estimated captures and capture rate of all birds (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	17 928 519	60.1	254	0.236	649	443–1 080	0.362	0.247–0.602
2003–04	23 333 597	20.7	46	0.095	376	198–802	0.161	0.085–0.344
2004–05	18 932 296	13.7	17	0.066	726	277–1 859	0.383	0.146–0.982
2005–06	14 888 723	24.5	29	0.080	323	147–787	0.217	0.099–0.529
2006–07	12 759 288	14.3	15	0.082	586	203–1 582	0.459	0.159–1.240
2007–08	14 127 896	22.0	22	0.071	444	185–1 122	0.314	0.131–0.794
2008–09	12 870 071	24.8	5	0.016	348	121–891	0.270	0.094–0.692
2009–10	13 602 940	12.6	10	0.058	397	152–1 004	0.292	0.112–0.738
2010–11	12 919 517	11.8	18	0.118	372	154–893	0.288	0.119–0.691
2011–12	11 571 447	17.5	4	0.020	247	92–634	0.213	0.080–0.548
2012–13	8 234 145	3.3	0	0.000	276	115–672	0.335	0.140–0.816
2013–14	16 459 721	11.7	46	0.240	664	317–1 470	0.403	0.193–0.893
2014–15	14 060 072	2.5	11	0.308	467	198–1 107	0.332	0.141–0.787
2015–16	18 604 396	10.8	80	0.398	590	308–1 145	0.317	0.166–0.615

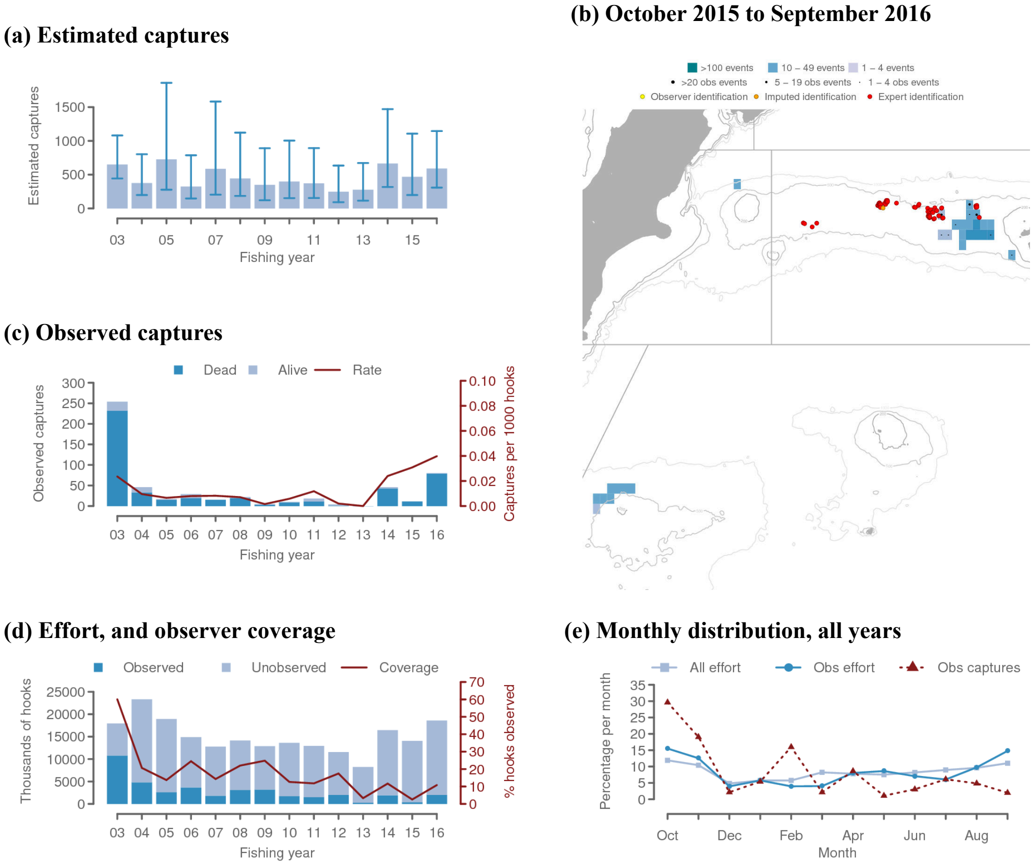


Figure B-3: All birds captures in large-vessel (≥ 28 m length) bottom-longline fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.1.4 All birds captures in small-vessel (< 28 m length) bottom-longline fisheries

Table B-12: Annual fishing effort and number of hooks observed in small-vessel (< 28 m length) bottom-longline fisheries, number of observed captures of all birds and observed capture rate (captures per thousand hooks), estimated captures and capture rate of all birds (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	19 865 349	0.0	3	5.46	2 245	1 531–3 591	1.13	0.77–1.81
2003–04	19 909 463	1.1	11	0.50	1 983	1 339–3 245	1.00	0.67–1.63
2004–05	22 922 762	1.3	13	0.45	2 182	1 450–3 548	0.95	0.63–1.55
2005–06	22 264 210	0.7	12	0.76	1 974	1 272–3 411	0.89	0.57–1.53
2006–07	25 370 472	1.9	44	0.89	2 381	1 506–4 185	0.94	0.59–1.65
2007–08	27 385 002	1.8	18	0.37	2 084	1 351–3 553	0.76	0.49–1.30
2008–09	24 567 417	3.5	34	0.39	1 961	1 286–3 335	0.80	0.52–1.36
2009–10	26 838 971	3.6	48	0.50	2 039	1 340–3 398	0.76	0.50–1.27
2010–11	27 982 749	0.8	2	0.09	2 236	1 479–3 788	0.80	0.53–1.35
2011–12	26 322 576	0.3	6	0.70	2 021	1 310–3 530	0.77	0.50–1.34
2012–13	24 274 494	2.2	6	0.11	1 715	1 120–3 006	0.71	0.46–1.24
2013–14	24 413 204	4.8	59	0.50	1 583	1 096–2 430	0.65	0.45–1.00
2014–15	25 279 199	1.5	16	0.41	1 537	1 031–2 504	0.61	0.41–0.99
2015–16	24 886 224	4.6	24	0.21	1 393	930–2 335	0.56	0.37–0.94

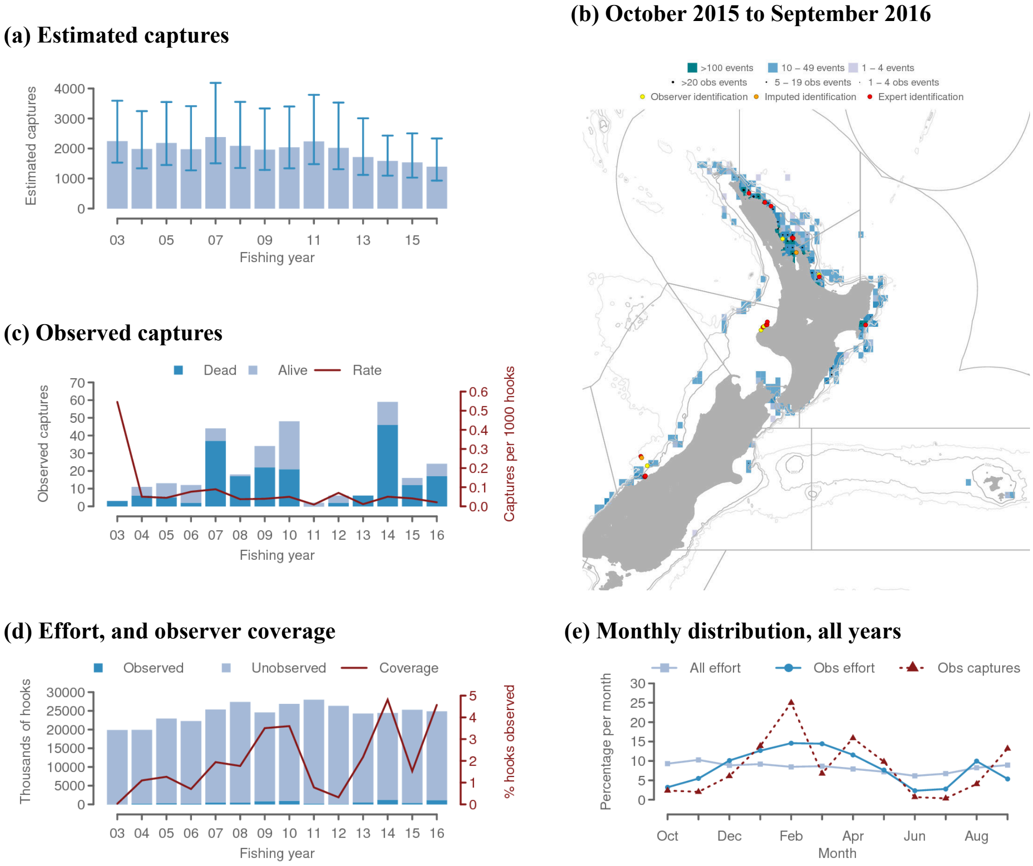


Figure B-4: All birds captures in small-vessel (< 28 m length) bottom-longline fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 (following confidentiality rules, 98.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.1.5 All birds captures in large-vessel (≥ 28 m length) surface-longline fisheries

Table B-13: Annual fishing effort and number of hooks observed in large-vessel (≥ 28 m length) surface-longline fisheries, number of observed captures of all birds and observed capture rate (captures per thousand hooks), estimated captures and capture rate of all birds (mean and 95% credible interval). following Fisheries New Zealand data anonymity rules, effort and rate data are not shown where there were fewer than three vessels fishing.

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	2 197 522	99.9	115	0.52	144	119–204	0.66	0.54–0.93
2003–04	1 655 920	88.9	64	0.43	169	86–523	1.02	0.52–3.16
2004–05	.	.	33	0.51	33	33–33	.	.–.
2005–06	.	.	15	0.25	28	17–54	.	.–.
2006–07	1 407 149	60.6	111	1.30	160	131–204	1.14	0.93–1.45
2007–08	.	.	24	0.84	43	28–70	.	.–.
2008–09	.	.	42	0.53	43	42–51	.	.–.
2009–10	.	.	56	1.17	56	56–56	.	.–.
2010–11	.	.	29	0.58	29	29–29	.	.–.
2011–12	.	.	35	0.63	35	35–35	.	.–.
2012–13	.	.	5	0.10	5	5–5	.	.–.
2013–14	.	.	16	0.24	16	16–16	.	.–.
2014–15	.	.	22	0.36	22	22–23	.	.–.
2015–16	.	.	27	11.37	45	30–80	.	.–.

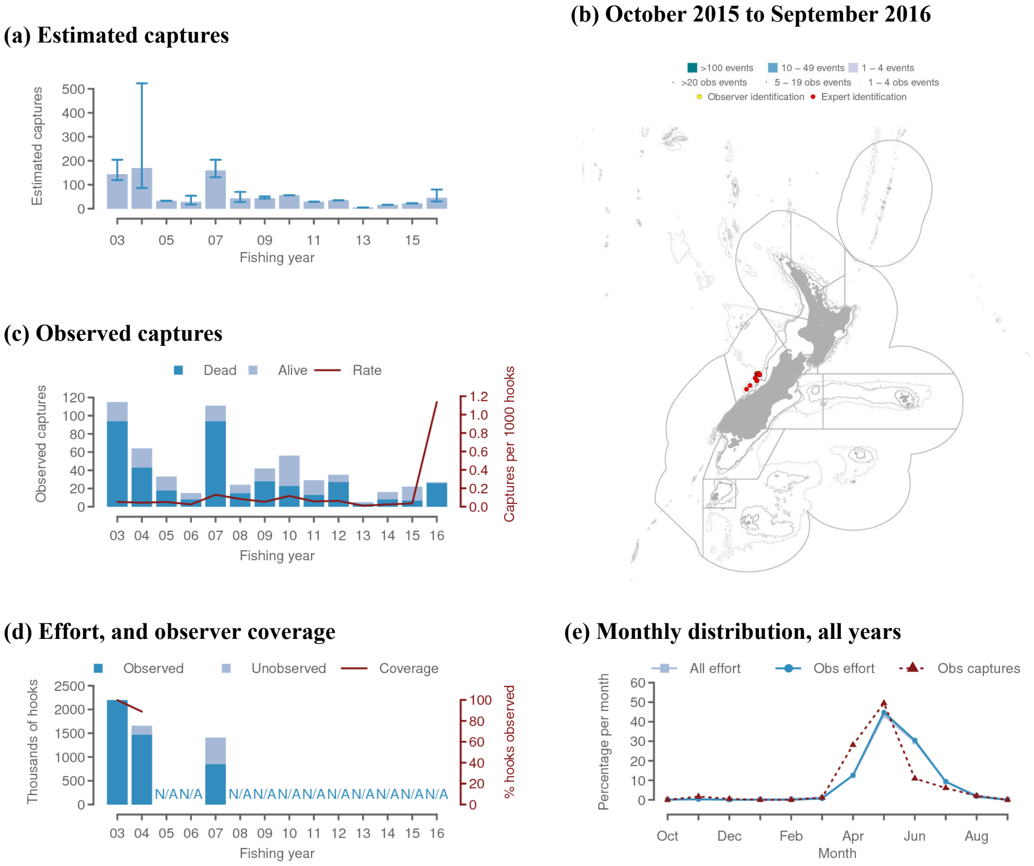


Figure B-5: All birds captures in large-vessel (≥ 28 m length) surface-longline fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures. following FNZ data anonymity rules, effort data are not shown (or marked as ‘N/A’) where there were fewer than three vessels fishing.

B.1.6 All birds captures in small-vessel (< 28 m length) surface-longline fisheries

Table B-14: Annual fishing effort and number of hooks observed in small-vessel (< 28 m length) surface-longline fisheries, number of observed captures of all birds and observed capture rate (captures per thousand hooks), estimated captures and capture rate of all birds (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	8 573 516	0.0	0	.	2 398	1 692–3 696	2.80	1.97–4.31
2003–04	5 730 419	2.4	7	0.52	1 706	1 221–2 536	2.98	2.13–4.43
2004–05	3 041 381	4.7	8	0.56	894	591–1 565	2.94	1.94–5.15
2005–06	3 027 789	3.2	22	2.26	904	630–1 374	2.99	2.08–4.54
2006–07	2 332 863	8.1	76	4.04	700	507–1 042	3.00	2.17–4.47
2007–08	1 678 404	8.1	13	0.95	522	357–787	3.11	2.13–4.69
2008–09	2 305 503	6.6	15	0.99	660	462–1 003	2.86	2.00–4.35
2009–10	2 517 986	7.7	89	4.57	801	600–1 110	3.18	2.38–4.41
2010–11	2 683 529	6.4	18	1.05	804	559–1 209	3.00	2.08–4.51
2011–12	2 548 837	6.8	31	1.79	821	588–1 179	3.22	2.31–4.63
2012–13	2 389 412	3.0	22	3.02	802	577–1 153	3.36	2.41–4.83
2013–14	1 896 434	6.8	20	1.55	666	470–978	3.51	2.48–5.16
2014–15	1 790 036	6.0	16	1.50	567	392–847	3.17	2.19–4.73
2015–16	2 305 441	13.0	104	3.48	794	596–1 112	3.44	2.59–4.82

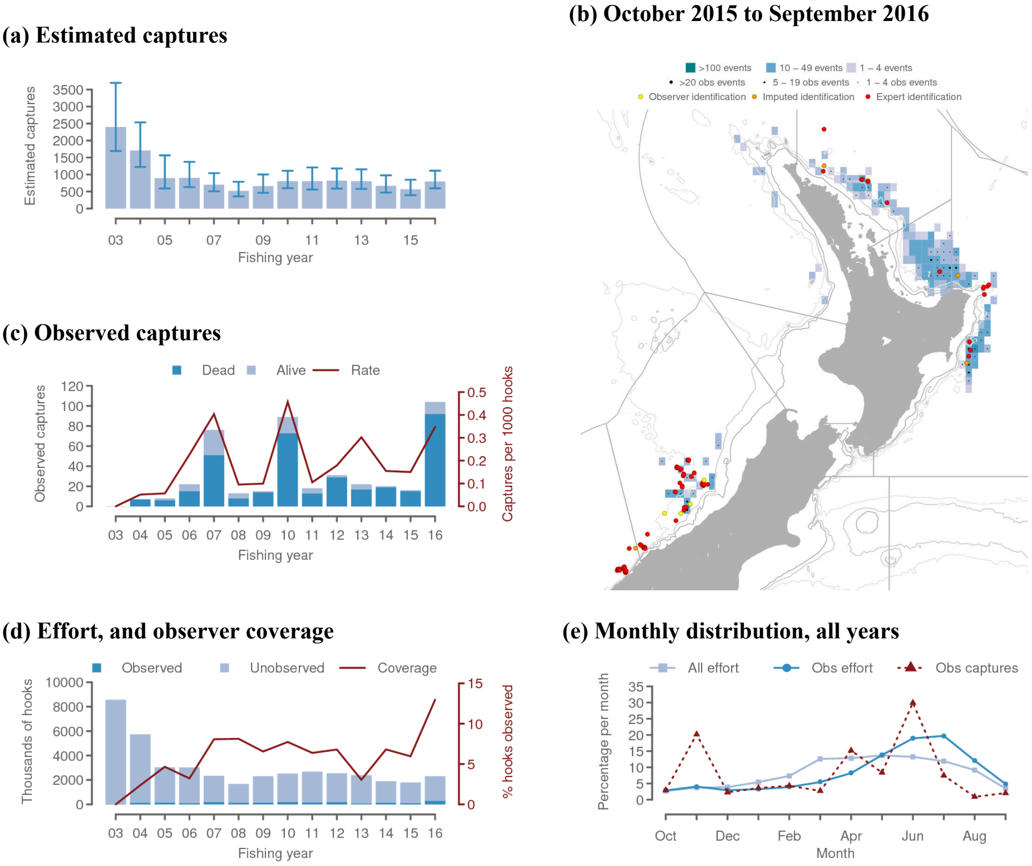


Figure B-6: All birds captures in small-vessel (< 28 m length) surface-longline fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.2 White-capped albatross captures

B.2.1 White-capped albatross captures in large-vessel (≥ 28 m length) trawl fisheries

Table B-15: Annual fishing effort and number of tows observed in large-vessel (≥ 28 m length) trawl fisheries, number of observed captures of white-capped albatross and observed capture rate (captures per hundred tows), estimated captures and capture rate of white-capped albatross (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	54 200	11.9	83	1.29	476	342–650	0.88	0.63–1.20
2003–04	47 339	13.4	138	2.17	593	448–792	1.25	0.95–1.67
2004–05	44 156	17.2	213	2.81	777	604–990	1.76	1.37–2.24
2005–06	39 121	15.8	63	1.02	335	235–463	0.86	0.60–1.18
2006–07	35 193	20.6	48	0.66	214	148–301	0.61	0.42–0.86
2007–08	32 767	25.3	44	0.53	153	107–215	0.47	0.33–0.66
2008–09	29 976	24.7	79	1.07	241	180–316	0.80	0.60–1.05
2009–10	29 505	26.0	33	0.43	134	89–197	0.45	0.30–0.67
2010–11	27 397	22.7	42	0.68	153	105–217	0.56	0.38–0.79
2011–12	25 593	32.8	60	0.72	179	132–242	0.70	0.52–0.95
2012–13	23 970	49.3	129	1.09	170	150–196	0.71	0.63–0.82
2013–14	25 660	43.7	75	0.67	113	96–136	0.44	0.37–0.53
2014–15	25 623	44.6	75	0.66	105	91–124	0.41	0.36–0.48
2015–16	25 008	46.1	104	0.90	140	123–162	0.56	0.49–0.65

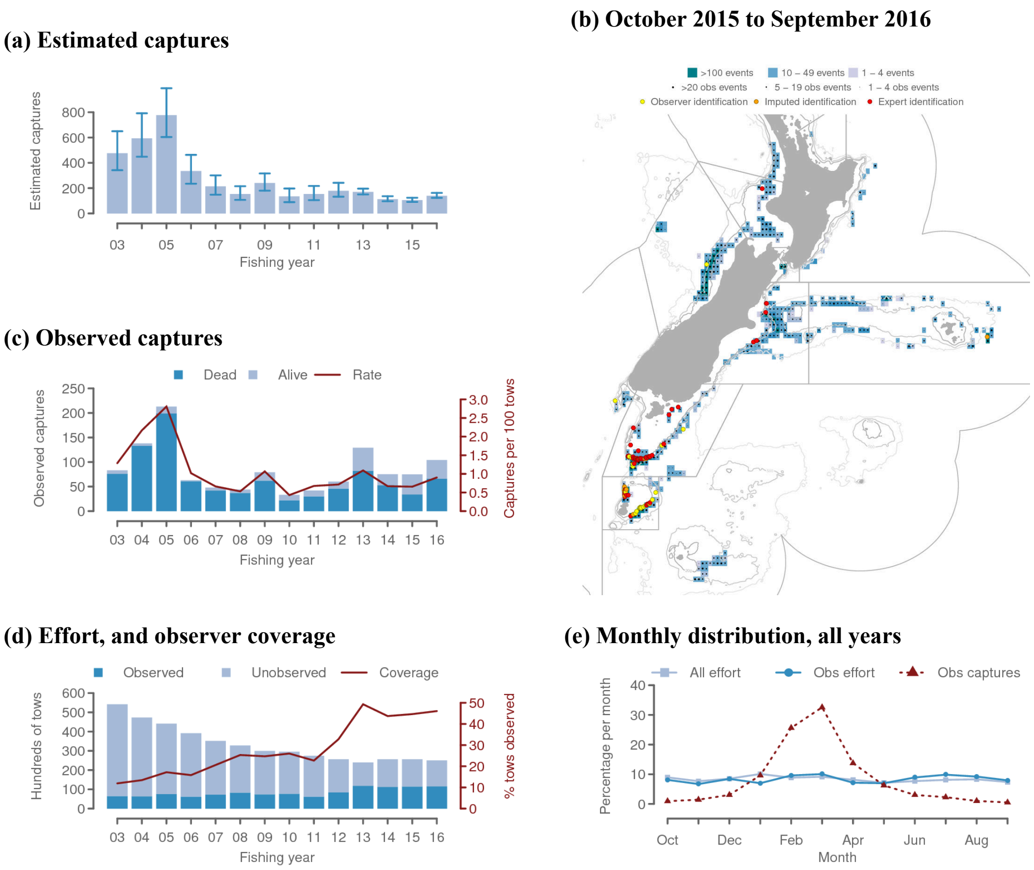


Figure B-7: White-capped albatross captures in large-vessel (≥ 28 m length) trawl fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.2.2 White-capped albatross captures in small-vessel (< 28 m length) trawl fisheries

Table B-16: Annual fishing effort and number of tows observed in small-vessel (< 28 m length) trawl fisheries, number of observed captures of white-capped albatross and observed capture rate (captures per hundred tows), estimated captures and capture rate of white-capped albatross (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	75 976	0.5	0	0.00	225	138–337	0.30	0.18–0.44
2003–04	73 511	0.3	0	0.00	220	134–338	0.30	0.18–0.46
2004–05	76 305	0.2	0	0.00	233	145–350	0.31	0.19–0.46
2005–06	70 830	0.6	0	0.00	218	136–327	0.31	0.19–0.46
2006–07	68 124	1.0	6	0.87	224	141–337	0.33	0.21–0.49
2007–08	56 769	1.3	0	0.00	176	107–265	0.31	0.19–0.47
2008–09	57 574	4.5	11	0.42	185	117–278	0.32	0.20–0.48
2009–10	63 384	2.9	9	0.49	207	128–308	0.33	0.20–0.49
2010–11	58 694	2.3	2	0.15	198	122–303	0.34	0.21–0.52
2011–12	58 831	1.6	10	1.06	199	127–297	0.34	0.22–0.50
2012–13	59 862	1.0	5	0.86	213	132–318	0.36	0.22–0.53
2013–14	59 453	3.3	4	0.20	206	129–308	0.35	0.22–0.52
2014–15	53 131	4.6	0	0.00	175	109–266	0.33	0.21–0.50
2015–16	53 032	5.0	4	0.15	190	119–284	0.36	0.22–0.54

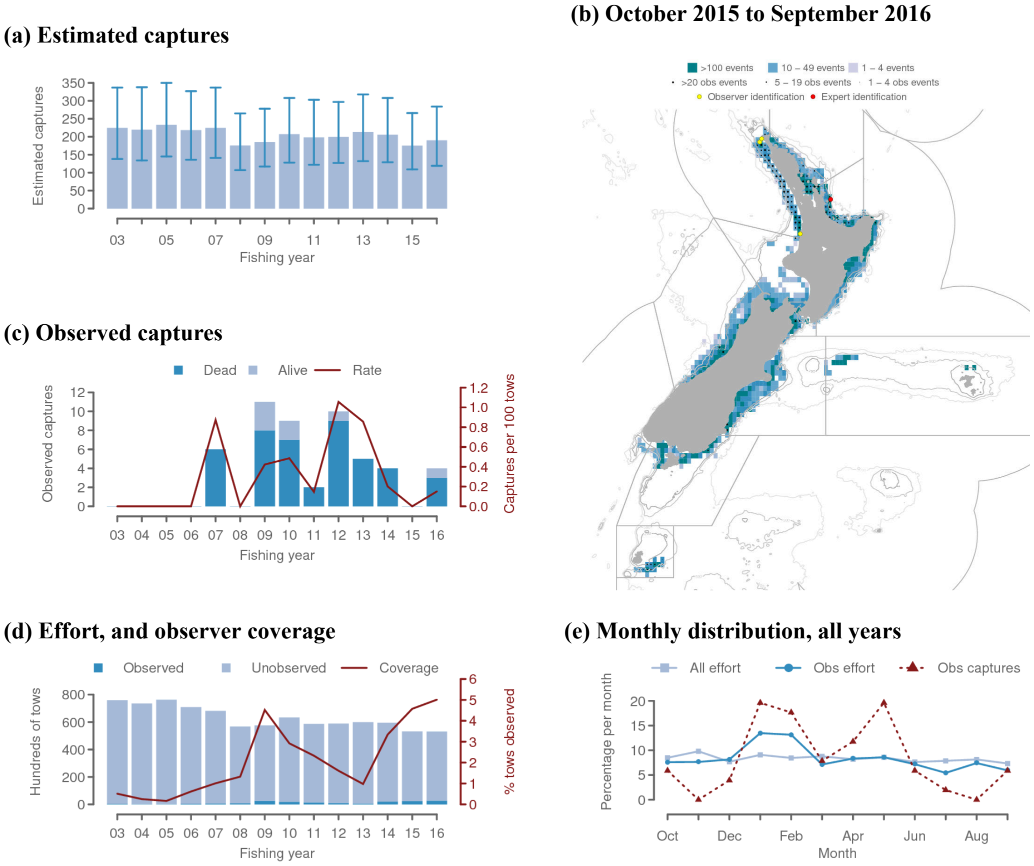


Figure B-8: White-capped albatross captures in small-vessel (< 28 m length) trawl fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.2.3 White-capped albatross captures in small-vessel (< 28 m length) surface-longline fisheries

Table B-17: Annual fishing effort and number of hooks observed in small-vessel (< 28 m length) surface-longline fisheries, number of observed captures of white-capped albatross and observed capture rate (captures per thousand hooks), estimated captures and capture rate of white-capped albatross (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	8 573 516	0.0	0	.	76	32–146	0.09	0.04–0.17
2003–04	5 730 419	2.4	1	0.07	116	53–216	0.20	0.09–0.38
2004–05	3 041 381	4.7	0	0.00	30	10–67	0.10	0.03–0.22
2005–06	3 027 789	3.2	1	0.10	30	10–64	0.10	0.03–0.21
2006–07	2 332 863	8.1	1	0.05	9	2–20	0.04	0.01–0.09
2007–08	1 678 404	8.1	0	0.00	30	8–72	0.18	0.05–0.43
2008–09	2 305 503	6.6	1	0.07	39	14–85	0.17	0.06–0.37
2009–10	2 517 986	7.7	21	1.08	70	40–124	0.28	0.16–0.49
2010–11	2 683 529	6.4	0	0.00	47	17–100	0.18	0.06–0.37
2011–12	2 548 837	6.8	2	0.12	134	61–258	0.53	0.24–1.01
2012–13	2 389 412	3.0	10	1.37	127	62–233	0.53	0.26–0.98
2013–14	1 896 434	6.8	7	0.54	104	48–199	0.55	0.25–1.05
2014–15	1 790 036	6.0	4	0.37	97	44–188	0.54	0.25–1.05
2015–16	2 305 441	13.0	28	0.94	128	71–226	0.56	0.31–0.98

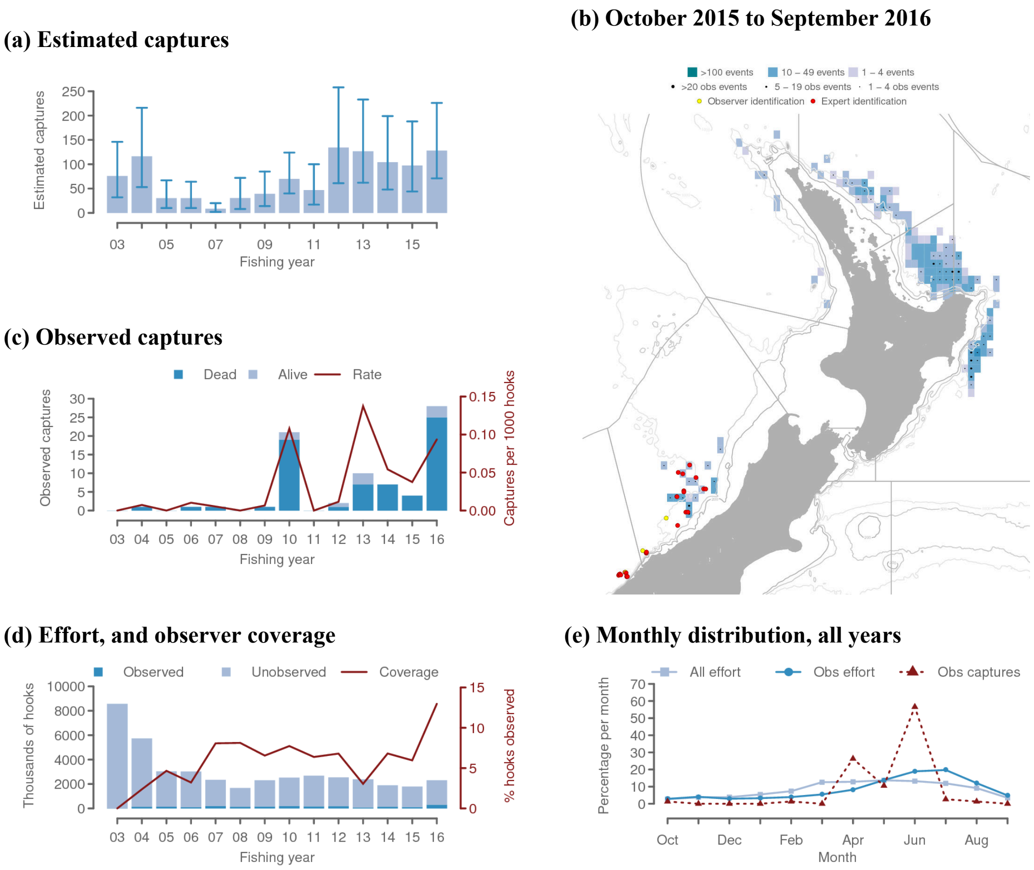


Figure B-9: White-capped albatross captures in small-vessel (< 28 m length) surface-longline fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.3 Salvin’s albatross captures

B.3.1 Salvin’s albatross captures in large-vessel (≥ 28 m length) trawl fisheries

Table B-18: Annual fishing effort and number of tows observed in large-vessel (≥ 28 m length) trawl fisheries, number of observed captures of Salvin’s albatross and observed capture rate (captures per hundred tows), estimated captures and capture rate of Salvin’s albatross (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	54 200	11.9	22	0.341	183	103–306	0.338	0.190–0.565
2003–04	47 339	13.4	8	0.126	148	64–284	0.313	0.135–0.600
2004–05	44 156	17.2	31	0.409	340	196–574	0.770	0.444–1.300
2005–06	39 121	15.8	6	0.097	88	35–169	0.225	0.089–0.432
2006–07	35 193	20.6	9	0.124	75	33–138	0.213	0.094–0.392
2007–08	32 767	25.3	3	0.036	45	13–98	0.137	0.040–0.299
2008–09	29 976	24.7	12	0.162	95	48–166	0.317	0.160–0.554
2009–10	29 505	26.0	33	0.430	145	90–227	0.491	0.305–0.769
2010–11	27 397	22.7	16	0.257	98	54–168	0.358	0.197–0.613
2011–12	25 593	32.8	21	0.250	90	53–148	0.352	0.207–0.578
2012–13	23 970	49.3	50	0.423	124	87–178	0.517	0.363–0.743
2013–14	25 660	43.7	44	0.392	114	81–164	0.444	0.316–0.639
2014–15	25 623	44.6	40	0.350	142	94–215	0.554	0.367–0.839
2015–16	25 008	46.1	32	0.278	94	62–139	0.376	0.248–0.556

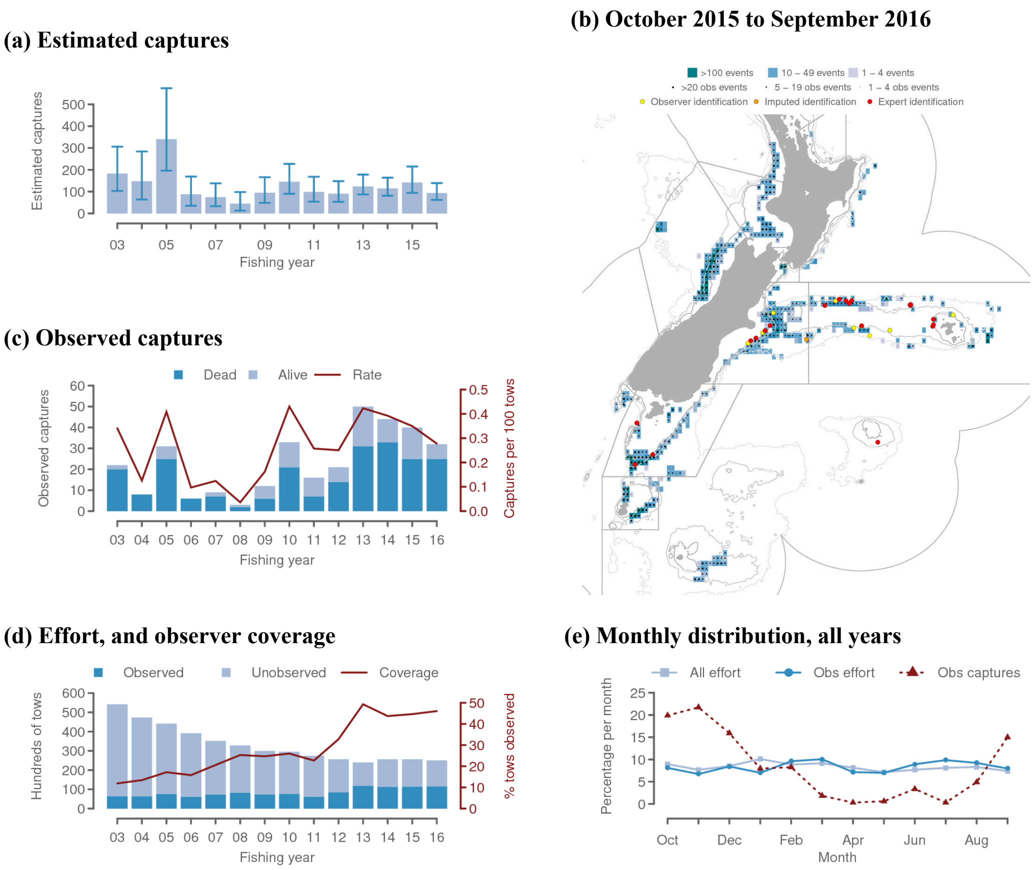


Figure B-10: Salvin’s albatross captures in large-vessel (≥ 28 m length) trawl fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.3.2 Salvin's albatross captures in small-vessel (< 28 m length) trawl fisheries

Table B-19: Annual fishing effort and number of tows observed in small-vessel (< 28 m length) trawl fisheries, number of observed captures of Salvin's albatross and observed capture rate (captures per hundred tows), estimated captures and capture rate of Salvin's albatross (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	75 976	0.5	0	0.00	297	164–492	0.39	0.22–0.65
2003–04	73 511	0.3	3	1.62	237	132–395	0.32	0.18–0.54
2004–05	76 305	0.2	2	1.59	281	162–459	0.37	0.21–0.60
2005–06	70 830	0.6	1	0.23	275	158–440	0.39	0.22–0.62
2006–07	68 124	1.0	2	0.29	248	144–403	0.36	0.21–0.59
2007–08	56 769	1.3	4	0.53	184	105–303	0.32	0.18–0.53
2008–09	57 574	4.5	24	0.92	211	129–335	0.37	0.22–0.58
2009–10	63 384	2.9	10	0.54	204	116–333	0.32	0.18–0.53
2010–11	58 694	2.3	4	0.29	219	126–349	0.37	0.21–0.59
2011–12	58 831	1.6	5	0.53	216	128–343	0.37	0.22–0.58
2012–13	59 862	1.0	2	0.34	224	130–360	0.37	0.22–0.60
2013–14	59 453	3.3	3	0.15	254	152–403	0.43	0.26–0.68
2014–15	53 131	4.6	6	0.25	233	138–369	0.44	0.26–0.69
2015–16	53 032	5.0	2	0.08	197	116–310	0.37	0.22–0.58

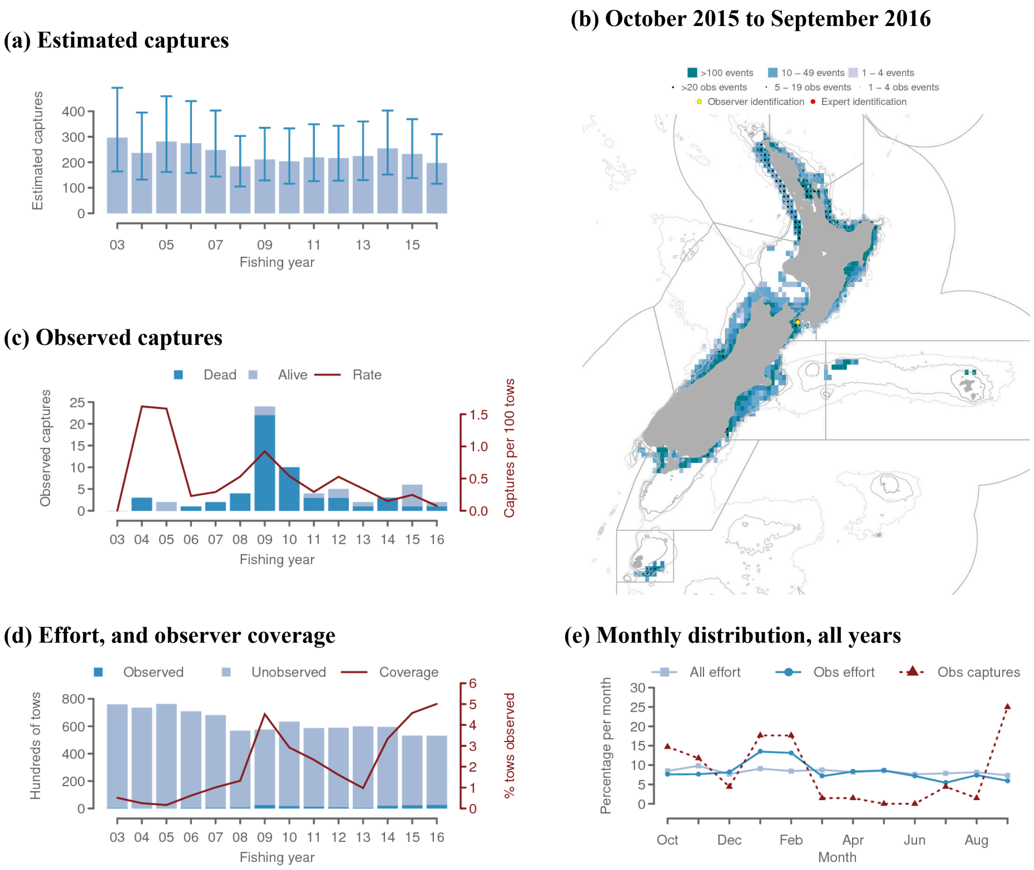


Figure B-11: Salvin's albatross captures in small-vessel (< 28 m length) trawl fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.3.3 Salvin's albatross captures in small-vessel (< 28 m length) bottom-longline fisheries

Table B-20: Annual fishing effort and number of hooks observed in small-vessel (< 28 m length) bottom-longline fisheries, number of observed captures of Salvin's albatross and observed capture rate (captures per thousand hooks), estimated captures and capture rate of Salvin's albatross (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	19 865 349	0.0	0	0.000	50	10–148	0.025	0.005–0.075
2003–04	19 909 463	1.1	0	0.000	45	7–157	0.023	0.004–0.079
2004–05	22 922 762	1.3	0	0.000	71	13–236	0.031	0.006–0.103
2005–06	22 264 210	0.7	0	0.000	60	9–224	0.027	0.004–0.101
2006–07	25 370 472	1.9	22	0.446	93	36–253	0.037	0.014–0.100
2007–08	27 385 002	1.8	0	0.000	82	15–258	0.030	0.005–0.094
2008–09	24 567 417	3.5	0	0.000	81	18–237	0.033	0.007–0.096
2009–10	26 838 971	3.6	0	0.000	83	17–261	0.031	0.006–0.097
2010–11	27 982 749	0.8	0	0.000	103	22–333	0.037	0.008–0.119
2011–12	26 322 576	0.3	0	0.000	109	23–368	0.041	0.009–0.140
2012–13	24 274 494	2.2	0	0.000	95	19–315	0.039	0.008–0.130
2013–14	24 413 204	4.8	0	0.000	82	19–250	0.034	0.008–0.102
2014–15	25 279 199	1.5	0	0.000	77	15–250	0.030	0.006–0.099
2015–16	24 886 224	4.6	0	0.000	74	15–230	0.030	0.006–0.092

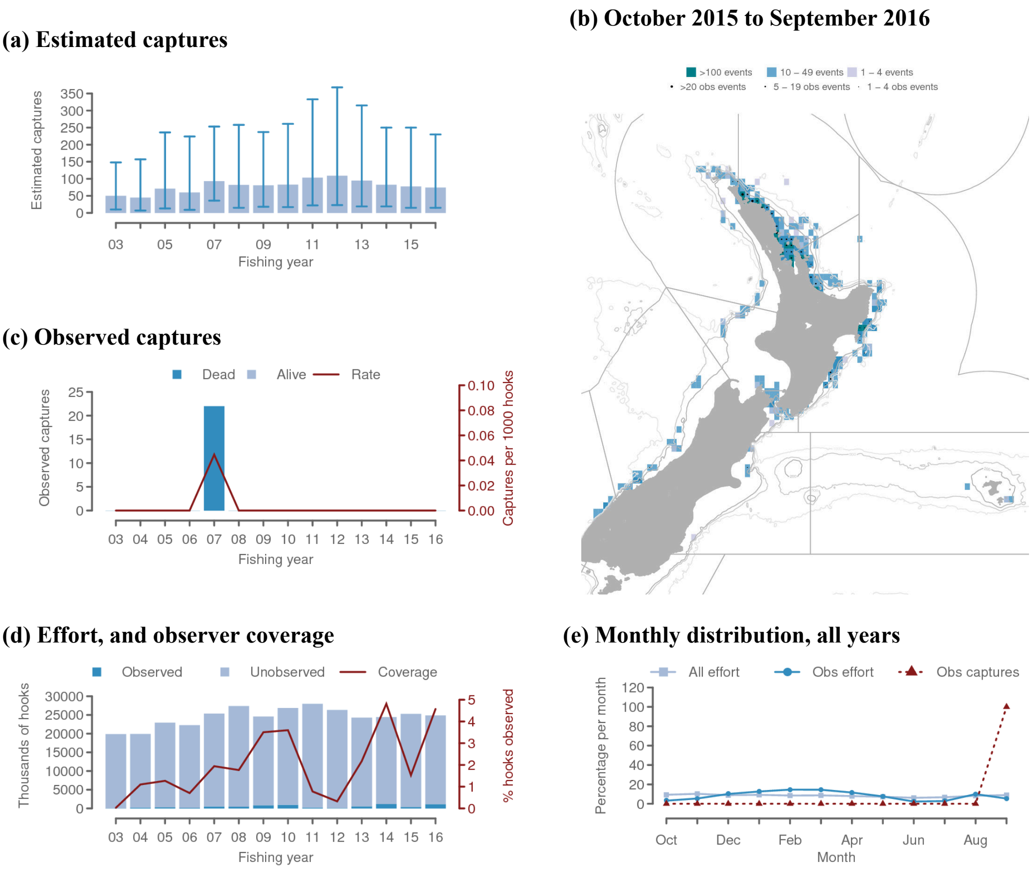


Figure B-12: Salvin's albatross captures in small-vessel (< 28 m length) bottom-longline fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 (following confidentiality rules, 98.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.4 Buller’s albatrosses captures

B.4.1 Buller’s albatrosses captures in large-vessel (≥ 28 m length) trawl fisheries

Table B-21: Annual fishing effort and number of tows observed in large-vessel (≥ 28 m length) trawl fisheries, number of observed captures of Buller’s albatrosses and observed capture rate (captures per hundred tows), estimated captures and capture rate of Buller’s albatrosses (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	54 200	11.9	6	0.093	77	33–141	0.142	0.061–0.260
2003–04	47 339	13.4	9	0.141	90	45–153	0.190	0.095–0.323
2004–05	44 156	17.2	22	0.290	140	89–215	0.317	0.202–0.487
2005–06	39 121	15.8	9	0.146	82	40–138	0.210	0.102–0.353
2006–07	35 193	20.6	6	0.083	51	23–93	0.145	0.065–0.264
2007–08	32 767	25.3	18	0.217	82	51–129	0.250	0.156–0.394
2008–09	29 976	24.7	16	0.216	57	35–88	0.190	0.117–0.294
2009–10	29 505	26.0	11	0.143	51	27–83	0.173	0.092–0.281
2010–11	27 397	22.7	22	0.354	72	47–108	0.263	0.172–0.394
2011–12	25 593	32.8	33	0.393	100	69–144	0.391	0.270–0.563
2012–13	23 970	49.3	58	0.491	84	70–104	0.350	0.292–0.434
2013–14	25 660	43.7	37	0.330	65	51–85	0.253	0.199–0.331
2014–15	25 623	44.6	34	0.297	69	51–94	0.269	0.199–0.367
2015–16	25 008	46.1	56	0.486	97	76–126	0.388	0.304–0.504

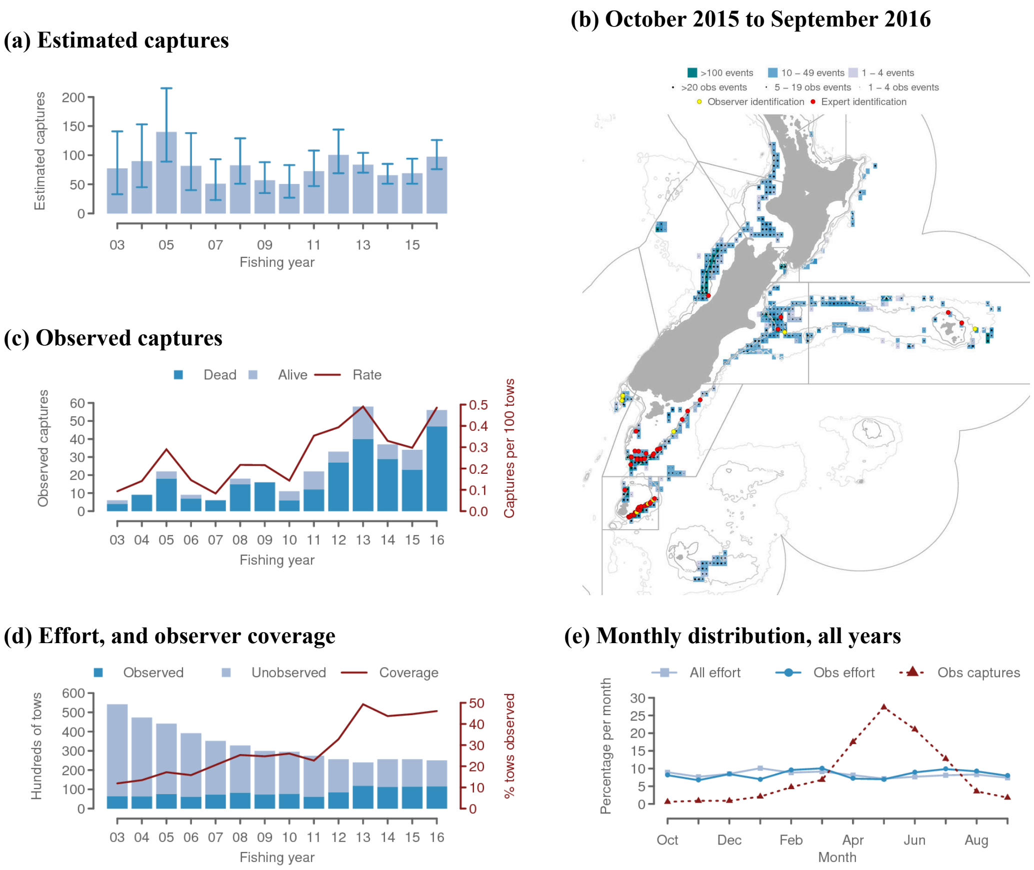


Figure B-13: Buller’s albatrosses captures in large-vessel (≥ 28 m length) trawl fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.4.2 Buller's albatrosses captures in small-vessel (< 28 m length) surface-longline fisheries

Table B-22: Annual fishing effort and number of hooks observed in small-vessel (< 28 m length) surface-longline fisheries, number of observed captures of Buller's albatrosses and observed capture rate (captures per thousand hooks), estimated captures and capture rate of Buller's albatrosses (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	8 573 516	0.0	0	.	396	207–698	0.46	0.24–0.81
2003–04	5 730 419	2.4	0	0.00	340	179–617	0.59	0.31–1.08
2004–05	3 041 381	4.7	3	0.21	120	57–230	0.39	0.19–0.76
2005–06	3 027 789	3.2	5	0.51	142	69–271	0.47	0.23–0.90
2006–07	2 332 863	8.1	1	0.05	75	32–158	0.32	0.14–0.68
2007–08	1 678 404	8.1	3	0.22	73	31–146	0.43	0.18–0.87
2008–09	2 305 503	6.6	2	0.13	103	46–199	0.45	0.20–0.86
2009–10	2 517 986	7.7	26	1.33	139	82–231	0.55	0.33–0.92
2010–11	2 683 529	6.4	4	0.23	117	60–208	0.44	0.22–0.78
2011–12	2 548 837	6.8	4	0.23	160	81–291	0.63	0.32–1.14
2012–13	2 389 412	3.0	8	1.10	137	72–243	0.57	0.30–1.02
2013–14	1 896 434	6.8	8	0.62	120	62–219	0.63	0.33–1.15
2014–15	1 790 036	6.0	3	0.28	99	47–189	0.55	0.26–1.06
2015–16	2 305 441	13.0	43	1.44	167	104–278	0.72	0.45–1.21

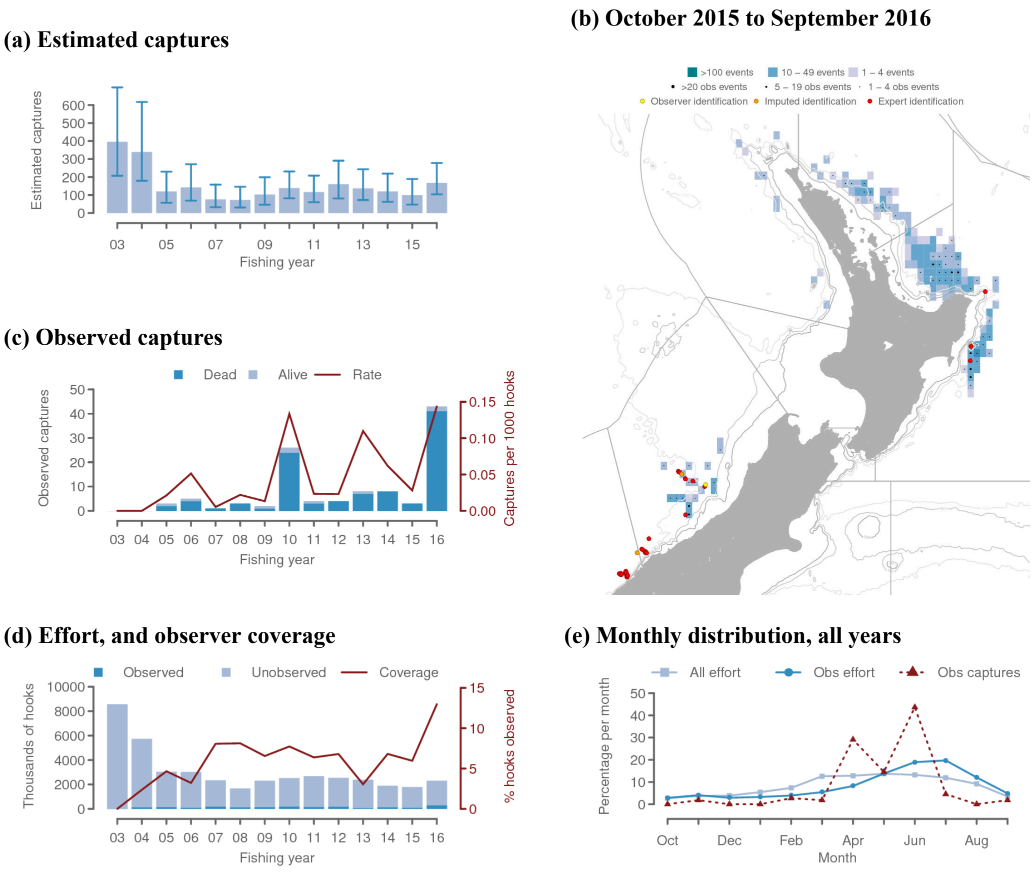


Figure B-14: Buller's albatrosses captures in small-vessel (< 28 m length) surface-longline fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.5 Other albatrosses captures

B.5.1 Other albatrosses captures in small-vessel (< 28 m length) bottom-longline fisheries

Table B-23: Annual fishing effort and number of hooks observed in small-vessel (< 28 m length) bottom-longline fisheries, number of observed captures of other albatrosses and observed capture rate (captures per thousand hooks), estimated captures and capture rate of other albatrosses (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	19 865 349	0.0	0	0.000	112	41–257	0.056	0.021–0.129
2003–04	19 909 463	1.1	0	0.000	110	38–270	0.055	0.019–0.136
2004–05	22 922 762	1.3	0	0.000	128	45–301	0.056	0.020–0.131
2005–06	22 264 210	0.7	0	0.000	120	41–290	0.054	0.018–0.130
2006–07	25 370 472	1.9	14	0.284	151	62–348	0.060	0.024–0.137
2007–08	27 385 002	1.8	4	0.083	154	58–362	0.056	0.021–0.132
2008–09	24 567 417	3.5	0	0.000	127	45–310	0.052	0.018–0.126
2009–10	26 838 971	3.6	0	0.000	135	48–330	0.050	0.018–0.123
2010–11	27 982 749	0.8	0	0.000	164	61–391	0.059	0.022–0.140
2011–12	26 322 576	0.3	0	0.000	138	52–323	0.052	0.020–0.123
2012–13	24 274 494	2.2	0	0.000	121	42–296	0.050	0.017–0.122
2013–14	24 413 204	4.8	1	0.009	114	43–261	0.047	0.018–0.107
2014–15	25 279 199	1.5	0	0.000	120	44–284	0.047	0.017–0.112
2015–16	24 886 224	4.6	2	0.018	110	41–259	0.044	0.016–0.104

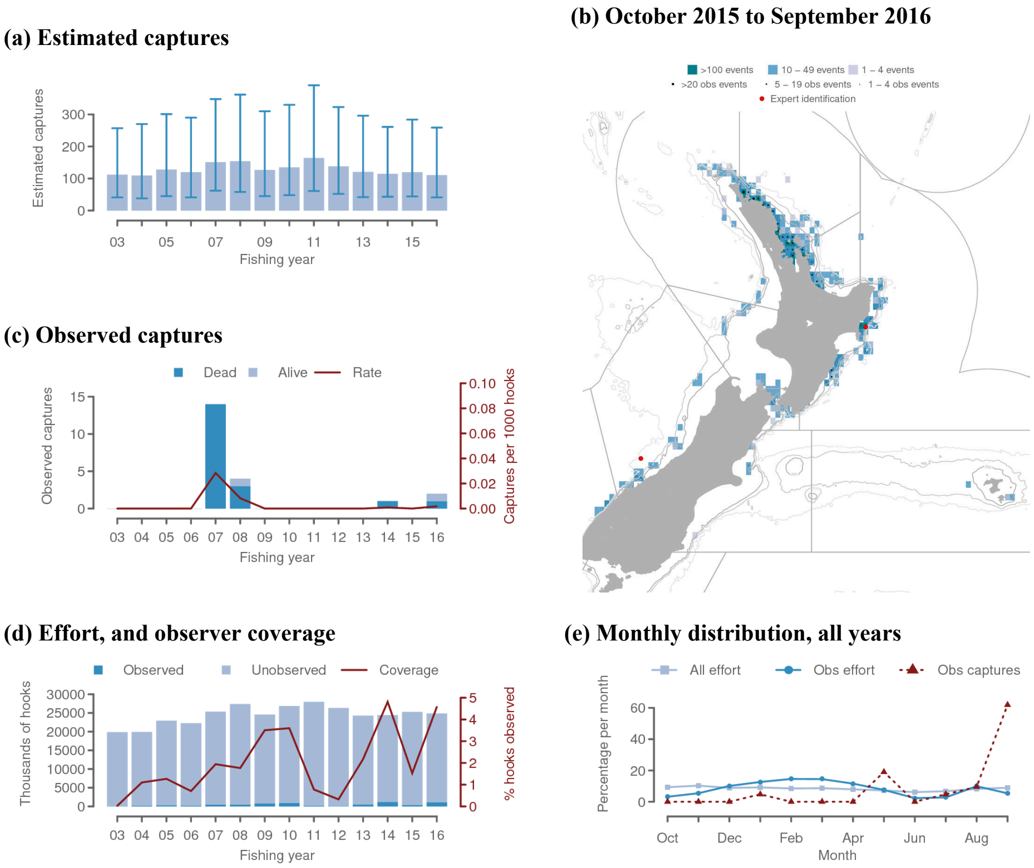


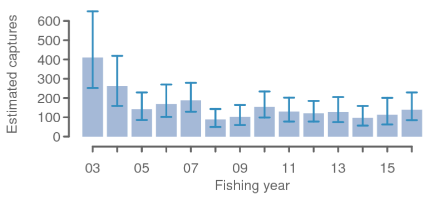
Figure B-15: Other albatrosses captures in small-vessel (< 28 m length) bottom-longline fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 (following confidentiality rules, 98.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.5.2 Other albatrosses captures in small-vessel (< 28 m length) surface-longline fisheries

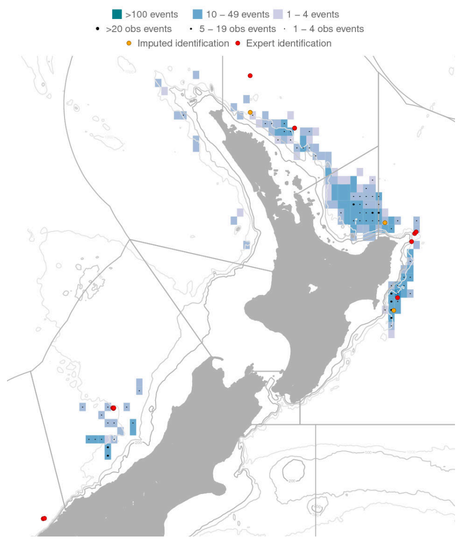
Table B-24: Annual fishing effort and number of hooks observed in small-vessel (< 28 m length) surface-longline fisheries, number of observed captures of other albatrosses and observed capture rate (captures per thousand hooks), estimated captures and capture rate of other albatrosses (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	8 573 516	0.0	0	.	410	252–650	0.48	0.29–0.76
2003–04	5 730 419	2.4	1	0.07	263	159–419	0.46	0.28–0.73
2004–05	3 041 381	4.7	3	0.21	142	86–229	0.47	0.28–0.75
2005–06	3 027 789	3.2	5	0.51	169	102–270	0.56	0.34–0.89
2006–07	2 332 863	8.1	56	2.97	187	129–279	0.80	0.55–1.20
2007–08	1 678 404	8.1	4	0.29	88	50–143	0.52	0.30–0.85
2008–09	2 305 503	6.6	5	0.33	102	60–164	0.44	0.26–0.71
2009–10	2 517 986	7.7	20	1.03	154	99–234	0.61	0.39–0.93
2010–11	2 683 529	6.4	4	0.23	129	78–202	0.48	0.29–0.75
2011–12	2 548 837	6.8	16	0.92	120	78–185	0.47	0.31–0.73
2012–13	2 389 412	3.0	4	0.55	127	75–205	0.53	0.31–0.86
2013–14	1 896 434	6.8	3	0.23	97	57–159	0.51	0.30–0.84
2014–15	1 790 036	6.0	6	0.56	113	63–201	0.63	0.35–1.12
2015–16	2 305 441	13.0	15	0.50	139	85–229	0.60	0.37–0.99

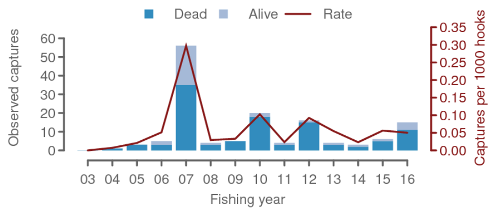
(a) Estimated captures



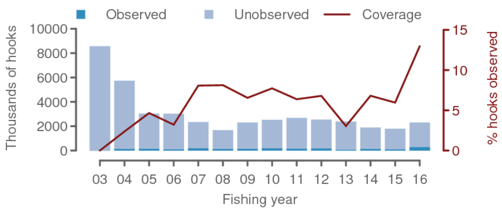
(b) October 2015 to September 2016



(c) Observed captures



(d) Effort, and observer coverage



(e) Monthly distribution, all years

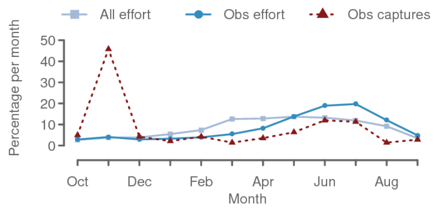


Figure B-16: Other albatrosses captures in small-vessel (< 28 m length) surface-longline fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.6 White-chinned petrel captures

B.6.1 White-chinned petrel captures in large-vessel (≥ 28 m length) trawl fisheries

Table B-25: Annual fishing effort and number of tows observed in large-vessel (≥ 28 m length) trawl fisheries, number of observed captures of white-chinned petrel and observed capture rate (captures per hundred tows), estimated captures and capture rate of white-chinned petrel (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	54 200	11.9	13	0.20	141	65–274	0.26	0.12–0.51
2003–04	47 339	13.4	18	0.28	104	54–194	0.22	0.11–0.41
2004–05	44 156	17.2	54	0.71	231	149–360	0.52	0.34–0.82
2005–06	39 121	15.8	72	1.16	419	253–667	1.07	0.65–1.70
2006–07	35 193	20.6	31	0.43	144	80–251	0.41	0.23–0.71
2007–08	32 767	25.3	58	0.70	245	150–400	0.75	0.46–1.22
2008–09	29 976	24.7	104	1.40	288	198–430	0.96	0.66–1.43
2009–10	29 505	26.0	73	0.95	278	176–442	0.94	0.60–1.50
2010–11	27 397	22.7	112	1.80	387	257–583	1.41	0.94–2.13
2011–12	25 593	32.8	58	0.69	178	116–278	0.70	0.45–1.09
2012–13	23 970	49.3	295	2.50	395	343–481	1.65	1.43–2.01
2013–14	25 660	43.7	151	1.35	221	185–276	0.86	0.72–1.08
2014–15	25 623	44.6	278	2.43	381	329–460	1.49	1.28–1.80
2015–16	25 008	46.1	160	1.39	226	190–284	0.90	0.76–1.14

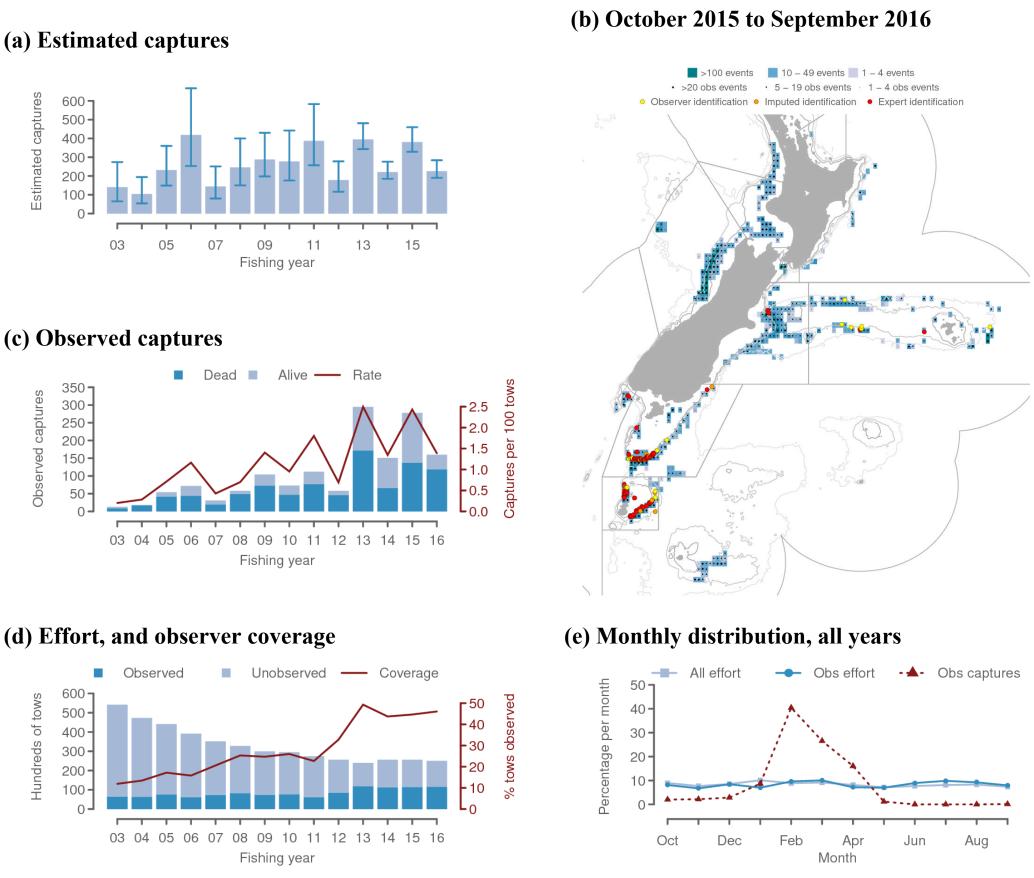


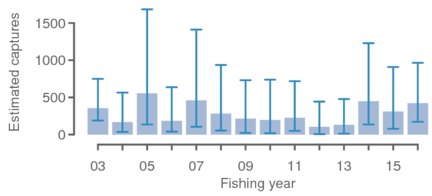
Figure B-17: White-chinned petrel captures in large-vessel (≥ 28 m length) trawl fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.6.2 White-chinned petrel captures in large-vessel (≥ 28 m length) bottom-longline fisheries

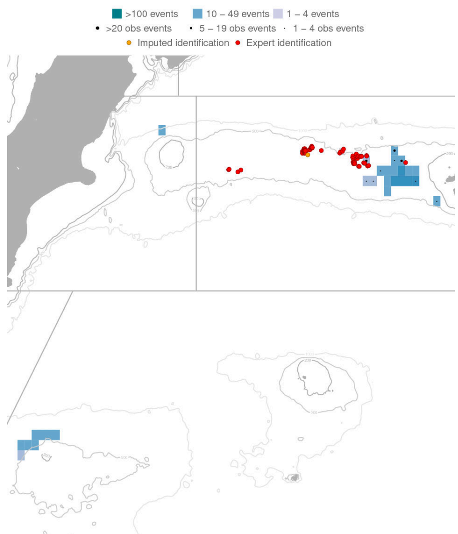
Table B-26: Annual fishing effort and number of hooks observed in large-vessel (≥ 28 m length) bottom-longline fisheries, number of observed captures of white-chinned petrel and observed capture rate (captures per thousand hooks), estimated captures and capture rate of white-chinned petrel (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	17 928 519	60.1	131	0.122	355	189–749	0.198	0.105–0.418
2003–04	23 333 597	20.7	15	0.031	168	36–564	0.072	0.015–0.242
2004–05	18 932 296	13.7	11	0.042	555	136–1 684	0.293	0.072–0.889
2005–06	14 888 723	24.5	13	0.036	185	39–637	0.124	0.026–0.428
2006–07	12 759 288	14.3	13	0.071	460	105–1 412	0.361	0.082–1.107
2007–08	14 127 896	22.0	7	0.023	282	54–936	0.200	0.038–0.663
2008–09	12 870 071	24.8	1	0.003	214	22–731	0.166	0.017–0.568
2009–10	13 602 940	12.6	1	0.006	196	19–738	0.144	0.014–0.543
2010–11	12 919 517	11.8	15	0.099	225	50–718	0.174	0.039–0.556
2011–12	11 571 447	17.5	1	0.005	103	6–443	0.089	0.005–0.383
2012–13	8 234 145	3.3	0	0.000	130	12–477	0.158	0.015–0.579
2013–14	16 459 721	11.7	36	0.188	448	136–1 229	0.272	0.083–0.747
2014–15	14 060 072	2.5	11	0.308	310	78–908	0.220	0.055–0.646
2015–16	18 604 396	10.8	72	0.358	422	171–965	0.227	0.092–0.519

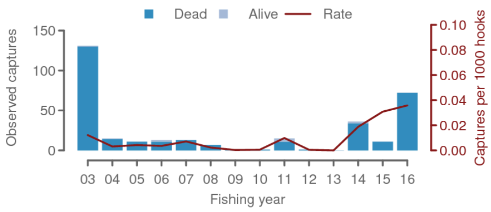
(a) Estimated captures



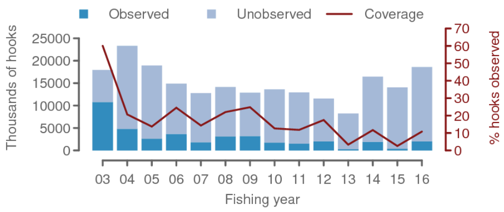
(b) October 2015 to September 2016



(c) Observed captures



(d) Effort, and observer coverage



(e) Monthly distribution, all years

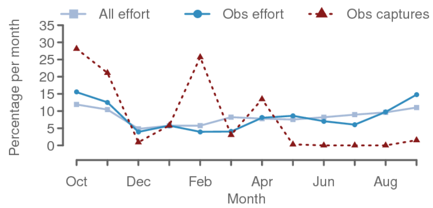


Figure B-18: White-chinned petrel captures in large-vessel (≥ 28 m length) bottom-longline fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.6.3 White-chinned petrel captures in small-vessel (< 28 m length) bottom-longline fisheries

Table B-27: Annual fishing effort and number of hooks observed in small-vessel (< 28 m length) bottom-longline fisheries, number of observed captures of white-chinned petrel and observed capture rate (captures per thousand hooks), estimated captures and capture rate of white-chinned petrel (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	19 865 349	0.0	0	0.000	260	57–772	0.131	0.029–0.389
2003–04	19 909 463	1.1	0	0.000	186	32–661	0.093	0.016–0.332
2004–05	22 922 762	1.3	0	0.000	368	76–1 255	0.161	0.033–0.547
2005–06	22 264 210	0.7	0	0.000	337	61–1 312	0.151	0.027–0.589
2006–07	25 370 472	1.9	1	0.020	460	86–1 718	0.181	0.034–0.677
2007–08	27 385 002	1.8	3	0.062	462	95–1 615	0.169	0.035–0.590
2008–09	24 567 417	3.5	0	0.000	453	98–1 491	0.184	0.040–0.607
2009–10	26 838 971	3.6	0	0.000	416	89–1 383	0.155	0.033–0.515
2010–11	27 982 749	0.8	0	0.000	508	109–1 754	0.182	0.039–0.627
2011–12	26 322 576	0.3	0	0.000	490	92–1 833	0.186	0.035–0.696
2012–13	24 274 494	2.2	0	0.000	410	82–1 459	0.169	0.034–0.601
2013–14	24 413 204	4.8	0	0.000	278	65–840	0.114	0.027–0.344
2014–15	25 279 199	1.5	0	0.000	288	59–999	0.114	0.023–0.395
2015–16	24 886 224	4.6	7	0.061	320	71–1 091	0.129	0.029–0.438

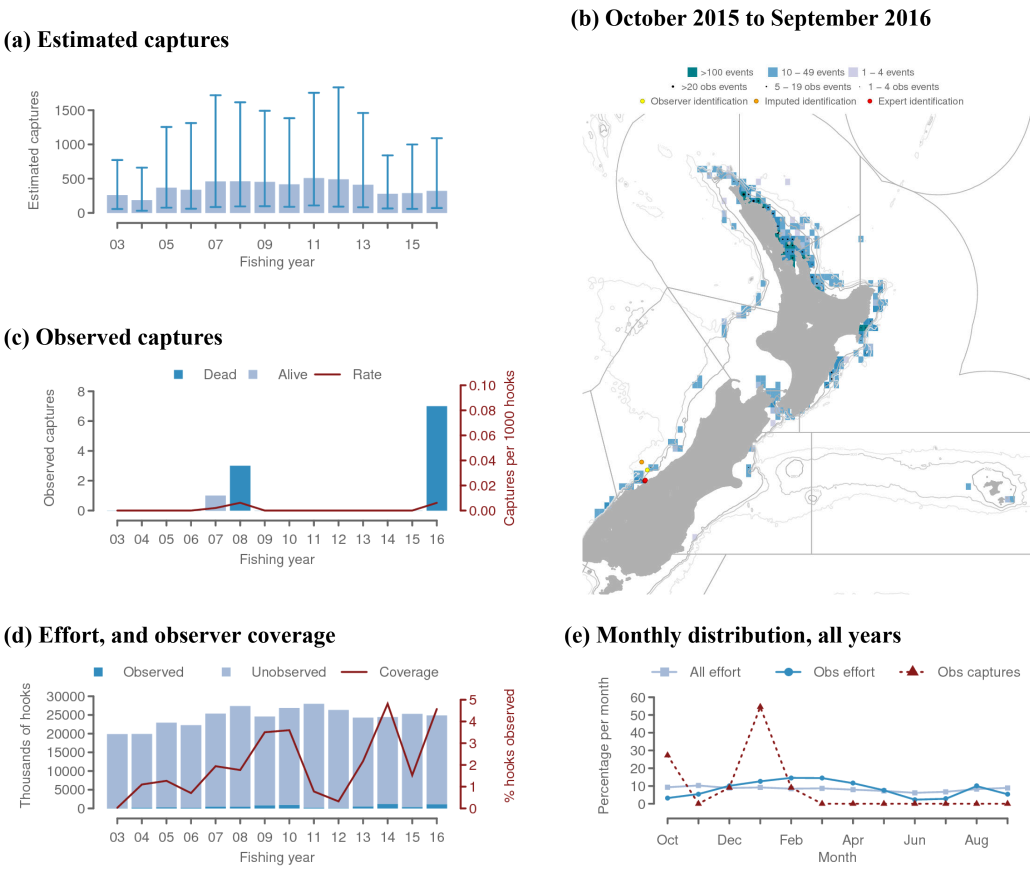


Figure B-19: White-chinned petrel captures in small-vessel (< 28 m length) bottom-longline fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 (following confidentiality rules, 98.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

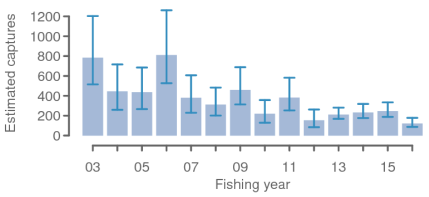
B.7 Sooty shearwater captures

B.7.1 Sooty shearwater captures in large-vessel (≥ 28 m length) trawl fisheries

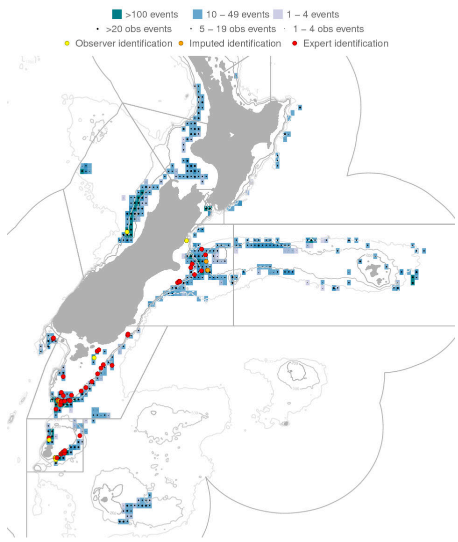
Table B-28: Annual fishing effort and number of tows observed in large-vessel (≥ 28 m length) trawl fisheries, number of observed captures of sooty shearwater and observed capture rate (captures per hundred tows), estimated captures and capture rate of sooty shearwater (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	54 200	11.9	118	1.83	784	515–1 203	1.45	0.95–2.22
2003–04	47 339	13.4	53	0.83	444	259–716	0.94	0.55–1.51
2004–05	44 156	17.2	75	0.99	437	266–685	0.99	0.60–1.55
2005–06	39 121	15.8	169	2.73	811	527–1 261	2.07	1.35–3.22
2006–07	35 193	20.6	70	0.97	380	229–607	1.08	0.65–1.72
2007–08	32 767	25.3	80	0.96	312	201–483	0.95	0.61–1.47
2008–09	29 976	24.7	142	1.92	459	313–688	1.53	1.04–2.30
2009–10	29 505	26.0	48	0.63	220	129–357	0.75	0.44–1.21
2010–11	27 397	22.7	99	1.59	382	253–582	1.39	0.92–2.12
2011–12	25 593	32.8	34	0.41	153	84–262	0.60	0.33–1.02
2012–13	23 970	49.3	135	1.14	211	168–281	0.88	0.70–1.17
2013–14	25 660	43.7	125	1.11	232	176–318	0.90	0.69–1.24
2014–15	25 623	44.6	135	1.18	246	188–334	0.96	0.73–1.30
2015–16	25 008	46.1	62	0.54	121	87–178	0.48	0.35–0.71

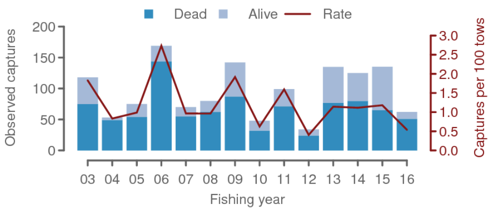
(a) Estimated captures



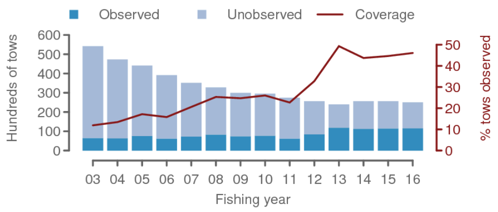
(b) October 2015 to September 2016



(c) Observed captures



(d) Effort, and observer coverage



(e) Monthly distribution, all years

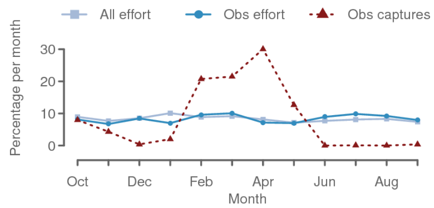


Figure B-20: Sooty shearwater captures in large-vessel (≥ 28 m length) trawl fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16, (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.7.2 Sooty shearwater captures in small-vessel (< 28 m length) trawl fisheries

Table B-29: Annual fishing effort and number of tows observed in small-vessel (< 28 m length) trawl fisheries, number of observed captures of sooty shearwater and observed capture rate (captures per hundred tows), estimated captures and capture rate of sooty shearwater (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	75 976	0.5	0	0.00	212	80–493	0.28	0.11–0.65
2003–04	73 511	0.3	0	0.00	144	50–337	0.20	0.07–0.46
2004–05	76 305	0.2	0	0.00	177	65–418	0.23	0.09–0.55
2005–06	70 830	0.6	0	0.00	190	74–444	0.27	0.10–0.63
2006–07	68 124	1.0	14	2.04	209	89–463	0.31	0.13–0.68
2007–08	56 769	1.3	2	0.27	146	54–330	0.26	0.10–0.58
2008–09	57 574	4.5	11	0.42	123	52–272	0.21	0.09–0.47
2009–10	63 384	2.9	0	0.00	139	50–320	0.22	0.08–0.50
2010–11	58 694	2.3	19	1.39	154	68–332	0.26	0.12–0.57
2011–12	58 831	1.6	0	0.00	137	48–336	0.23	0.08–0.57
2012–13	59 862	1.0	0	0.00	132	47–316	0.22	0.08–0.53
2013–14	59 453	3.3	0	0.00	126	47–286	0.21	0.08–0.48
2014–15	53 131	4.6	1	0.04	134	48–315	0.25	0.09–0.59
2015–16	53 032	5.0	0	0.00	129	48–310	0.24	0.09–0.58

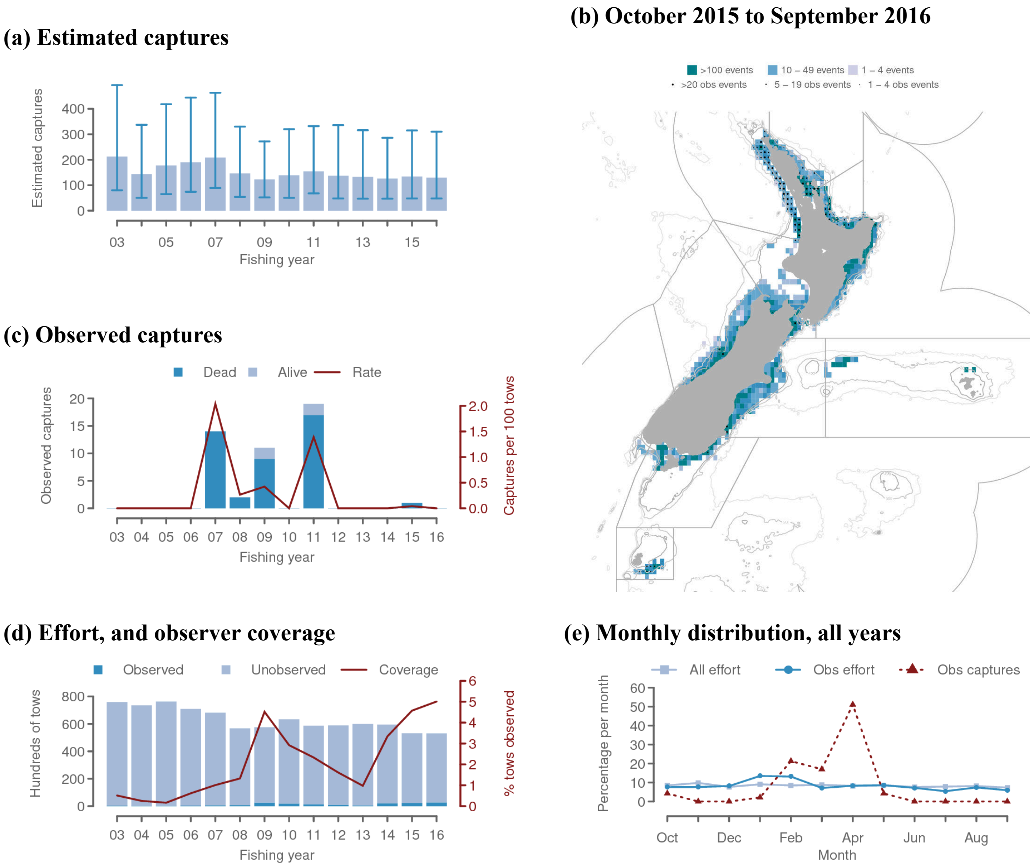


Figure B-21: Sooty shearwater captures in small-vessel (< 28 m length) trawl fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.8 Black petrel captures

B.8.1 Black petrel captures in small-vessel (< 28 m length) bottom-longline fisheries

Table B-30: Annual fishing effort and number of hooks observed in small-vessel (< 28 m length) bottom-longline fisheries, number of observed captures of black petrel and observed capture rate (captures per thousand hooks), estimated captures and capture rate of black petrel (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	19 865 349	0.0	0	0.000	658	261–1 657	0.331	0.131–0.834
2003–04	19 909 463	1.1	2	0.091	605	235–1 473	0.304	0.118–0.740
2004–05	22 922 762	1.3	1	0.034	569	214–1 451	0.248	0.093–0.633
2005–06	22 264 210	0.7	2	0.127	568	203–1 498	0.255	0.091–0.673
2006–07	25 370 472	1.9	4	0.081	710	246–1 870	0.280	0.097–0.737
2007–08	27 385 002	1.8	3	0.062	494	185–1 226	0.180	0.068–0.448
2008–09	24 567 417	3.5	8	0.093	446	170–1 130	0.182	0.069–0.460
2009–10	26 838 971	3.6	33	0.342	536	217–1 333	0.200	0.081–0.497
2010–11	27 982 749	0.8	2	0.092	478	187–1 179	0.171	0.067–0.421
2011–12	26 322 576	0.3	0	0.000	418	155–1 082	0.159	0.059–0.411
2012–13	24 274 494	2.2	2	0.038	289	122–685	0.119	0.050–0.282
2013–14	24 413 204	4.8	7	0.060	296	121–729	0.121	0.050–0.299
2014–15	25 279 199	1.5	2	0.052	277	112–696	0.110	0.044–0.275
2015–16	24 886 224	4.6	0	0.000	215	83–539	0.086	0.033–0.217

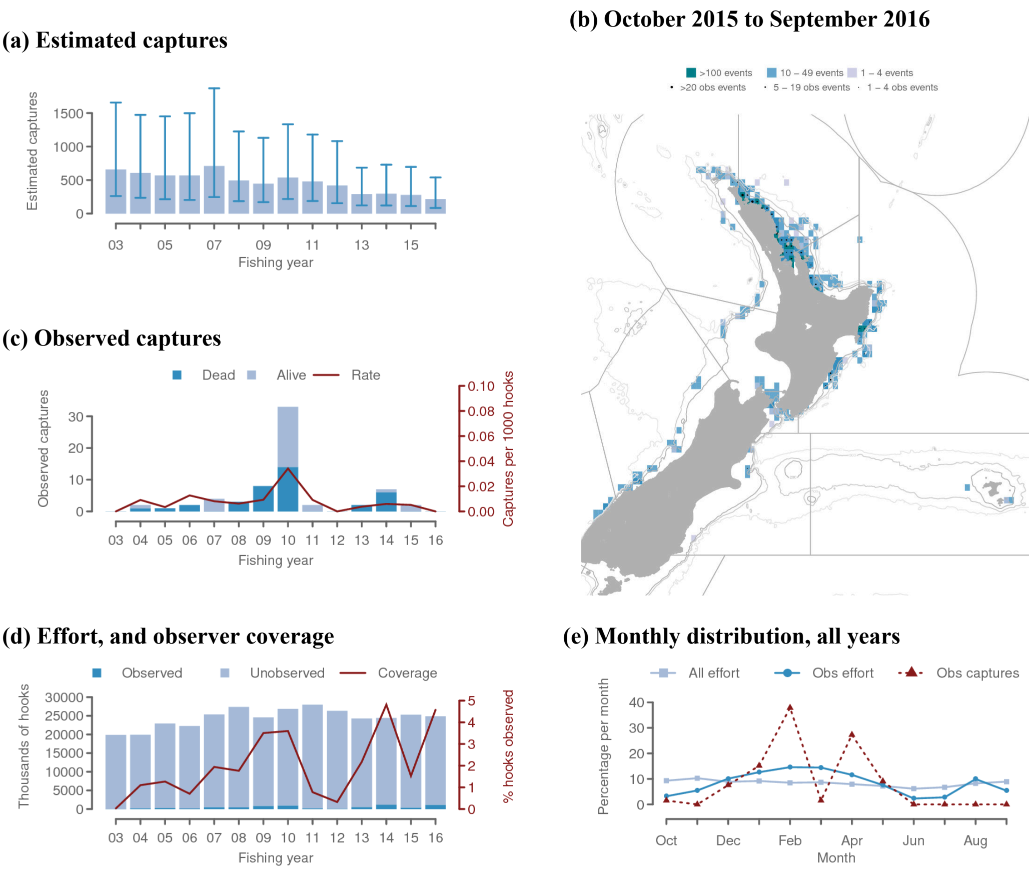


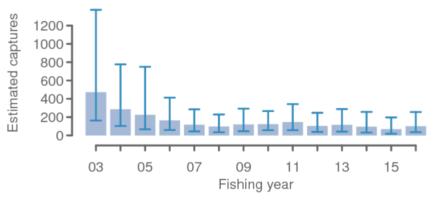
Figure B-22: Black petrel captures in small-vessel (< 28 m length) bottom-longline fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 (following confidentiality rules, 98.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.8.2 Black petrel captures in small-vessel (< 28 m length) surface-longline fisheries

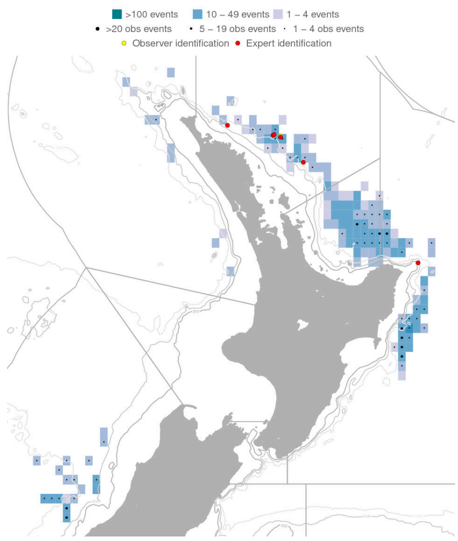
Table B-31: Annual fishing effort and number of hooks observed in small-vessel (< 28 m length) surface-longline fisheries, number of observed captures of black petrel and observed capture rate (captures per thousand hooks), estimated captures and capture rate of black petrel (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	8 573 516	0.0	0	.	472	162–1 372	0.551	0.189–1.600
2003–04	5 730 419	2.4	1	0.074	285	103–777	0.497	0.180–1.356
2004–05	3 041 381	4.7	0	0.000	225	67–749	0.740	0.220–2.463
2005–06	3 027 789	3.2	0	0.000	164	59–412	0.542	0.195–1.361
2006–07	2 332 863	8.1	0	0.000	117	44–285	0.502	0.189–1.222
2007–08	1 678 404	8.1	1	0.073	96	34–229	0.572	0.203–1.364
2008–09	2 305 503	6.6	2	0.132	120	46–292	0.520	0.200–1.267
2009–10	2 517 986	7.7	16	0.821	122	57–266	0.485	0.226–1.056
2010–11	2 683 529	6.4	1	0.058	146	57–342	0.544	0.212–1.274
2011–12	2 548 837	6.8	1	0.058	103	38–247	0.404	0.149–0.969
2012–13	2 389 412	3.0	0	0.000	116	41–288	0.485	0.172–1.205
2013–14	1 896 434	6.8	0	0.000	95	31–257	0.501	0.163–1.355
2014–15	1 790 036	6.0	0	0.000	68	18–197	0.380	0.101–1.101
2015–16	2 305 441	13.0	7	0.234	100	36–255	0.434	0.156–1.106

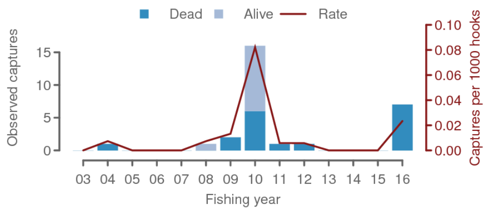
(a) Estimated captures



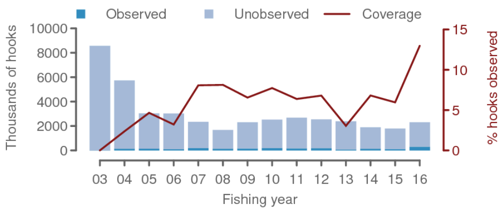
(b) October 2015 to September 2016



(c) Observed captures



(d) Effort, and observer coverage



(e) Monthly distribution, all years

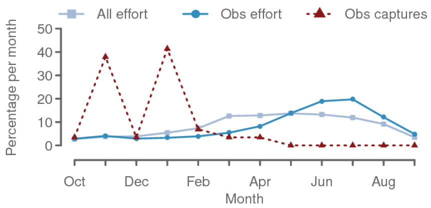


Figure B-23: Black petrel captures in small-vessel (< 28 m length) surface-longline fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.9 Grey petrel captures

B.9.1 Grey petrel captures in small-vessel (< 28 m length) bottom-longline fisheries

Table B-32: Annual fishing effort and number of hooks observed in small-vessel (< 28 m length) bottom-longline fisheries, number of observed captures of grey petrel and observed capture rate (captures per thousand hooks), estimated captures and capture rate of grey petrel (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	19 865 349	0.0	0	0.000	209	60–568	0.105	0.030–0.286
2003–04	19 909 463	1.1	0	0.000	183	53–500	0.092	0.027–0.251
2004–05	22 922 762	1.3	0	0.000	184	53–520	0.080	0.023–0.227
2005–06	22 264 210	0.7	0	0.000	190	52–550	0.085	0.023–0.247
2006–07	25 370 472	1.9	0	0.000	202	53–619	0.080	0.021–0.244
2007–08	27 385 002	1.8	0	0.000	195	49–593	0.071	0.018–0.217
2008–09	24 567 417	3.5	2	0.023	168	44–518	0.068	0.018–0.211
2009–10	26 838 971	3.6	0	0.000	217	59–637	0.081	0.022–0.237
2010–11	27 982 749	0.8	0	0.000	201	58–577	0.072	0.021–0.206
2011–12	26 322 576	0.3	0	0.000	172	47–500	0.065	0.018–0.190
2012–13	24 274 494	2.2	0	0.000	154	43–442	0.063	0.018–0.182
2013–14	24 413 204	4.8	2	0.017	174	50–508	0.071	0.020–0.208
2014–15	25 279 199	1.5	3	0.078	180	51–534	0.071	0.020–0.211
2015–16	24 886 224	4.6	0	0.000	153	40–451	0.061	0.016–0.181

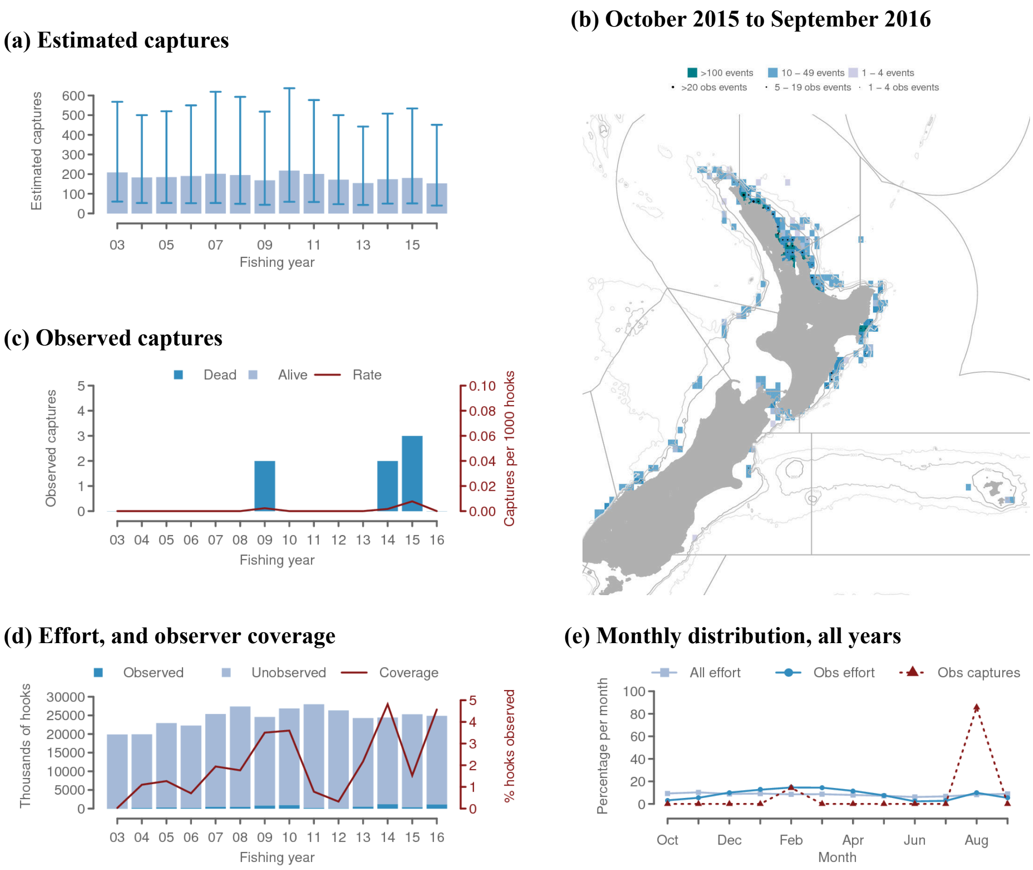


Figure B-24: Grey petrel captures in small-vessel (< 28 m length) bottom-longline fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 (following confidentiality rules, 98.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.10 Flesh-footed shearwater captures

B.10.1 Flesh-footed shearwater captures in small-vessel (< 28 m length) trawl fisheries

Table B-33: Annual fishing effort and number of tows observed in small-vessel (< 28 m length) trawl fisheries, number of observed captures of flesh-footed shearwater and observed capture rate (captures per hundred tows), estimated captures and capture rate of flesh-footed shearwater (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	75 976	0.5	0	0.00	131	68–244	0.17	0.09–0.32
2003–04	73 511	0.3	0	0.00	121	65–215	0.16	0.09–0.29
2004–05	76 305	0.2	0	0.00	121	64–207	0.16	0.08–0.27
2005–06	70 830	0.6	8	1.83	114	65–187	0.16	0.09–0.26
2006–07	68 124	1.0	6	0.87	114	64–200	0.17	0.09–0.29
2007–08	56 769	1.3	5	0.66	101	56–173	0.18	0.10–0.30
2008–09	57 574	4.5	3	0.12	101	56–169	0.18	0.10–0.29
2009–10	63 384	2.9	2	0.11	120	64–224	0.19	0.10–0.35
2010–11	58 694	2.3	15	1.10	123	71–213	0.21	0.12–0.36
2011–12	58 831	1.6	1	0.11	94	51–167	0.16	0.09–0.28
2012–13	59 862	1.0	0	0.00	106	56–201	0.18	0.09–0.34
2013–14	59 453	3.3	9	0.45	103	56–189	0.17	0.09–0.32
2014–15	53 131	4.6	9	0.37	95	53–166	0.18	0.10–0.31
2015–16	53 032	5.0	2	0.08	89	45–167	0.17	0.08–0.31

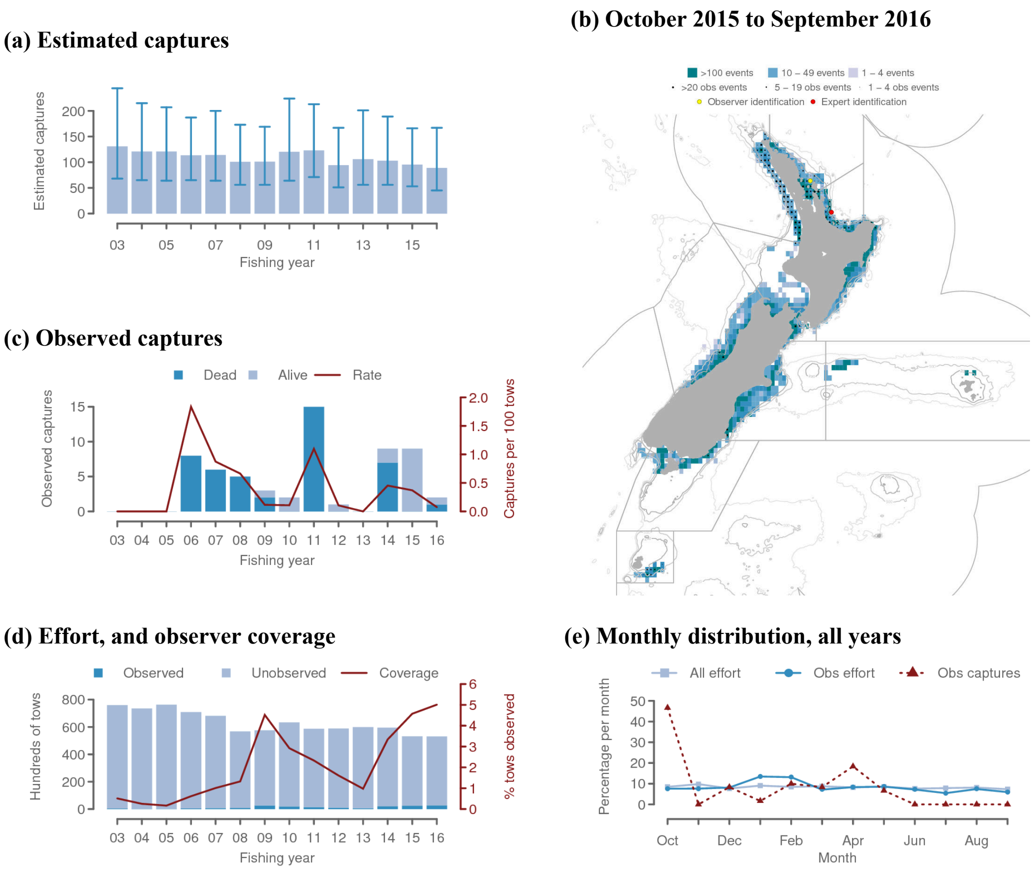


Figure B-25: Flesh-footed shearwater captures in small-vessel (< 28 m length) trawl fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.10.2 Flesh-footed shearwater captures in small-vessel (< 28 m length) bottom-longline fisheries

Table B-34: Annual fishing effort and number of hooks observed in small-vessel (< 28 m length) bottom-longline fisheries, number of observed captures of flesh-footed shearwater and observed capture rate (captures per thousand hooks), estimated captures and capture rate of flesh-footed shearwater (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	19 865 349	0.0	0	0.000	515	288–1 019	0.259	0.145–0.513
2003–04	19 909 463	1.1	3	0.137	459	253–955	0.231	0.127–0.480
2004–05	22 922 762	1.3	9	0.310	435	243–856	0.190	0.106–0.373
2005–06	22 264 210	0.7	0	0.000	344	184–683	0.155	0.083–0.307
2006–07	25 370 472	1.9	0	0.000	356	193–710	0.140	0.076–0.280
2007–08	27 385 002	1.8	0	0.000	300	168–576	0.110	0.061–0.210
2008–09	24 567 417	3.5	15	0.174	313	181–590	0.127	0.074–0.240
2009–10	26 838 971	3.6	14	0.145	288	166–543	0.107	0.062–0.202
2010–11	27 982 749	0.8	0	0.000	331	186–623	0.118	0.066–0.223
2011–12	26 322 576	0.3	0	0.000	279	164–490	0.106	0.062–0.186
2012–13	24 274 494	2.2	2	0.038	300	166–567	0.124	0.068–0.234
2013–14	24 413 204	4.8	31	0.264	302	177–579	0.124	0.073–0.237
2014–15	25 279 199	1.5	8	0.207	283	155–542	0.112	0.061–0.214
2015–16	24 886 224	4.6	12	0.105	234	132–436	0.094	0.053–0.175

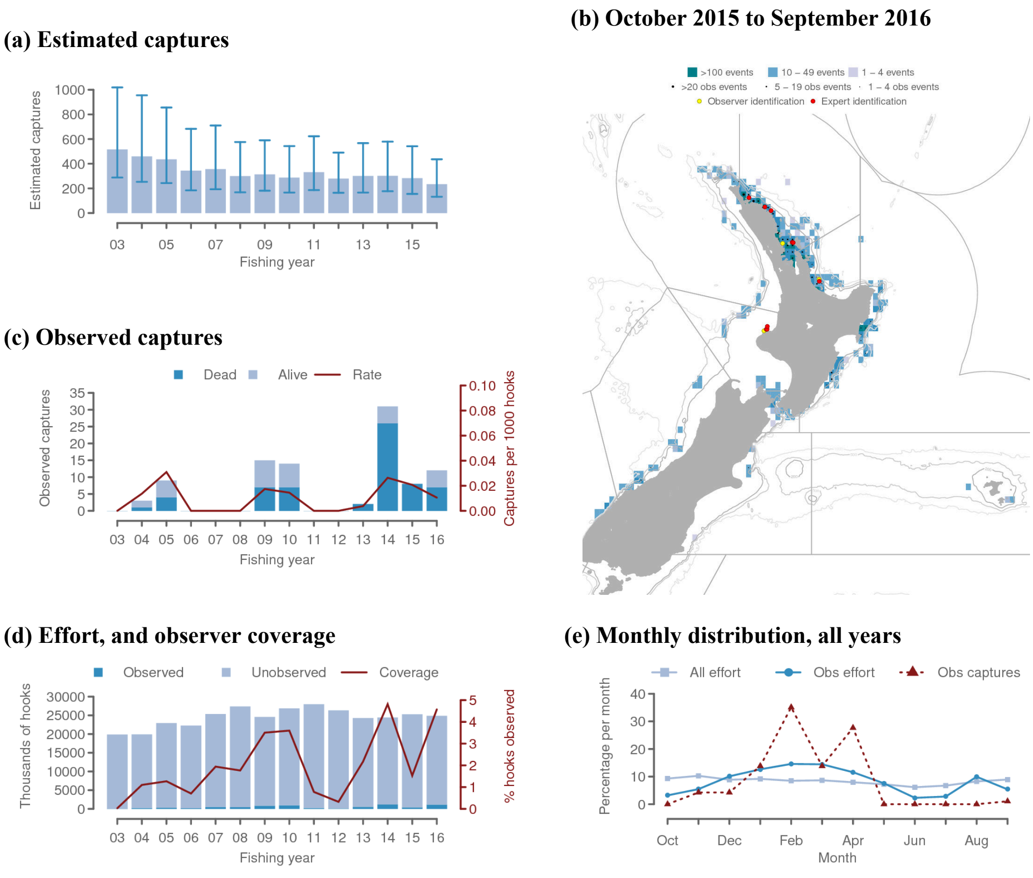


Figure B-26: Flesh-footed shearwater captures in small-vessel (< 28 m length) bottom-longline fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 (following confidentiality rules, 98.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.10.3 Flesh-footed shearwater captures in small-vessel (< 28 m length) surface-longline fisheries

Table B-35: Annual fishing effort and number of hooks observed in small-vessel (< 28 m length) surface-longline fisheries, number of observed captures of flesh-footed shearwater and observed capture rate (captures per thousand hooks), estimated captures and capture rate of flesh-footed shearwater (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	8 573 516	0.0	0	.	671	303–1 341	0.783	0.353–1.564
2003–04	5 730 419	2.4	0	0.000	426	189–880	0.743	0.330–1.536
2004–05	3 041 381	4.7	1	0.071	252	94–569	0.829	0.309–1.871
2005–06	3 027 789	3.2	4	0.411	254	105–547	0.839	0.347–1.807
2006–07	2 332 863	8.1	3	0.159	206	81–461	0.883	0.347–1.976
2007–08	1 678 404	8.1	2	0.147	172	64–392	1.025	0.381–2.336
2008–09	2 305 503	6.6	0	0.000	220	84–491	0.954	0.364–2.130
2009–10	2 517 986	7.7	0	0.000	216	85–464	0.858	0.338–1.843
2010–11	2 683 529	6.4	2	0.117	275	108–619	1.025	0.402–2.307
2011–12	2 548 837	6.8	0	0.000	217	80–494	0.851	0.314–1.938
2012–13	2 389 412	3.0	0	0.000	199	72–467	0.833	0.301–1.954
2013–14	1 896 434	6.8	0	0.000	170	54–402	0.896	0.285–2.120
2014–15	1 790 036	6.0	1	0.094	103	27–281	0.575	0.151–1.570
2015–16	2 305 441	13.0	0	0.000	142	45–349	0.616	0.195–1.514

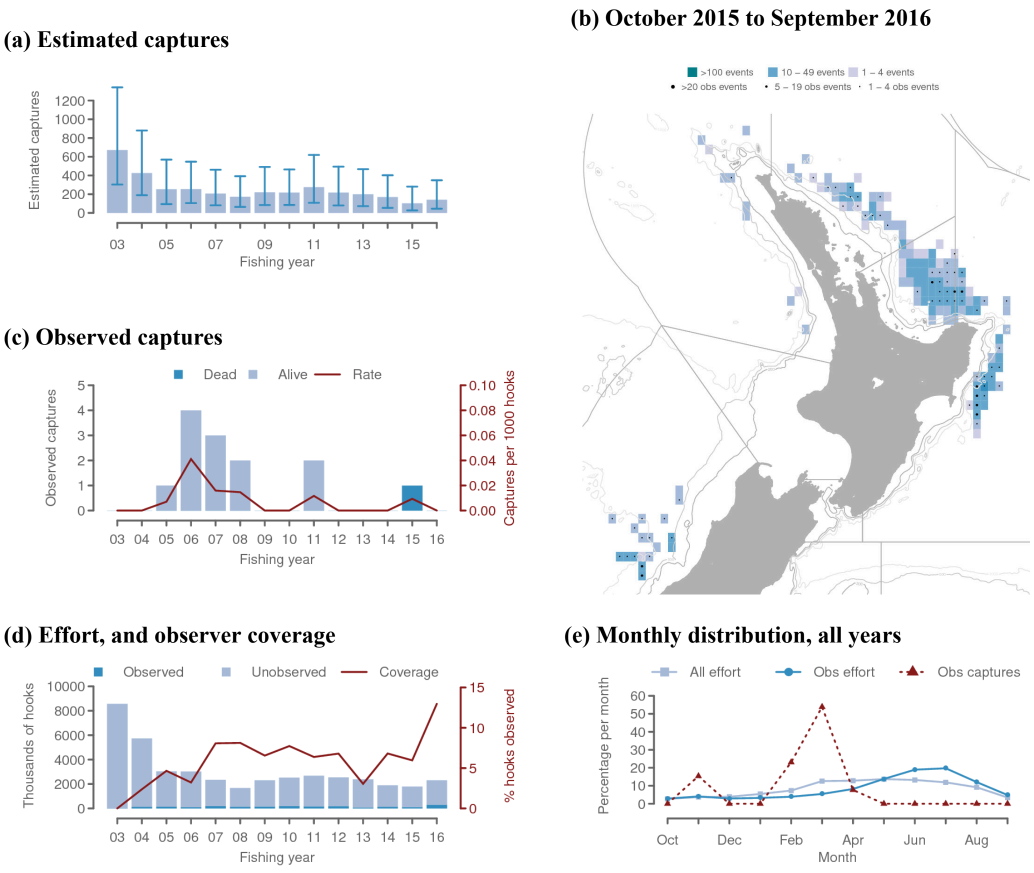


Figure B-27: Flesh-footed shearwater captures in small-vessel (< 28 m length) surface-longline fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.11 Other birds captures

B.11.1 Other birds captures in large-vessel (≥ 28 m length) trawl fisheries

Table B-36: Annual fishing effort and number of tows observed in large-vessel (≥ 28 m length) trawl fisheries, number of observed captures of other birds and observed capture rate (captures per hundred tows), estimated captures and capture rate of other birds (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	54 200	11.9	17	0.263	131	75–214	0.242	0.138–0.395
2003–04	47 339	13.4	15	0.236	99	56–164	0.209	0.118–0.346
2004–05	44 156	17.2	21	0.277	118	71–192	0.267	0.161–0.435
2005–06	39 121	15.8	9	0.146	69	37–120	0.176	0.095–0.307
2006–07	35 193	20.6	8	0.110	52	25–92	0.148	0.071–0.261
2007–08	32 767	25.3	11	0.133	55	30–94	0.168	0.092–0.287
2008–09	29 976	24.7	12	0.162	54	29–90	0.180	0.097–0.300
2009–10	29 505	26.0	25	0.326	85	55–134	0.288	0.186–0.454
2010–11	27 397	22.7	38	0.611	111	74–169	0.405	0.270–0.617
2011–12	25 593	32.8	12	0.143	41	24–68	0.160	0.094–0.266
2012–13	23 970	49.3	21	0.178	41	28–60	0.171	0.117–0.250
2013–14	25 660	43.7	15	0.134	35	22–54	0.136	0.086–0.210
2014–15	25 623	44.6	28	0.245	59	42–85	0.230	0.164–0.332
2015–16	25 008	46.1	14	0.121	35	22–56	0.140	0.088–0.224

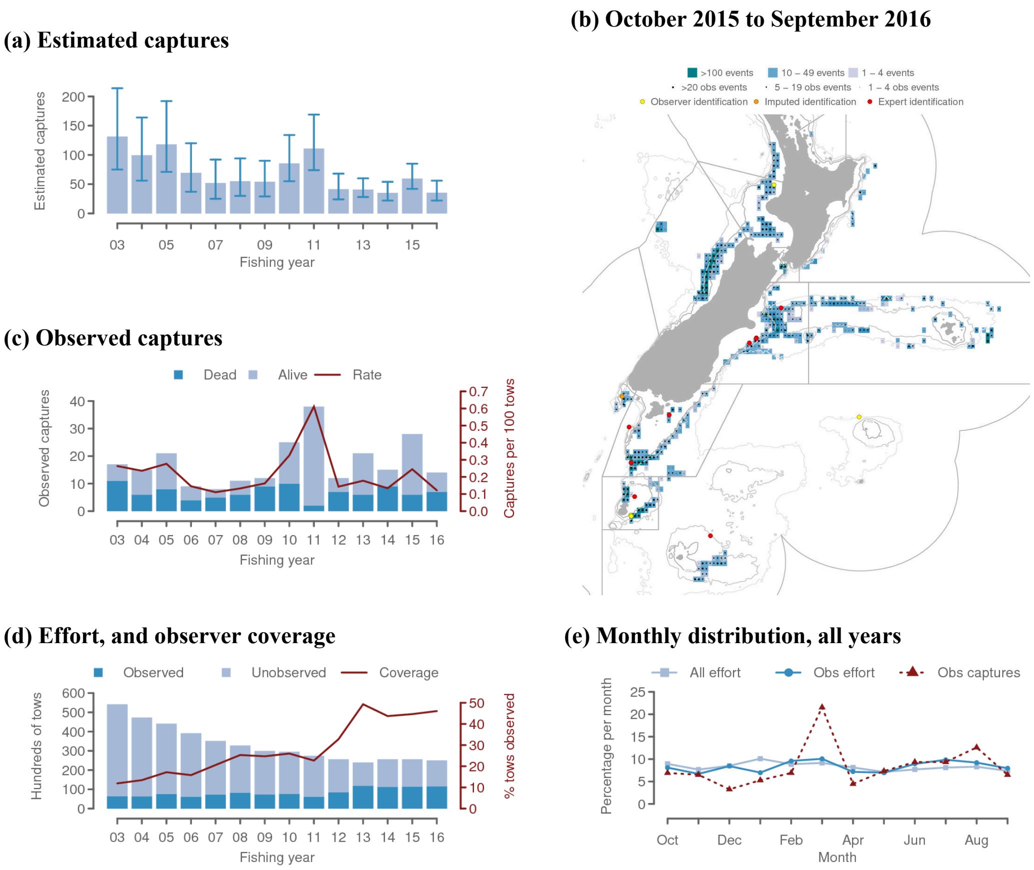


Figure B-28: Other birds captures in large-vessel (≥ 28 m length) trawl fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.11.2 Other birds captures in small-vessel (< 28 m length) trawl fisheries

Table B-37: Annual fishing effort and number of tows observed in small-vessel (< 28 m length) trawl fisheries, number of observed captures of other birds and observed capture rate (captures per hundred tows), estimated captures and capture rate of other birds (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	75 976	0.5	0	0.00	361	183–670	0.48	0.24–0.88
2003–04	73 511	0.3	0	0.00	352	177–662	0.48	0.24–0.90
2004–05	76 305	0.2	0	0.00	357	185–668	0.47	0.24–0.88
2005–06	70 830	0.6	1	0.23	329	167–610	0.46	0.24–0.86
2006–07	68 124	1.0	2	0.29	329	166–627	0.48	0.24–0.92
2007–08	56 769	1.3	0	0.00	271	132–512	0.48	0.23–0.90
2008–09	57 574	4.5	35	1.35	291	162–528	0.51	0.28–0.92
2009–10	63 384	2.9	0	0.00	282	142–540	0.44	0.22–0.85
2010–11	58 694	2.3	0	0.00	238	121–431	0.41	0.21–0.73
2011–12	58 831	1.6	0	0.00	254	127–471	0.43	0.22–0.80
2012–13	59 862	1.0	0	0.00	255	128–471	0.43	0.21–0.79
2013–14	59 453	3.3	2	0.10	249	127–455	0.42	0.21–0.77
2014–15	53 131	4.6	5	0.21	217	111–402	0.41	0.21–0.76
2015–16	53 032	5.0	6	0.23	232	119–431	0.44	0.22–0.81

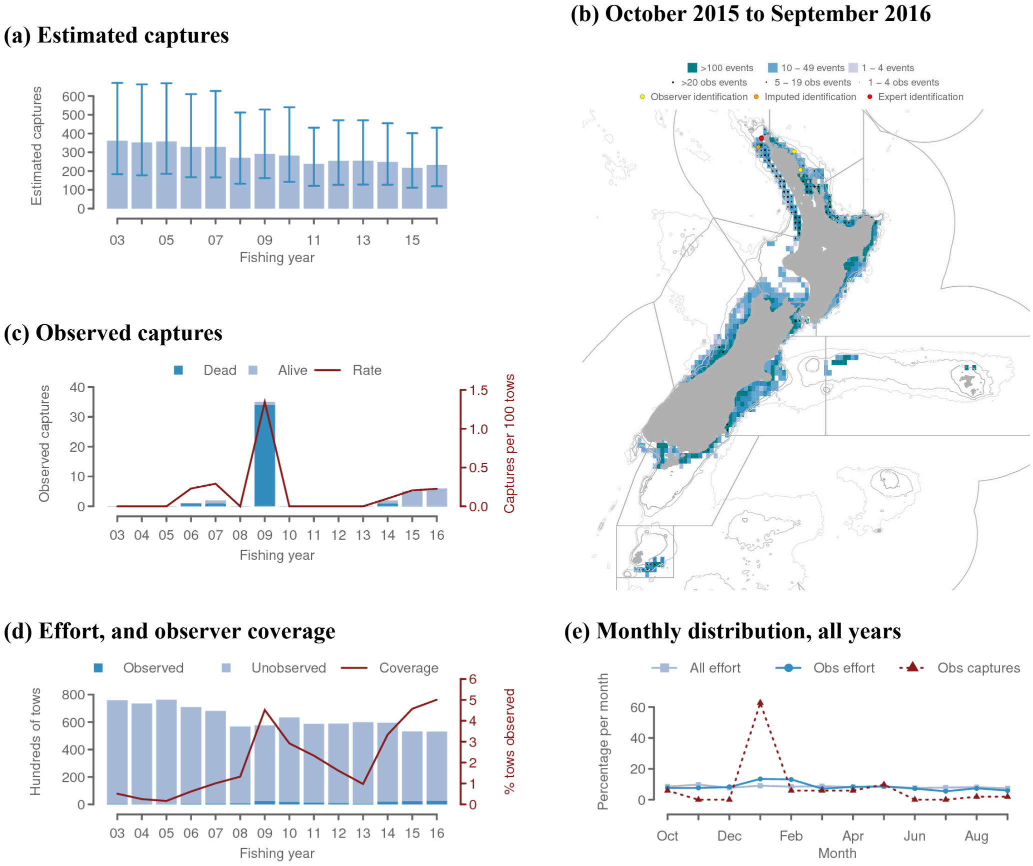


Figure B-29: Other birds captures in small-vessel (< 28 m length) trawl fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.11.3 Other birds captures in large-vessel (≥ 28 m length) bottom-longline fisheries

Table B-38: Annual fishing effort and number of hooks observed in large-vessel (≥ 28 m length) bottom-longline fisheries, number of observed captures of other birds and observed capture rate (captures per thousand hooks), estimated captures and capture rate of other birds (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	17 928 519	60.1	22	0.020	58	34–99	0.032	0.019–0.055
2003–04	23 333 597	20.7	5	0.010	45	18–92	0.019	0.008–0.039
2004–05	18 932 296	13.7	2	0.008	37	12–81	0.020	0.006–0.043
2005–06	14 888 723	24.5	6	0.016	36	15–77	0.024	0.010–0.052
2006–07	12 759 288	14.3	1	0.005	27	6–66	0.021	0.005–0.052
2007–08	14 127 896	22.0	1	0.003	27	7–63	0.019	0.005–0.045
2008–09	12 870 071	24.8	1	0.003	22	5–52	0.017	0.004–0.040
2009–10	13 602 940	12.6	2	0.012	36	10–86	0.026	0.007–0.063
2010–11	12 919 517	11.8	0	0.000	25	4–66	0.019	0.003–0.051
2011–12	11 571 447	17.5	0	0.000	17	2–44	0.015	0.002–0.038
2012–13	8 234 145	3.3	0	0.000	29	8–71	0.035	0.010–0.086
2013–14	16 459 721	11.7	2	0.010	45	17–100	0.027	0.010–0.061
2014–15	14 060 072	2.5	0	0.000	33	10–79	0.023	0.007–0.056
2015–16	18 604 396	10.8	0	0.000	34	10–76	0.018	0.005–0.041

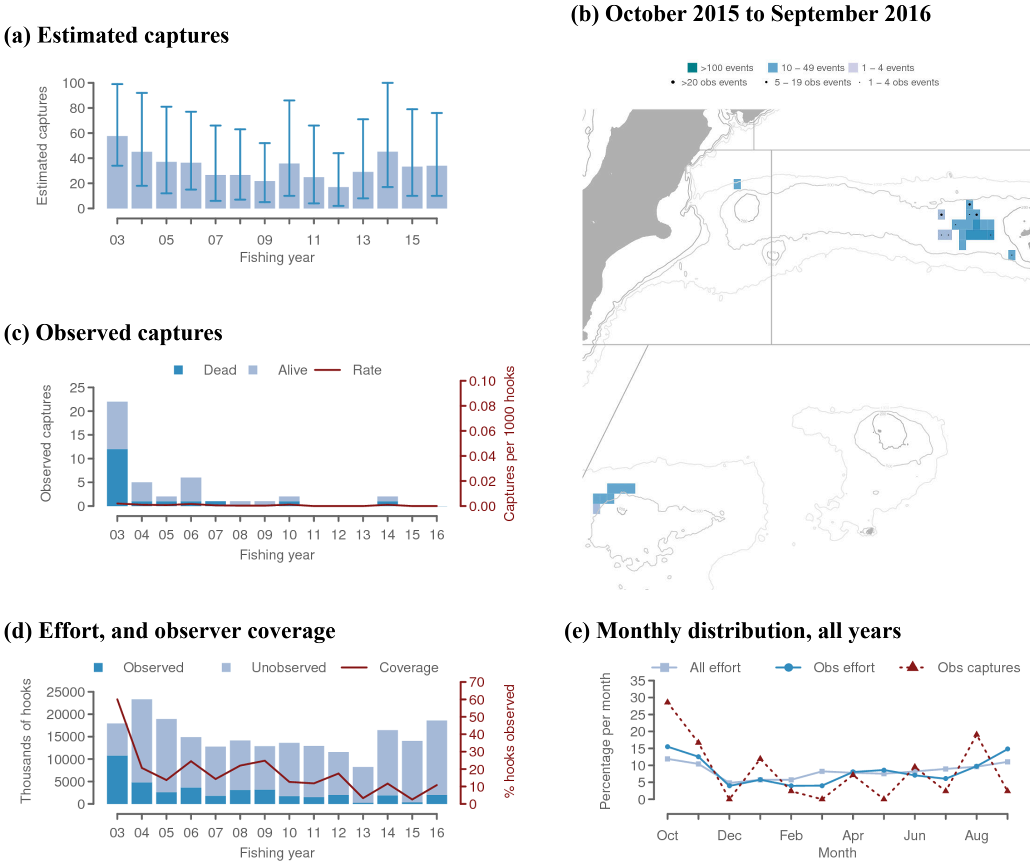


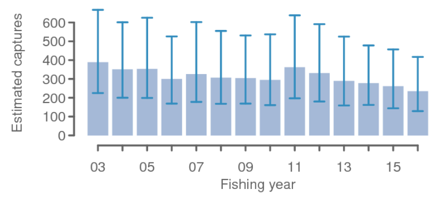
Figure B-30: Other birds captures in large-vessel (≥ 28 m length) bottom-longline fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.11.4 Other birds captures in small-vessel (< 28 m length) bottom-longline fisheries

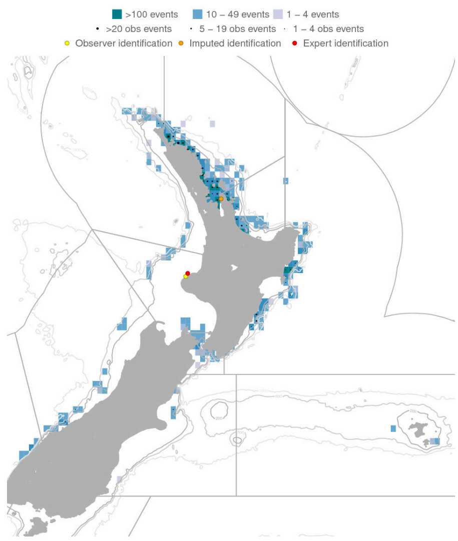
Table B-39: Annual fishing effort and number of hooks observed in small-vessel (< 28 m length) bottom-longline fisheries, number of observed captures of other birds and observed capture rate (captures per thousand hooks), estimated captures and capture rate of other birds (mean and 95% credible interval).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	19 865 349	0.0	2	3.64	389	225–667	0.20	0.11–0.34
2003–04	19 909 463	1.1	5	0.23	351	200–601	0.18	0.10–0.30
2004–05	22 922 762	1.3	3	0.10	353	199–625	0.15	0.09–0.27
2005–06	22 264 210	0.7	10	0.64	300	169–526	0.13	0.08–0.24
2006–07	25 370 472	1.9	3	0.06	326	178–602	0.13	0.07–0.24
2007–08	27 385 002	1.8	6	0.12	307	168–555	0.11	0.06–0.20
2008–09	24 567 417	3.5	9	0.10	304	169–531	0.12	0.07–0.22
2009–10	26 838 971	3.6	1	0.01	295	161–537	0.11	0.06–0.20
2010–11	27 982 749	0.8	0	0.00	362	197–638	0.13	0.07–0.23
2011–12	26 322 576	0.3	1	0.12	331	180–591	0.13	0.07–0.22
2012–13	24 274 494	2.2	2	0.04	289	159–525	0.12	0.07–0.22
2013–14	24 413 204	4.8	17	0.14	278	162–478	0.11	0.07–0.20
2014–15	25 279 199	1.5	2	0.05	261	144–457	0.10	0.06–0.18
2015–16	24 886 224	4.6	3	0.03	235	129–417	0.09	0.05–0.17

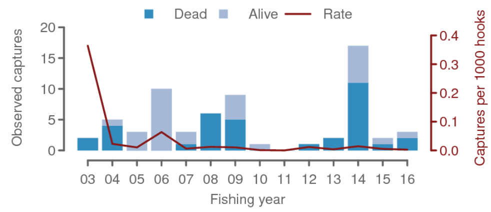
(a) Estimated captures



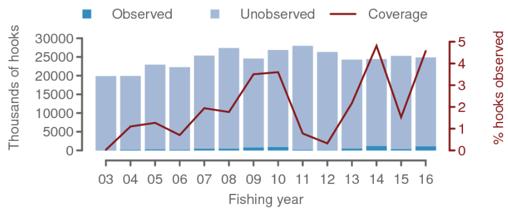
(b) October 2015 to September 2016



(c) Observed captures



(d) Effort, and observer coverage



(e) Monthly distribution, all years

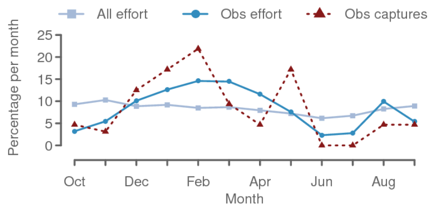


Figure B-31: Other birds captures in small-vessel (< 28 m length) bottom-longline fisheries. (a) Estimated captures, with 95% bootstrap credible intervals, (b) Mapped effort and captures in 2015–16 (following confidentiality rules, 98.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

APPENDIX C: SEABIRD ESTIMATION MODEL STAN CODE

Code for Bayesian estimation of seabird bycatch from fishing effort data and observed captures. This code works with Stan, from the R software package 'rstan' version 2.16.2. (Carpenter et al. 2015).

```
data {

  int NOBS;
  int ROWS;
  int METHOD[ROWS];
  int METHODS;

  int METHCLASS_NOTFIXED_N;
  int METHCLASS_NOTFIXED_i [METHCLASS_NOTFIXED_N];
  int METHCLASS_NOTFIXED_j [METHCLASS_NOTFIXED_N];
  int METHCLASS_FIXED_i;
  int METHCLASS_FIXED_j;

  int SEASON[ROWS];
  int SEASONS;
  int SEASON_NOTFIXED_N;
  int SEASON_NOTFIXED_i [SEASON_NOTFIXED_N];
  int SEASON_FIXED_i;

  int NZHALF[ROWS];
  int NZHALF_FIXED_i;
  int NZHALF_NOTFIXED_i;

  int VCLASS[ROWS];
  int AREA[ROWS];
  int AREAS;
  int FISHERY[ROWS];
  int FISHERIES;
  int YEAR[ROWS];
  int YEARS;
  int COUNT[NOBS];
  int EVENTS[ROWS];
}

parameters {

  real log_beta0;
  real log_beta_method_v [METHCLASS_NOTFIXED_N];
  real log_beta_region_v;
  real log_beta_season_v [SEASON_NOTFIXED_N];

  real<lower=1E-8, upper=5> sd_eta_y [METHODS];
  real<lower=1E-8, upper=5> sd_eta_f;
  real<lower=1E-8, upper=5> sd_eta_a;
  real<lower=0.0025, upper=400> phi [METHODS];

  vector<lower=1E-8, upper=10>[YEARS] eta_y [METHODS];
  real<lower=1E-8, upper=10> eta_f [FISHERIES];
  real<lower=1E-8, upper=10> eta_a [AREAS];

}

transformed parameters {

  real eta_y_k [ROWS];
  real beta [ROWS];
  vector [ROWS] mustar;
  matrix[METHODS, 2] log_beta_method;
  vector[2] log_beta_region;
  vector[4] log_beta_season;

  log_beta_method[METHCLASS_FIXED_i, METHCLASS_FIXED_j] = 0.0;
  for (i in 1:METHCLASS_NOTFIXED_N) {
    log_beta_method[METHCLASS_NOTFIXED_i[i], METHCLASS_NOTFIXED_j[i]] = log_beta_method_v[i];
  }

  log_beta_region[NZHALF_FIXED_i] = 0.0;
  log_beta_region[NZHALF_NOTFIXED_i] = log_beta_region_v;

  for (i in 1:SEASON_NOTFIXED_N) {
    log_beta_season[SEASON_NOTFIXED_i[i]] = log_beta_season_v[i];
  }
  log_beta_season[SEASON_FIXED_i] = 0.0;

  for (k in 1:ROWS) {
    eta_y_k[k] = ((VCLASS[k] == 2) ? 1 : eta_y[METHOD[k], YEAR[k]]);
  }

  for (k in 1:ROWS) {
    beta[k] = exp(log_beta0 + log_beta_method[METHOD[k], VCLASS[k]] + log_beta_region[NZHALF[k]] + log_beta_season[SEASON[k]]);
    mustar[k] = beta[k] * eta_y_k[k] * eta_f[FISHERY[k]] * eta_a[AREA[k]];
  }

}

model {

  /* INTERCEPT */
  log_beta0 ~ normal(-3, 5);

  /* METHOD / VCLASS fixed effect */
```

```
  log_beta_method_v ~ normal(0, 5);

  /* NZHALF fixed effect */
  log_beta_region_v ~ normal(0, 5);

  /* SEASON fixed effect */
  log_beta_season_v ~ normal(0, 5);

  /* YEAR random effect */
  for (m in 1:METHODS){
    sd_eta_y[m] ~ lognormal(0, 1);
    for (y in 1:YEARS) {
       eta_y[m, y] ~ gamma(pow(sd_eta_y[m], -2), pow(sd_eta_y[m], -2));
    }
  }

  /* FISHERY random effect */
  sd_eta_f ~ lognormal(0, 1);
  for (f in 1:FISHERIES){
    eta_f[f] ~ gamma(pow(sd_eta_f, -2), pow(sd_eta_f, -2));
  }

  /* AREA random effect */
  sd_eta_a ~  lognormal(0, 1);
  for (a in 1:AREAS){
    eta_a[a] ~ gamma(pow(sd_eta_a, -2), pow(sd_eta_a, -2));
  }

  for (m in 1:METHODS) {
    phi[m] ~ lognormal(0, 1);
  }

  for (k in 1:NOBS) {
    COUNT[k] ~ neg_binomial_2(EVENTS[k] * mustar[k], EVENTS[k] * phi[METHOD[k]]);
  }
}

generated quantities{
  vector[NOBS] log_lik;
  vector[ROWS] estimate;
  vector[METHODS] sd_overdispersion;
  real prior_phi;
  real prior_sd;
  real prior_eta;
  real prior_log_beta;

  /* Log likelihood */
  for (k in 1:NOBS){
    log_lik[k] = neg_binomial_2_lpmf(COUNT[k] | EVENTS[k] * mustar[k], EVENTS[k] * phi[METHOD[k]]);
  }

  /* Estimates */
  for (k in 1:ROWS) {
    estimate[k] = neg_binomial_2_rng(EVENTS[k] * mustar[k], EVENTS[k] * phi[METHOD[k]]);
  }

  /* Priors */
  prior_phi = lognormal_rng(0, 1);
  prior_sd  = exponential_rng(0.5);
  prior_eta = gamma_rng(pow(prior_sd, -2), pow(prior_sd, -2));
  prior_log_beta = normal_rng(0, 5);

  /* SD of the overdispersion */
  for (m in 1:METHODS){
    sd_overdispersion[m] = pow(phi[m], -0.5);
  }
}
```

APPENDIX D: SUMMARIES OF MODELS USED FOR THE SEABIRD ESTIMATION

D.1 White-capped albatross

Table D-40: Model strata with the highest number of estimated captures of white-capped albatross in each of trawl, surface-longline (SLL), and bottom-longline (BLL) fisheries. Only the 15 strata with the most estimated captures are shown, sorted in decreasing order of mean estimated captures. The strata were defined as combinations of fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2015–16 for bottom- and surface-longline fisheries, and between 2002–03 and 2015–16 for trawl fisheries are shown, along with the number of fishing events observed, the proportion of fishing events observed (observer coverage), the associated ratio estimate of the total number of captures, and the mean and 95% credible interval of the total estimated number of captures. IWL: Integrated weight line.

Fishery	Vessel size	Area	Season	Observations				Estimated captures	
				Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
Trawl									
Squid trawl	Vessels $\geq$ 28 m	Stewart Snares Shelf	Summer	408	9573	0.364	1119	1256	998–1550
Squid trawl	Vessels $\geq$ 28 m	Auckland Islands	Summer	311	6591	0.475	654	563	427–713
Squid trawl	Vessels $\geq$ 28 m	Stewart Snares Shelf	Autumn	112	2605	0.303	369	431	307–592
Squid trawl	Vessels $\geq$ 28 m	Auckland Islands	Autumn	88	2734	0.362	242	309	215–429
Inshore trawl	Vessels $<$ 28 m	Stewart Snares Shelf	Summer	2	163	0.021	93	230	116–411
Inshore trawl	Vessels $<$ 28 m	Stewart Snares Shelf	Autumn	0	0	0.000		158	72–297
Flatfish trawl	Vessels $<$ 28 m	Stewart Snares Shelf	Summer	0	581	0.024	0	151	44–346
Inshore trawl	Vessels $<$ 28 m	West Coast South Island	Summer	12	499	0.047	252	148	77–257
Inshore trawl	Vessels $<$ 28 m	West Coast South Island	Autumn	2	13	0.001	1372	133	66–229
Inshore trawl	Vessels $<$ 28 m	Western Chatham Rise	Summer	0	637	0.029	0	113	53–206
Inshore trawl	Vessels $<$ 28 m	Western Chatham Rise	Autumn	0	0	0.000		108	49–201
Flatfish trawl	Vessels $<$ 28 m	Stewart Snares Shelf	Autumn	3	47	0.003	1050	107	28–250
Inshore trawl	Vessels $<$ 28 m	Stewart Snares Shelf	Spring	0	22	0.004	0	105	46–195
Inshore trawl	Vessels $<$ 28 m	West Coast South Island	Spring	1	159	0.014	70	91	41–168
Scampi trawl	Vessels $<$ 28 m	Auckland Islands	Autumn	6	417	0.088	68	88	40–165
Surface longline									
Southern bluefin SLL	Vessels $<$ 43 m	West Coast South Island	Autumn	67	205	0.084	795	651	331–1164
Southern bluefin SLL	Vessels $<$ 43 m	Fiordland	Autumn	10	10	0.027	366	110	37–254
Southern bluefin SLL	Vessels $\geq$ 43 m	Fiordland	Autumn	80	3055	0.900	88	104	65–152
Southern bluefin SLL	Vessels $<$ 43 m	East of North Island	Autumn	2	333	0.042	48	98	34–205
Southern bluefin SLL	Vessels $<$ 43 m	West Coast South Island	Summer	0	0	0.000		87	31–183
Southern bluefin SLL	Vessels $<$ 43 m	West Coast South Island	Winter	0	36	0.052	0	64	25–130
Swordfish SLL	Vessels $<$ 43 m	West Coast South Island	Summer	1	20	0.050	20	41	6–129
Swordfish SLL	Vessels $<$ 43 m	West Coast South Island	Autumn	2	36	0.153	13	25	3–82
Bigeye SLL	Vessels $<$ 43 m	East of North Island	Summer	0	174	0.028	0	14	1–48
Southern bluefin SLL	Vessels $<$ 43 m	North East	Winter	1	311	0.095	10	12	2–31
Bigeye SLL	Vessels $<$ 43 m	East of North Island	Autumn	0	96	0.022	0	11	0–36
Bigeye SLL	Vessels $<$ 43 m	West Coast North Island	Summer	0	60	0.023	0	11	0–38
Bigeye SLL	Vessels $<$ 43 m	North East	Summer	0	144	0.027	0	10	0–34
Southern bluefin SLL	Vessels $\geq$ 43 m	West Coast South Island	Autumn	4	334	0.918	4	10	2–23
Albacore SLL	Vessels $<$ 43 m	East of North Island	Autumn	0	23	0.015	0	9	0–41
Bottom longline									
Ling manual-set BLL	Vessels $<$ 34 m	West Coast South Island	Autumn	4	35	0.015	258	43	9–104
Ling manual-set BLL	Vessels $<$ 34 m	West Coast South Island	Summer	0	12	0.006	0	39	8–95
Ling manual-set BLL	Vessels $<$ 34 m	West Coast South Island	Spring	0	1	0.000	0	29	5–73
Ling manual-set BLL	Vessels $<$ 34 m	West Coast South Island	Winter	0	6	0.002	0	20	4–50
Ling manual-set BLL	Vessels $<$ 34 m	Cook Strait	Autumn	0	4	0.004	0	13	1–37
Ling manual-set BLL	Vessels $<$ 34 m	Cook Strait	Spring	0	0	0.000		11	1–33
Ling manual-set BLL	Vessels $<$ 34 m	Western Chatham Rise	Autumn	0	52	0.031	0	11	2–30
Ling manual-set BLL	Vessels $<$ 34 m	Western Chatham Rise	Spring	0	59	0.020	0	11	1–29
Ling manual-set BLL	Vessels $<$ 34 m	Fiordland	Winter	0	3	0.002	0	10	1–28
Ling manual-set BLL	Vessels $<$ 34 m	Cook Strait	Summer	0	4	0.006	0	8	1–25
Minor targets BLL	Vessels $<$ 34 m	Cook Strait	Summer	0	0	0.000		8	0–36
Snapper BLL	Vessels $<$ 34 m	North East	Autumn	0	521	0.015	0	8	0–34
Snapper BLL	Vessels $<$ 34 m	North East	Summer	0	1074	0.029	0	8	0–34
Hāpuku BLL	Vessels $<$ 34 m	West Coast South Island	Summer	0	0	0.000		7	0–36
Ling autoline BLL (no IWL)	Vessels $\geq$ 34 m	Stewart Snares Shelf	Spring	5	909	0.464	10	7	1–18

Table D-41: Summary of model parameters, for white-capped albatross capture in New Zealand commercial trawl, bottom-, and surface-longline fisheries. For each parameter, the table gives summary statistics of the posterior distribution (mean, median, and 95% credible interval, based on the 2.5% and 97.5% quantiles), and diagnostics (the number of chains that fail convergence and half-width tests (Heidelberger & Welch 1983), and the effective length of the chains (without autocorrelation). Trace plots of the chains are also shown. Base levels of the factor covariates are: Large trawl for method, South for region, and Summer (Jan-Mar) for season. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. IWL, integrated weight line.

Parameter	Statistic			Diagnostics			
	Mean	Median	95% c.i.	Conv.	H.W.	Effective length	Trace
S.d.(Year)							
BLL	1.160	1.106	0.248 – 2.379			3125	
SLL	0.741	0.727	0.367 – 1.189			4125	
Trawl	0.353	0.340	0.201 – 0.568			3844	
S.d.(Area)	0.962	0.926	0.581 – 1.546			3525	
S.d.(Fishery)	0.948	0.925	0.593 – 1.485			4002	
Overdispersion							
BLL	1.234	1.073	0.385 – 3.035			4273	
SLL	5.038	4.967	3.518 – 7.043			3895	
Trawl	7.930	7.892	6.387 – 9.554			4114	
Intercept	0.008	0.007	0.003 – 0.021			3627	
Method / Vessel class							
BLL / vessels $\geq$ 34 m	0.427	0.243	0.042 – 1.895			3891	
SLL / vessels $\geq$ 43 m	2.163	1.648	0.430 – 6.916			4002	
Trawl / vessels $\geq$ 28 m	1.000	1.000	1.000 – 1.000	3			
BLL / vessels $<$ 34 m	1.563	1.156	0.212 – 5.465			4002	
SLL / vessels $<$ 43 m	20.042	15.333	4.345 – 65.853			4002	
Trawl / vessels $<$ 28 m	1.179	1.116	0.596 – 2.124			4002	
Region							
North	0.092	0.067	0.018 – 0.315	1		4002	
South	1.000	1.000	1.000 – 1.000	3			
Season							
Autumn (Apr-Jun)	1.052	1.042	0.817 – 1.336			4623	
Spring (Oct-Dec)	0.578	0.567	0.384 – 0.822			4002	
Summer (Jan-Mar)	1.000	1.000	1.000 – 1.000	3			
Winter (Jul-Sep)	0.366	0.358	0.229 – 0.546			4997	
Fishery							
Albacore SLL	0.840	0.605	0.015 – 2.936			3932	
Bigeye SLL	0.424	0.324	0.034 – 1.395			4002	
Bluenose BLL	0.745	0.533	0.012 – 2.675			4002	
Deepwater trawl	0.158	0.139	0.039 – 0.395			4002	
Flatfish trawl	0.333	0.289	0.078 – 0.873			4084	
Hake trawl	0.619	0.582	0.244 – 1.221			3888	
Hāpuku BLL	0.872	0.645	0.016 – 2.953			3896	
Hoki trawl	0.622	0.594	0.289 – 1.116			4002	
Inshore trawl	1.608	1.498	0.632 – 3.186			4306	
Ling autoline BLL (no IWL)	1.552	1.270	0.232 – 4.503			4185	
Ling autoline BLL (IWL)	0.480	0.319	0.005 – 1.924			3630	
Ling manual-set BLL	1.997	1.698	0.442 – 5.125			4002	
Ling trawl	1.153	1.051	0.437 – 2.472			4639	
Mackerel trawl	0.689	0.643	0.257 – 1.391			4114	
Middle depths trawl	1.669	1.611	0.794 – 2.954			4402	
Minor targets BLL	0.678	0.489	0.009 – 2.434			4002	
Minor surface longline	0.830	0.604	0.012 – 2.907			4002	
Southern blue whiting trawl	0.348	0.220	0.004 – 1.375			4111	
Scampi trawl	1.091	1.006	0.442 – 2.209			3987	
Snapper BLL	0.606	0.431	0.009 – 2.182			4132	
Squid trawl	2.601	2.500	1.260 – 4.554			4127	
Southern bluefin SLL	2.206	1.968	0.575 – 5.213			3864	
Swordfish SLL	0.796	0.657	0.121 – 2.284			4002	
Area							
Auckland Islands	2.131	2.028	0.971 – 3.947			4002	
Cook Strait	0.756	0.678	0.227 – 1.692			3672	
East of North Island	0.872	0.751	0.146 – 2.354			4002	
Eastern Chatham Rise	0.224	0.204	0.074 – 0.487			3788	
East Subantarctic	0.272	0.185	0.003 – 1.043			3929	
Fiordland	1.296	1.222	0.533 – 2.505			3990	
Kermadec Islands	0.800	0.576	0.013 – 3.064			4002	
North East	0.744	0.629	0.120 – 2.044			3875	
South Subantarctic	0.198	0.150	0.013 – 0.683			3899	
Stewart Snares Shelf	2.469	2.364	1.106 – 4.434			4002	
Western Chatham Rise	0.419	0.396	0.171 – 0.808			3671	
West Coast North Island	1.492	1.283	0.298 – 3.931			4002	
West Coast South Island	1.177	1.113	0.503 – 2.235			3842	

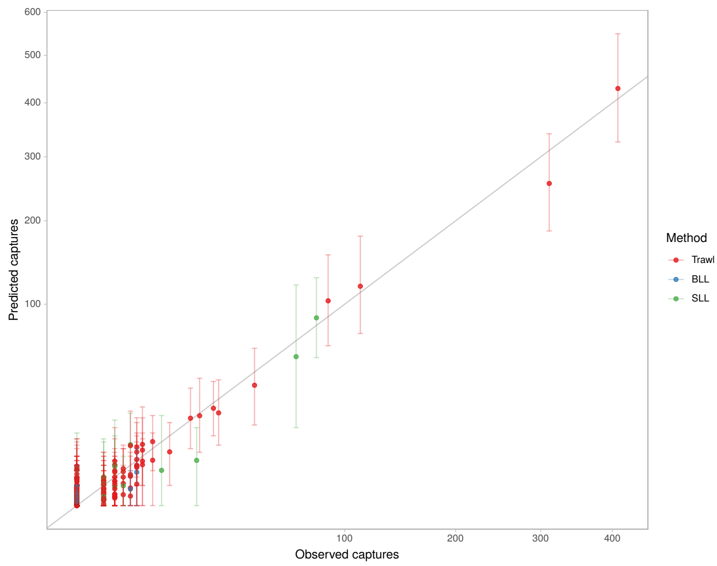


Figure D-32: Comparison between the observed and the predicted number of captures of white-capped albatross (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points were coloured according to the fishing method (BLL, bottom longline; SLL, surface longline).

Table D-42: List of strata, defined as combinations of region, fishery, vessel size, area, and season, for which the number of observed captures of white-capped albatross was outside the 95% credible interval (c.i.) of the estimated number of captures. There were eight of these strata, representing 1.3% of all 602 strata. SLL, surface longline; BLL, bottom longline. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL.

Method	Fishery	Vessel size	Region	Area	Season	Observations	Captures	Mean	95% c.i.
SLL	Southern bluefin SLL	Large	South	Stewart Snares Shelf	Autumn (Apr-Jun)	98	20	5.04	0–15
Trawl	Hoki trawl	Large	South	Fiordland	Autumn (Apr-Jun)	137	4	0.77	0–3
BLL	Ling manual-set BLL	Small	South	West Coast South Island	Autumn (Apr-Jun)	35	4	0.68	0–3
Trawl	Flatfish trawl	Small	South	Stewart Snares Shelf	Autumn (Apr-Jun)	47	3	0.29	0–2
Trawl	Ling trawl	Small	South	West Coast South Island	Autumn (Apr-Jun)	20	4	0.22	0–2
Trawl	Scampi trawl	Small	North	North East	Autumn (Apr-Jun)	379	2	0.17	0–1
Trawl	Inshore trawl	Small	North	West Coast North Island	Winter (Jul-Sep)	340	2	0.14	0–1
Trawl	Inshore trawl	Small	North	East of North Island	Spring (Oct-Dec)	19	1	0.01	0–0

D.2 Salvin’s albatross

Table D-43: Model strata with the highest number of estimated captures of Salvin’s albatross in each of trawl, surface-longline (SLL), and bottom-longline (BLL) fisheries. Only the 15 strata with the most estimated captures are shown, sorted in decreasing order of mean estimated captures. The strata were defined as combinations of fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2015–16 for bottom- and surface-longline fisheries, and between 2002–03 and 2015–16 for trawl fisheries are shown, along with the number of fishing events observed, the proportion of fishing events observed (observer coverage), the associated ratio estimate of the total number of captures, and the mean and 95% credible interval of the total estimated number of captures. IWL: Integrated weight line.

Fishery	Vessel size	Area	Season	Observations				Estimated captures	
				Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
Trawl									
Inshore trawl	Vessels < 28 m	Western Chatham Rise	Spring	4	205	0.012	340	634	278–1216
Middle depths trawl	Vessels < 28 m	Western Chatham Rise	Spring	0	38	0.007	0	330	125–723
Hoki trawl	Vessels ≥ 28 m	Eastern Chatham Rise	Spring	65	2306	0.240	271	279	176–419
Inshore trawl	Vessels < 28 m	Western Chatham Rise	Summer	14	637	0.029	489	258	122–481
Scampi trawl	Vessels < 28 m	Eastern Chatham Rise	Spring	11	541	0.099	110	242	117–459
Hoki trawl	Vessels ≥ 28 m	Western Chatham Rise	Spring	32	2403	0.195	164	239	154–356
Inshore trawl	Vessels < 28 m	Western Chatham Rise	Winter	1	131	0.011	90	230	92–465
Inshore trawl	Vessels < 28 m	East of North Island	Spring	0	19	0.001	0	164	43–418
Middle depths trawl	Vessels < 28 m	Western Chatham Rise	Summer	4	256	0.037	106	127	49–280
Hoki trawl	Vessels ≥ 28 m	Eastern Chatham Rise	Summer	21	1500	0.131	160	99	57–156
Middle depths trawl	Vessels ≥ 28 m	Eastern Chatham Rise	Spring	9	227	0.091	98	98	44–182
Middle depths trawl	Vessels < 28 m	Western Chatham Rise	Winter	0	29	0.009	0	98	34–223
Flatfish trawl	Vessels < 28 m	Western Chatham Rise	Spring	0	69	0.004	0	82	0–339
Middle depths trawl	Vessels ≥ 28 m	Western Chatham Rise	Spring	32	867	0.329	97	81	40–143
Hoki trawl	Vessels ≥ 28 m	Western Chatham Rise	Summer	8	1606	0.127	63	80	44–130
Surface longline									
Bigeye SLL	Vessels < 43 m	East of North Island	Summer	7	174	0.028	246	135	50–263
Bigeye SLL	Vessels < 43 m	East of North Island	Spring	0	13	0.015	0	61	21–126
Bigeye SLL	Vessels < 43 m	North East	Spring	2	188	0.028	72	47	10–116
Bigeye SLL	Vessels < 43 m	North East	Winter	0	100	0.013	0	28	5–72
Bigeye SLL	Vessels < 43 m	East of North Island	Autumn	0	96	0.022	0	23	6–51
Southern bluefin SLL	Vessels < 43 m	East of North Island	Winter	0	195	0.111	0	18	3–44
Bigeye SLL	Vessels < 43 m	North East	Summer	0	144	0.027	0	12	2–31
Southern bluefin SLL	Vessels < 43 m	East of North Island	Autumn	1	333	0.042	24	11	1–31
Albacore SLL	Vessels < 43 m	East of North Island	Summer	0	7	0.011	0	6	0–27
Minor surface longline	Vessels < 43 m	East of North Island	Summer	0	9	0.017	0	6	0–27
Bigeye SLL	Vessels < 43 m	East of North Island	Winter	0	1	0.007	0	5	1–14
Bigeye SLL	Vessels < 43 m	Eastern Chatham Rise	Summer	0	1	0.067	0	4	0–13
Albacore SLL	Vessels < 43 m	East of North Island	Autumn	0	23	0.015	0	3	0–16
Southern bluefin SLL	Vessels < 43 m	North East	Winter	1	311	0.095	10	3	0–12
Albacore SLL	Vessels < 43 m	East of North Island	Spring	0	0	0.000		2	0–9
Bottom longline									
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	East Subantarctic	Spring	100	548	0.417	239	260	51–812
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Eastern Chatham Rise	Winter	2	1011	0.145	13	257	84–631
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Eastern Chatham Rise	Spring	18	464	0.143	125	231	68–596
Ling manual-set BLL	Vessels < 34 m	Eastern Chatham Rise	Spring	6	106	0.049	122	196	50–535
Ling manual-set BLL	Vessels < 34 m	Western Chatham Rise	Spring	1	59	0.020	49	195	51–549
Ling manual-set BLL	Vessels < 34 m	Eastern Chatham Rise	Winter	22	161	0.046	478	169	50–446
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	East Subantarctic	Summer	22	526	0.368	59	122	24–382
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Western Chatham Rise	Spring	0	57	0.024	0	118	30–330
Hāpuku BLL	Vessels < 34 m	Eastern Chatham Rise	Spring	0	24	0.016	0	109	0–618
Ling manual-set BLL	Vessels < 34 m	Western Chatham Rise	Winter	0	90	0.029	0	107	29–272
Bluenose BLL	Vessels < 34 m	Eastern Chatham Rise	Spring	0	0	0.000		55	0–298
Minor targets BLL	Vessels < 34 m	Eastern Chatham Rise	Spring	2	8	0.014	141	53	1–283
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Western Chatham Rise	Winter	0	47	0.027	0	51	10–143
Hāpuku BLL	Vessels < 34 m	Eastern Chatham Rise	Summer	0	0	0.000		50	0–289
Hāpuku BLL	Vessels < 34 m	Eastern Chatham Rise	Winter	0	1	0.001	0	41	0–226

Table D-44: Summary of model parameters, for Salvin's albatross capture in New Zealand commercial trawl, bottom-, and surface-longline fisheries. For each parameter, the table gives summary statistics of the posterior distribution (mean, median, and 95% credible interval, based on the 2.5% and 97.5% quantiles), and diagnostics (the number of chains that fail convergence and half-width tests (Heidelberger & Welch 1983), and the effective length of the chains (without autocorrelation). Trace plots of the chains are also shown. Base levels of the factor covariates are: Large trawl for method, South for region, and Spring (Oct-Dec) for season. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. IWL, integrated weight line.

Parameter	Statistic			Diagnostics			
	Mean	Median	95% c.i.	Conv.	H.W.	Effective length	Trace
S.d.(Year)							
BLL	1.226	1.192	0.639 – 2.069			4235	
SLL	0.928	0.825	0.152 – 2.216			2629	
Trawl	0.528	0.513	0.269 – 0.870			4002	
S.d.(Area)	1.764	1.717	1.233 – 2.527			4165	
S.d.(Fishery)	1.064	1.039	0.656 – 1.603			3901	
Overdispersion							
BLL	12.235	12.136	8.464 – 16.789			4002	
SLL	1.429	1.199	0.414 – 3.907			4165	
Trawl	9.495	9.444	7.593 – 11.587			4002	
Intercept	0.032	0.020	0.006 – 0.118			3730	
Method / Vessel class							
BLL / vessels $\geq$ 34 m	2.302	1.234	0.217 – 10.670			4050	
SLL / vessels $\geq$ 43 m	29.756	14.684	1.709 – 140.163			3855	
Trawl / vessels $\geq$ 28 m	1.000	1.000	1.000 – 1.000	3			
BLL / vessels $<$ 34 m	3.527	2.099	0.377 – 15.247			3829	
SLL / vessels $<$ 43 m	17.756	11.137	2.066 – 73.822			4002	
Trawl / vessels $<$ 28 m	1.831	1.670	0.725 – 3.871			4006	
Region							
North	0.406	0.070	0.007 – 1.889			4162	
South	1.000	1.000	1.000 – 1.000	3			
Season							
Autumn (Apr-Jun)	0.076	0.073	0.037 – 0.129			3797	
Spring (Oct-Dec)	1.000	1.000	1.000 – 1.000	3			
Summer (Jan-Mar)	0.327	0.321	0.222 – 0.469			3865	
Winter (Jul-Sep)	0.544	0.531	0.344 – 0.817			3435	
Fishery							
Albacore SLL	0.712	0.462	0.005 – 2.839			4179	
Bigeye SLL	2.251	1.934	0.488 – 5.968			4167	
Bluenose BLL	0.685	0.423	0.005 – 2.851			4012	
Deepwater trawl	0.126	0.116	0.039 – 0.269			4112	
Flatfish trawl	0.139	0.076	0.001 – 0.644			4114	
Hake trawl	1.682	1.537	0.534 – 3.730			4002	
Hāpuku BLL	0.790	0.493	0.004 – 3.200			3662	
Hoki trawl	0.993	0.937	0.383 – 1.898			3800	
Inshore trawl	1.104	0.985	0.311 – 2.636			3983	
Ling autoline BLL (no IWL)	1.940	1.620	0.253 – 5.557			4226	
Ling autoline BLL (IWL)	0.140	0.063	0.000 – 0.709			3803	
Ling manual-set BLL	1.631	1.309	0.218 – 4.943			4109	
Ling trawl	1.621	1.462	0.504 – 3.700			4007	
Mackerel trawl	0.437	0.363	0.071 – 1.224			4002	
Middle depths trawl	1.604	1.525	0.621 – 3.061			3833	
Minor targets BLL	1.154	0.863	0.089 – 3.901			4348	
Minor surface longline	0.869	0.591	0.006 – 3.315			4002	
Southern blue whiting trawl	0.370	0.313	0.076 – 0.981			3737	
Scampi trawl	0.967	0.871	0.292 – 2.134			4002	
Snapper BLL	0.621	0.391	0.003 – 2.499			4002	
Squid trawl	1.616	1.498	0.597 – 3.250			3883	
Southern bluefin SLL	0.642	0.506	0.084 – 1.927			4006	
Swordfish SLL	0.805	0.532	0.006 – 3.229			4002	
Area							
Auckland Islands	0.026	0.018	0.002 – 0.099			4002	
Cook Strait	0.432	0.351	0.058 – 1.284	1		3471	
East of North Island	2.752	2.204	0.094 – 8.468			3988	
Eastern Chatham Rise	1.660	1.467	0.305 – 4.053			3592	
East Subantarctic	4.459	4.147	0.947 – 9.255			3835	
Fiordland	0.034	0.022	0.002 – 0.139			3229	
Kermadec Islands	0.224	0.040	0.000 – 1.606			3604	
North East	0.298	0.199	0.007 – 1.160			4126	
South Subantarctic	0.126	0.101	0.016 – 0.384			3709	
Stewart Snares Shelf	0.173	0.152	0.031 – 0.456			3566	
Western Chatham Rise	1.197	1.066	0.224 – 2.999	1		3686	
West Coast North Island	0.036	0.006	0.000 – 0.260			3884	
West Coast South Island	0.007	0.004	0.000 – 0.028			3866	

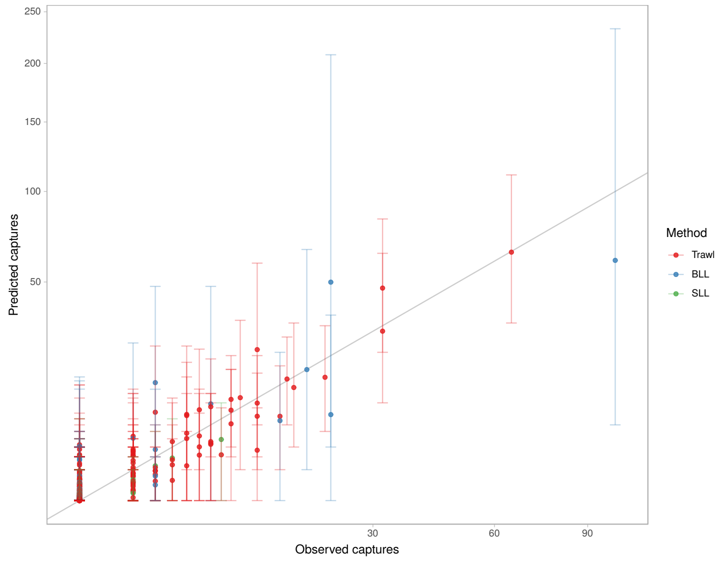


Figure D-33: Comparison between the observed and the predicted number of captures of Salvin's albatross (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points were coloured according to the fishing method (BLL, bottom longline; SLL, surface longline).

Table D-45: List of strata, defined as combinations of region, fishery, vessel size, area, and season, for which the number of observed captures of Salvin's albatross was outside the 95% credible interval (c.i.) of the estimated number of captures. There were two of these strata, representing 0.3% of all 602 strata. SLL, surface longline; BLL, bottom longline. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL.

Method	Fishery	Vessel size	Region	Area	Season	Observations	Captures	Mean	95% c.i.
Trawl	Middle depths trawl	Large	South	Western Chatham Rise	Winter (Jul-Sep)	213	11	2.65	0–9
Trawl	Middle depths trawl	Small	South	West Coast South Island	Summer (Jan-Mar)	126	1	0.01	0–0

D.3 Buller's albatrosses

Table D-46: Model strata with the highest number of estimated captures of Buller's albatrosses in each of trawl, surface-longline (SLL), and bottom-longline (BLL) fisheries. Only the 15 strata with the most estimated captures are shown, sorted in decreasing order of mean estimated captures. The strata were defined as combinations of fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2015–16 for bottom- and surface-longline fisheries, and between 2002–03 and 2015–16 for trawl fisheries are shown, along with the number of fishing events observed, the proportion of fishing events observed (observer coverage), the associated ratio estimate of the total number of captures, and the mean and 95% credible interval of the total estimated number of captures. IWL: Integrated weight line.

Fishery	Vessel size	Area	Season	Observations				Estimated captures	
				Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
Trawl									
Squid trawl	Vessels ≥ 28 m	Stewart Snares Shelf	Autumn	70	2605	0.303	230	186	117–276
Hoki trawl	Vessels ≥ 28 m	West Coast South Island	Winter	37	13112	0.328	112	97	65–141
Squid trawl	Vessels ≥ 28 m	Auckland Islands	Autumn	38	2734	0.362	104	76	43–120
Squid trawl	Vessels ≥ 28 m	Stewart Snares Shelf	Summer	25	9573	0.364	68	75	46–109
Hoki trawl	Vessels ≥ 28 m	Stewart Snares Shelf	Autumn	18	1771	0.269	66	73	40–118
Hoki trawl	Vessels ≥ 28 m	Eastern Chatham Rise	Autumn	1	801	0.139	7	53	25–93
Flatfish trawl	Vessels < 28 m	Stewart Snares Shelf	Autumn	0	47	0.003	0	52	0–208
Hoki trawl	Vessels ≥ 28 m	West Coast South Island	Autumn	26	2206	0.376	69	52	28–84
Hoki trawl	Vessels ≥ 28 m	Western Chatham Rise	Autumn	10	2234	0.156	63	50	25–85
Squid trawl	Vessels ≥ 28 m	Fiordland	Autumn	8	275	0.204	39	45	17–94
Middle depths trawl	Vessels ≥ 28 m	Stewart Snares Shelf	Autumn	23	746	0.373	61	40	17–73
Middle depths trawl	Vessels ≥ 28 m	Eastern Chatham Rise	Autumn	8	248	0.111	72	39	16–77
Flatfish trawl	Vessels < 28 m	West Coast South Island	Autumn	0	14	0.001	0	30	0–122
Middle depths trawl	Vessels < 28 m	West Coast South Island	Autumn	0	2	0.001	0	30	5–87
Scampi trawl	Vessels < 28 m	Auckland Islands	Autumn	1	417	0.088	11	29	8–66
Surface longline									
Bigeye SLL	Vessels < 43 m	East of North Island	Autumn	1	96	0.022	46	758	287–1651
Southern bluefin SLL	Vessels < 43 m	West Coast South Island	Autumn	68	205	0.084	807	677	341–1237
Southern bluefin SLL	Vessels < 43 m	East of North Island	Autumn	17	333	0.042	408	507	265–892
Southern bluefin SLL	Vessels ≥ 43 m	Fiordland	Autumn	422	3055	0.900	468	491	354–667
Albacore SLL	Vessels < 43 m	East of North Island	Autumn	1	23	0.015	68	337	81–946
Southern bluefin SLL	Vessels < 43 m	Fiordland	Autumn	18	10	0.027	658	238	81–522
Bigeye SLL	Vessels < 43 m	North East	Autumn	2	54	0.012	170	162	53–364
Bigeye SLL	Vessels < 43 m	East of North Island	Summer	7	174	0.028	246	133	50–283
Bigeye SLL	Vessels < 43 m	North East	Winter	2	100	0.013	150	82	26–188
Southern bluefin SLL	Vessels < 43 m	West Coast South Island	Winter	2	36	0.052	38	60	24–126
Southern bluefin SLL	Vessels < 43 m	East of North Island	Winter	3	195	0.111	27	35	14–68
Swordfish SLL	Vessels < 43 m	West Coast South Island	Autumn	0	36	0.153	0	35	1–161
Albacore SLL	Vessels < 43 m	West Coast South Island	Autumn	0	0	0.000		27	0–135
Bigeye SLL	Vessels < 43 m	North East	Summer	0	144	0.027	0	24	6–55
Southern bluefin SLL	Vessels ≥ 43 m	West Coast South Island	Autumn	16	334	0.918	17	23	8–50
Bottom longline									
Bluenose BLL	Vessels < 34 m	Eastern Chatham Rise	Autumn	2	28	0.017	116	80	16–207
Ling manual-set BLL	Vessels < 34 m	West Coast South Island	Autumn	4	35	0.015	258	59	18–131
Hāpuku BLL	Vessels < 34 m	Eastern Chatham Rise	Autumn	0	0	0.000		52	0–237
Ling manual-set BLL	Vessels < 34 m	Eastern Chatham Rise	Winter	0	161	0.046	0	34	10–75
Ling manual-set BLL	Vessels < 34 m	Eastern Chatham Rise	Autumn	1	42	0.043	23	31	9–66
Ling manual-set BLL	Vessels < 34 m	Fiordland	Winter	0	3	0.002	0	26	6–61
Bluenose BLL	Vessels < 34 m	East of North Island	Autumn	0	11	0.004	0	25	3–71
Ling manual-set BLL	Vessels < 34 m	West Coast South Island	Winter	0	6	0.002	0	25	7–54
Snapper BLL	Vessels < 34 m	North East	Autumn	0	521	0.015	0	23	0–93
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Eastern Chatham Rise	Autumn	0	157	0.070	0	21	6–50
Ling manual-set BLL	Vessels < 34 m	Western Chatham Rise	Autumn	0	52	0.031	0	19	5–43
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Eastern Chatham Rise	Winter	0	1011	0.145	0	18	4–41
Bluenose BLL	Vessels < 34 m	Fiordland	Autumn	0	0	0.000		15	2–42
Minor targets BLL	Vessels < 34 m	Eastern Chatham Rise	Autumn	0	0	0.000		15	0–70
Bluenose BLL	Vessels < 34 m	Eastern Chatham Rise	Winter	0	2	0.002	0	13	2–36

Table D-47: Summary of model parameters, for Buller's albatrosses capture in New Zealand commercial trawl, bottom-, and surface-longline fisheries. For each parameter, the table gives summary statistics of the posterior distribution (mean, median, and 95% credible interval, based on the 2.5% and 97.5% quantiles), and diagnostics (the number of chains that fail convergence and half-width tests (Heidelberger & Welch 1983), and the effective length of the chains (without autocorrelation). Trace plots of the chains are also shown. Base levels of the factor covariates are: Large SLL for method, South for region, and Autumn (Apr-Jun) for season. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. IWL, integrated weight line.

Parameter	Statistic			Diagnostics			
	Mean	Median	95% c.i.	Conv.	H.W.	Effective length	Trace
S.d.(Year)							
BLL	1.043	0.974	0.173 – 2.310			2887	
SLL	0.349	0.338	0.085 – 0.690			3302	
Trawl	0.400	0.389	0.179 – 0.685			3839	
S.d.(Area)	1.435	1.393	0.842 – 2.264			4190	
S.d.(Fishery)	1.015	0.991	0.621 – 1.557			4002	
Overdispersion							
BLL	1.415	1.200	0.425 – 3.650			4128	
SLL	5.652	5.613	4.203 – 7.251			3539	
Trawl	8.860	8.830	6.453 – 11.512			4119	
Intercept	0.144	0.096	0.024 – 0.545			4002	
Method / Vessel class							
BLL / vessels ≥ 34 m	0.089	0.048	0.006 – 0.417			4019	
SLL / vessels ≥ 43 m	1.000	1.000	1.000 – 1.000	3			
Trawl / vessels ≥ 28 m	0.105	0.080	0.018 – 0.346			4002	
BLL / vessels < 34 m	0.348	0.230	0.038 – 1.413			4076	
SLL / vessels < 43 m	4.642	4.334	2.113 – 8.680	1		4091	
Trawl / vessels < 28 m	0.087	0.061	0.012 – 0.335			4002	
Region							
North	0.299	0.114	0.020 – 1.476			4008	
South	1.000	1.000	1.000 – 1.000	3			
Season							
Autumn (Apr-Jun)	1.000	1.000	1.000 – 1.000	3			
Spring (Oct-Dec)	0.082	0.080	0.043 – 0.139			4004	
Summer (Jan-Mar)	0.131	0.129	0.088 – 0.184			3898	
Winter (Jul-Sep)	0.315	0.310	0.213 – 0.444			4216	
Fishery							
Albacore SLL	1.988	1.723	0.462 – 5.233			4002	
Bigeye SLL	1.704	1.488	0.430 – 4.177			4122	
Bluenose BLL	1.656	1.396	0.310 – 4.513			4214	
Deepwater trawl	0.111	0.095	0.024 – 0.284	1		4342	
Flatfish trawl	0.357	0.234	0.002 – 1.438			3889	
Hake trawl	0.493	0.433	0.134 – 1.189			3636	
Hāpuku BLL	0.726	0.516	0.006 – 2.703			3875	
Hoki trawl	1.024	0.963	0.402 – 1.965			4002	
Inshore trawl	0.325	0.205	0.002 – 1.326			4002	
Ling autoline BLL (no IWL)	1.785	1.482	0.261 – 5.179			4002	
Ling autoline BLL (IWL)	0.316	0.186	0.002 – 1.376			4002	
Ling manual-set BLL	1.187	0.993	0.198 – 3.311			4002	
Ling trawl	1.464	1.289	0.402 – 3.500			3818	
Mackerel trawl	0.574	0.508	0.140 – 1.364			4002	
Middle depths trawl	1.847	1.751	0.742 – 3.498			3589	
Minor targets BLL	0.659	0.450	0.008 – 2.516			3899	
Minor surface longline	0.825	0.582	0.007 – 3.177			4107	
Southern blue whiting trawl	0.955	0.712	0.064 – 3.360			4002	
Scampi trawl	1.623	1.433	0.414 – 3.852			4002	
Snapper BLL	0.559	0.368	0.005 – 2.161			4178	
Squid trawl	2.084	1.971	0.838 – 4.030			3791	
Southern bluefin SLL	0.671	0.583	0.156 – 1.724			4112	
Swordfish SLL	0.319	0.199	0.012 – 1.318			3565	
Area							
Auckland Islands	0.753	0.683	0.182 – 1.814			4002	
Cook Strait	0.056	0.023	0.000 – 0.304			4224	
East of North Island	2.673	2.273	0.224 – 7.608			3852	
Eastern Chatham Rise	1.534	1.386	0.384 – 3.609			3737	
East Subantarctic	0.186	0.069	0.000 – 1.045			3847	
Fiordland	2.907	2.682	0.790 – 6.616			3762	
Kermadec Islands	0.311	0.118	0.000 – 1.651			4002	
North East	0.587	0.450	0.039 – 1.937			3898	
South Subantarctic	0.109	0.065	0.004 – 0.473			4002	
Stewart Snares Shelf	1.736	1.596	0.434 – 3.878			4125	
Western Chatham Rise	0.562	0.508	0.134 – 1.323			4002	
West Coast North Island	0.096	0.031	0.000 – 0.601			3830	
West Coast South Island	1.251	1.147	0.318 – 2.824			4002	

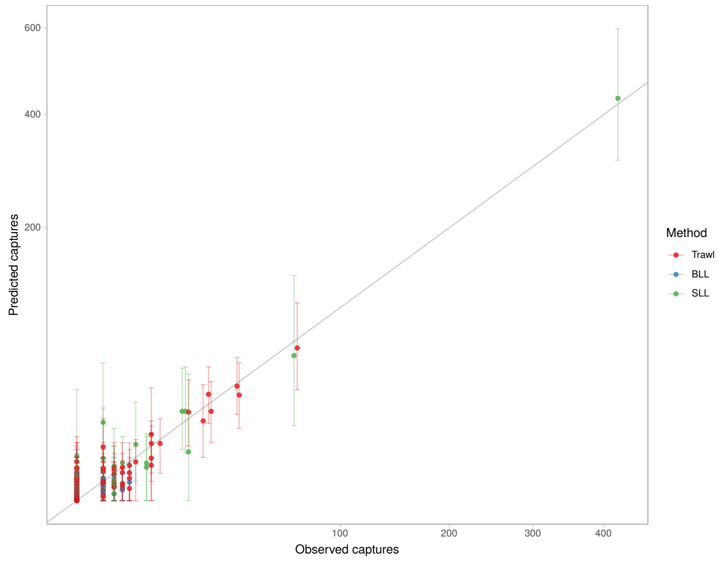


Figure D-34: Comparison between the observed and the predicted number of captures of Buller's albatrosses (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points were coloured according to the fishing method (BLL, bottom longline; SLL, surface longline).

Table D-48: List of strata, defined as combinations of region, fishery, vessel size, area, and season, for which the number of observed captures of Buller's albatrosses was outside the 95% credible interval (c.i.) of the estimated number of captures. There were six of these strata, representing 1.0% of all 602 strata. SLL, surface longline; BLL, bottom longline. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL.

Method	Fishery	Vessel size	Region	Area	Season	Observations	Captures	Mean	95% c.i.
SLL	Bigeye SLL	Small	North	East of North Island	Autumn (Apr-Jun)	96	1	16.44	2–51
Trawl	Scampi trawl	Small	South	Eastern Chatham Rise	Summer (Jan-Mar)	240	3	0.40	0–2
Trawl	Middle depths trawl	Large	South	Eastern Chatham Rise	Spring (Oct-Dec)	227	4	0.39	0–2
BLL	Ling autoline BLL (no IWL)	Large	South	Eastern Chatham Rise	Spring (Oct-Dec)	464	3	0.30	0–2
BLL	Ling autoline BLL (no IWL)	Large	South	Western Chatham Rise	Winter (Jul-Sep)	47	2	0.12	0–1
SLL	Southern bluefin SLL	Large	North	East of North Island	Autumn (Apr-Jun)	9	2	0.12	0–1

D.4 Other albatrosses

Table D-49: Model strata with the highest number of estimated captures of other albatrosses in each of trawl, surface-longline (SLL), and bottom-longline (BLL) fisheries. Only the 15 strata with the most estimated captures are shown, sorted in decreasing order of mean estimated captures. The strata were defined as combinations of fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2015–16 for bottom- and surface-longline fisheries, and between 2002–03 and 2015–16 for trawl fisheries are shown, along with the number of fishing events observed, the proportion of fishing events observed (observer coverage), the associated ratio estimate of the total number of captures, and the mean and 95% credible interval of the total estimated number of captures. IWL: Integrated weight line.

Fishery	Vessel size	Area	Season	Observations				Estimated captures	
				Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
Trawl									
Inshore trawl	Vessels < 28 m	East of North Island	Spring	0	19	0.001	0	27	3–78
Hoki trawl	Vessels ≥ 28 m	Eastern Chatham Rise	Spring	2	2306	0.240	8	20	8–37
Flatfish trawl	Vessels < 28 m	Stewart Snares Shelf	Spring	0	7	0.000	0	16	0–57
Hoki trawl	Vessels ≥ 28 m	West Coast South Island	Winter	7	13112	0.328	21	16	5–31
Deepwater trawl	Vessels ≥ 28 m	Eastern Chatham Rise	Spring	7	2604	0.273	25	15	5–28
Hoki trawl	Vessels ≥ 28 m	Western Chatham Rise	Spring	2	2403	0.195	10	14	4–28
Squid trawl	Vessels ≥ 28 m	Stewart Snares Shelf	Summer	6	9573	0.364	16	14	5–28
Flatfish trawl	Vessels < 28 m	Western Chatham Rise	Spring	0	69	0.004	0	12	0–42
Inshore trawl	Vessels < 28 m	North East	Spring	0	745	0.025	0	12	1–37
Scampi trawl	Vessels < 28 m	Eastern Chatham Rise	Spring	2	541	0.099	20	12	2–29
Inshore trawl	Vessels < 28 m	East of North Island	Winter	0	100	0.004	0	10	0–32
Inshore trawl	Vessels < 28 m	Western Chatham Rise	Spring	0	205	0.012	0	9	0–29
Hoki trawl	Vessels ≥ 28 m	Stewart Snares Shelf	Spring	1	1507	0.242	4	8	2–16
Inshore trawl	Vessels < 28 m	East of North Island	Autumn	0	180	0.008	0	8	0–24
Southern blue whiting trawl	Vessels ≥ 28 m	South Subantarctic	Winter	5	5041	0.549	9	8	2–19
Surface longline									
Bigeye SLL	Vessels < 43 m	North East	Spring	23	188	0.028	833	497	262–864
Southern bluefin SLL	Vessels < 43 m	East of North Island	Autumn	14	333	0.042	336	494	268–834
Bigeye SLL	Vessels < 43 m	East of North Island	Summer	6	174	0.028	210	303	136–607
Bigeye SLL	Vessels < 43 m	East of North Island	Autumn	0	96	0.022	0	271	111–555
Bigeye SLL	Vessels < 43 m	North East	Winter	2	100	0.013	150	238	113–452
Albacore SLL	Vessels < 43 m	East of North Island	Autumn	0	23	0.015	0	210	60–527
Bigeye SLL	Vessels < 43 m	East of North Island	Spring	1	13	0.015	67	140	52–286
Bigeye SLL	Vessels < 43 m	North East	Autumn	1	54	0.012	85	129	59–250
Southern bluefin SLL	Vessels < 43 m	East of North Island	Winter	14	195	0.111	126	123	60–225
Bigeye SLL	Vessels < 43 m	North East	Summer	3	144	0.027	110	121	56–228
Southern bluefin SLL	Vessels < 43 m	North East	Winter	6	311	0.095	62	108	50–206
Southern bluefin SLL	Vessels < 43 m	West Coast South Island	Autumn	10	205	0.084	118	75	32–146
Albacore SLL	Vessels < 43 m	East of North Island	Summer	0	7	0.011	0	69	15–190
Swordfish SLL	Vessels < 43 m	East of North Island	Autumn	0	12	0.061	0	55	10–156
Swordfish SLL	Vessels < 43 m	East of North Island	Summer	0	0	0.000		51	11–146
Bottom longline									
Bluenose BLL	Vessels < 34 m	East of North Island	Spring	0	0	0.000		210	33–745
Ling manual-set BLL	Vessels < 34 m	East of North Island	Spring	0	0	0.000		149	33–422
Ling manual-set BLL	Vessels < 34 m	East of North Island	Winter	2	92	0.017	120	118	35–292
Ling manual-set BLL	Vessels < 34 m	Eastern Chatham Rise	Spring	3	106	0.049	61	111	30–288
Bluenose BLL	Vessels < 34 m	North East	Spring	0	9	0.002	0	97	16–325
Ling manual-set BLL	Vessels < 34 m	Western Chatham Rise	Spring	0	59	0.020	0	82	19–230
Snapper BLL	Vessels < 34 m	North East	Spring	0	493	0.012	0	82	2–300
Ling manual-set BLL	Vessels < 34 m	Eastern Chatham Rise	Winter	13	161	0.046	282	76	23–186
Ling manual-set BLL	Vessels < 34 m	West Coast South Island	Spring	0	1	0.000	0	69	15–191
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Eastern Chatham Rise	Spring	4	464	0.143	27	63	18–165
Hāpuku BLL	Vessels < 34 m	Eastern Chatham Rise	Spring	0	24	0.016	0	58	3–237
Hāpuku BLL	Vessels < 34 m	East of North Island	Spring	0	0	0.000		52	3–213
Bluenose BLL	Vessels < 34 m	East of North Island	Summer	0	20	0.005	0	51	7–178
Bluenose BLL	Vessels < 34 m	East of North Island	Winter	0	14	0.005	0	51	7–170
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Eastern Chatham Rise	Winter	8	1011	0.145	55	51	16–121

Table D-50: Summary of model parameters, for other albatrosses capture in New Zealand commercial trawl, bottom-, and surface-longline fisheries. For each parameter, the table gives summary statistics of the posterior distribution (mean, median, and 95% credible interval, based on the 2.5% and 97.5% quantiles), and diagnostics (the number of chains that fail convergence and half-width tests (Heidelberger & Welch 1983), and the effective length of the chains (without autocorrelation). Trace plots of the chains are also shown. Base levels of the factor covariates are: Small SLL for method, North for region, and Spring (Oct-Dec) for season. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. IWL, integrated weight line.

Parameter	Statistic			Diagnostics			
	Mean	Median	95% c.i.	Conv.	H.W.	Effective length	Trace
S.d.(Year)							
BLL	1.385	1.345	0.603 – 2.381			4002	
SLL	0.431	0.395	0.092 – 0.976			3614	
Trawl	0.414	0.402	0.120 – 0.810			3743	
S.d.(Area)	0.717	0.698	0.424 – 1.145			3815	
S.d.(Fishery)	0.792	0.779	0.385 – 1.270			3898	
Overdispersion							
BLL	11.733	11.549	7.469 – 17.133			4038	
SLL	5.625	5.609	4.323 – 7.052			3807	
Trawl	1.140	1.006	0.371 – 2.669			4002	
Intercept	0.221	0.178	0.058 – 0.650			4366	
Method / Vessel class							
BLL / vessels $\geq$ 34 m	0.116	0.060	0.011 – 0.565			4002	
SLL / vessels $\geq$ 43 m	0.861	0.806	0.386 – 1.654			3959	
Trawl / vessels $\geq$ 28 m	0.008	0.007	0.002 – 0.024			4002	
BLL / vessels $<$ 34 m	0.128	0.094	0.023 – 0.437			4002	
SLL / vessels $<$ 43 m	1.000	1.000	1.000 – 1.000	3			
Trawl / vessels $<$ 28 m	0.007	0.006	0.001 – 0.024			4002	
Region							
North	1.000	1.000	1.000 – 1.000	3			
South	1.176	1.005	0.313 – 3.102			3981	
Season							
Autumn (Apr-Jun)	0.392	0.380	0.224 – 0.636			3897	
Spring (Oct-Dec)	1.000	1.000	1.000 – 1.000	3			
Summer (Jan-Mar)	0.321	0.309	0.173 – 0.546			4250	
Winter (Jul-Sep)	0.443	0.427	0.254 – 0.725			3790	
Fishery							
Albacore SLL	1.196	1.080	0.323 – 2.729			4002	
Bigeye SLL	0.569	0.520	0.174 – 1.247			4367	
Bluenose BLL	1.344	1.163	0.295 – 3.501			4002	
Deepwater trawl	0.770	0.720	0.309 – 1.507			3774	
Flatfish trawl	0.654	0.536	0.023 – 2.013			4002	
Hake trawl	0.873	0.792	0.190 – 2.099			3650	
Hāpuku BLL	1.084	0.908	0.130 – 3.069			4311	
Hoki trawl	1.075	1.026	0.466 – 1.995			3893	
Inshore trawl	0.562	0.469	0.061 – 1.554			4240	
Ling autoline BLL (no IWL)	0.961	0.832	0.145 – 2.502			4254	
Ling autoline BLL (IWL)	0.750	0.651	0.090 – 2.038			4002	
Ling manual-set BLL	1.756	1.564	0.492 – 4.137			4154	
Ling trawl	1.061	0.938	0.242 – 2.591			4002	
Mackerel trawl	0.366	0.285	0.009 – 1.167			4195	
Middle depths trawl	1.039	0.974	0.387 – 2.083			3926	
Minor targets BLL	0.803	0.691	0.079 – 2.259			4002	
Minor surface longline	0.624	0.498	0.020 – 2.033			3898	
Southern blue whiting trawl	1.607	1.450	0.566 – 3.607			4273	
Scampi trawl	1.240	1.132	0.387 – 2.705			3937	
Snapper BLL	0.180	0.108	0.002 – 0.751			4304	
Squid trawl	1.463	1.362	0.593 – 2.953			3883	
Southern bluefin SLL	0.591	0.540	0.185 – 1.286			4002	
Swordfish SLL	2.428	2.196	0.909 – 5.185			4130	
Area							
Auckland Islands	1.229	1.146	0.486 – 2.471			4129	
Cook Strait	1.050	0.967	0.286 – 2.382			3979	
East of North Island	1.809	1.694	0.642 – 3.682			4002	
Eastern Chatham Rise	1.845	1.762	0.906 – 3.292			3382	
East Subantarctic	0.544	0.472	0.080 – 1.443			4002	
Fiordland	0.246	0.221	0.081 – 0.551			3807	
Kermadec Islands	1.081	0.979	0.309 – 2.500			4171	
North East	0.852	0.795	0.276 – 1.740			4002	
South Subantarctic	1.218	1.140	0.484 – 2.394			3730	
Stewart Snares Shelf	1.075	1.021	0.482 – 1.981			3989	
Western Chatham Rise	0.979	0.914	0.396 – 1.948			4002	
West Coast North Island	0.258	0.220	0.047 – 0.671			3883	
West Coast South Island	0.864	0.818	0.360 – 1.625			4007	

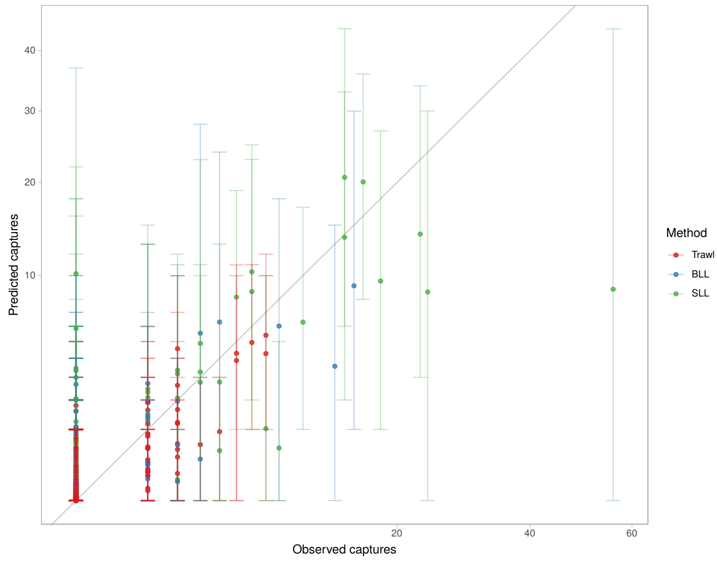


Figure D-35: Comparison between the observed and the predicted number of captures of other albatrosses (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points were coloured according to the fishing method (BLL, bottom longline; SLL, surface longline).

Table D-51: List of strata, defined as combinations of region, fishery, vessel size, area, and season, for which the number of observed captures of other albatrosses was outside the 95% credible interval (c.i.) of the estimated number of captures. There were eight of these strata, representing 1.3% of all 602 strata. SLL, surface longline; BLL, bottom longline. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL.

Method	Fishery	Vessel size	Region	Area	Season	Observations	Captures	Mean	95% c.i.
SLL	Swordfish SLL	Small	North	Kermadec Islands	Spring (Oct-Dec)	21	56	8.82	0–44
Trawl	Hoki trawl	Large	South	Western Chatham Rise	Autumn (Apr-Jun)	2234	4	0.94	0–3
SLL	Southern bluefin SLL	Large	North	East of North Island	Autumn (Apr-Jun)	9	8	0.55	0–5
SLL	Bigeye SLL	Small	North	West Coast North Island	Spring (Oct-Dec)	23	4	0.49	0–3
Trawl	Scampi trawl	Small	North	North East	Autumn (Apr-Jun)	379	2	0.15	0–1
SLL	Southern bluefin SLL	Small	South	Fiordland	Autumn (Apr-Jun)	10	2	0.09	0–1
BLL	Ling autoline BLL (no IWL)	Large	South	Auckland Islands	Autumn (Apr-Jun)	20	2	0.07	0–1
Trawl	Hoki trawl	Large	South	South Subantarctic	Summer (Jan-Mar)	44	1	0.02	0–0

D.5 White-chinned petrel

Table D-52: Model strata with the highest number of estimated captures of white-chinned petrel in each of trawl, surface-longline (SLL), and bottom-longline (BLL) fisheries. Only the 15 strata with the most estimated captures are shown, sorted in decreasing order of mean estimated captures. The strata were defined as combinations of fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2015–16 for bottom- and surface-longline fisheries, and between 2002–03 and 2015–16 for trawl fisheries are shown, along with the number of fishing events observed, the proportion of fishing events observed (observer coverage), the associated ratio estimate of the total number of captures, and the mean and 95% credible interval of the total estimated number of captures. IWL: Integrated weight line.

Fishery	Vessel size	Area	Season	Observations				Estimated captures	
				Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
Trawl									
Squid trawl	Vessels ≥ 28 m	Stewart Snares Shelf	Summer	510	9573	0.364	1399	1168	848–1567
Squid trawl	Vessels ≥ 28 m	Auckland Islands	Summer	400	6591	0.475	842	792	535–1135
Squid trawl	Vessels ≥ 28 m	Auckland Islands	Autumn	92	2734	0.362	253	201	120–313
Squid trawl	Vessels ≥ 28 m	Stewart Snares Shelf	Autumn	125	2605	0.303	412	167	101–255
Middle depths trawl	Vessels ≥ 28 m	Stewart Snares Shelf	Spring	29	1465	0.276	105	99	50–173
Scampi trawl	Vessels ≥ 28 m	Auckland Islands	Spring	1	413	0.179	5	92	28–229
Middle depths trawl	Vessels ≥ 28 m	Stewart Snares Shelf	Summer	72	1408	0.540	133	71	33–130
Hoki trawl	Vessels ≥ 28 m	Western Chatham Rise	Summer	9	1606	0.127	70	68	37–114
Hoki trawl	Vessels ≥ 28 m	Eastern Chatham Rise	Summer	3	1500	0.131	22	67	34–113
Ling trawl	Vessels ≥ 28 m	Stewart Snares Shelf	Spring	6	874	0.193	31	64	20–144
Hoki trawl	Vessels ≥ 28 m	Stewart Snares Shelf	Spring	5	1507	0.242	20	57	28–102
Squid trawl	Vessels ≥ 28 m	Stewart Snares Shelf	Spring	0	133	0.093	0	53	17–113
Hoki trawl	Vessels ≥ 28 m	Western Chatham Rise	Spring	16	2403	0.195	82	49	25–83
Hoki trawl	Vessels ≥ 28 m	Eastern Chatham Rise	Spring	20	2306	0.240	83	45	22–79
Scampi trawl	Vessels ≥ 28 m	Auckland Islands	Autumn	0	115	0.094	0	42	10–108
Surface longline									
Bigeye SLL	Vessels < 43 m	East of North Island	Summer	3	174	0.028	105	140	34–397
Bigeye SLL	Vessels < 43 m	North East	Spring	1	188	0.028	36	91	19–262
Bigeye SLL	Vessels < 43 m	North East	Summer	0	144	0.027	0	88	19–256
Albacore SLL	Vessels < 43 m	Eastern Chatham Rise	Summer	0	0	0.000		73	0–583
Swordfish SLL	Vessels < 43 m	West Coast South Island	Summer	3	20	0.050	60	72	7–297
Albacore SLL	Vessels < 43 m	Western Chatham Rise	Summer	0	0	0.000		46	0–316
Bigeye SLL	Vessels < 43 m	East of North Island	Autumn	0	96	0.022	0	44	9–125
Albacore SLL	Vessels < 43 m	East of North Island	Autumn	0	23	0.015	0	43	2–186
Albacore SLL	Vessels < 43 m	East of North Island	Summer	0	7	0.011	0	40	2–185
Bigeye SLL	Vessels < 43 m	West Coast North Island	Summer	0	60	0.023	0	36	5–109
Southern bluefin SLL	Vessels ≥ 43 m	Fiordland	Autumn	21	3055	0.900	23	34	17–62
Bigeye SLL	Vessels < 43 m	North East	Autumn	1	54	0.012	85	33	6–96
Bigeye SLL	Vessels < 43 m	Eastern Chatham Rise	Summer	0	1	0.067	0	26	0–184
Southern bluefin SLL	Vessels < 43 m	Fiordland	Autumn	0	10	0.027	0	26	1–114
Southern bluefin SLL	Vessels < 43 m	West Coast South Island	Autumn	0	205	0.084	0	20	1–79
Bottom longline									
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Stewart Snares Shelf	Spring	143	909	0.464	307	1111	384–2568
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Eastern Chatham Rise	Spring	366	464	0.143	2560	819	319–1836
Ling manual-set BLL	Vessels < 34 m	Western Chatham Rise	Spring	3	59	0.020	148	727	168–2304
Bluenose BLL	Vessels < 34 m	Eastern Chatham Rise	Summer	0	32	0.018	0	602	25–2960
Ling manual-set BLL	Vessels < 34 m	Eastern Chatham Rise	Spring	24	106	0.049	488	602	136–1863
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Eastern Chatham Rise	Summer	40	285	0.157	255	578	182–1446
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	East Subantarctic	Summer	82	526	0.368	222	503	115–1464
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Western Chatham Rise	Spring	5	57	0.024	207	501	163–1203
Ling manual-set BLL	Vessels < 34 m	Eastern Chatham Rise	Summer	0	8	0.006	0	461	95–1468
Hāpuku BLL	Vessels < 34 m	Eastern Chatham Rise	Summer	0	0	0.000		459	0–2894
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	South Subantarctic	Summer	13	12	0.007	1787	373	83–1089
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Western Chatham Rise	Summer	6	65	0.048	124	346	85–916
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	East Subantarctic	Spring	68	548	0.417	162	344	85–957
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Eastern Chatham Rise	Autumn	30	157	0.070	430	343	123–806
Ling manual-set BLL	Vessels < 34 m	Western Chatham Rise	Summer	0	2	0.002	0	314	56–1073

Table D-53: Summary of model parameters, for white-chinned petrel capture in New Zealand commercial trawl, bottom-, and surface-longline fisheries. For each parameter, the table gives summary statistics of the posterior distribution (mean, median, and 95% credible interval, based on the 2.5% and 97.5% quantiles), and diagnostics (the number of chains that fail convergence and half-width tests (Heidelberger & Welch 1983), and the effective length of the chains (without autocorrelation). Trace plots of the chains are also shown. Base levels of the factor covariates are: Large trawl for method, South for region, and Summer (Jan-Mar) for season. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. IWL, integrated weight line.

Parameter	Statistic			Diagnostics			
	Mean	Median	95% c.i.	Conv.	H.W.	Effective length	Trace
S.d.(Year)							
BLL	0.831	0.836	0.304 – 1.332			4002	
SLL	0.530	0.488	0.102 – 1.192			3615	
Trawl	0.675	0.654	0.443 – 1.019			3785	
S.d.(Area)	0.848	0.821	0.530 – 1.312			3881	
S.d.(Fishery)	1.203	1.179	0.820 – 1.693			3880	
Overdispersion							
BLL	12.061	11.971	9.784 – 14.879			4002	
SLL	7.479	7.305	3.953 – 11.876			4002	
Trawl	11.801	11.775	10.007 – 13.730			3754	
Intercept	0.016	0.013	0.005 – 0.044			4002	
Method / Vessel class							
BLL / vessels $\geq$ 34 m	19.203	12.026	2.081 – 82.689			3831	
SLL / vessels $\geq$ 43 m	58.077	28.474	3.095 – 284.362			4002	
Trawl / vessels $\geq$ 28 m	1.000	1.000	1.000 – 1.000	3			
BLL / vessels $<$ 34 m	42.087	21.164	3.385 – 171.141			3674	
SLL / vessels $<$ 43 m	255.154	121.678	15.859 – 1372.381			4000	
Trawl / vessels $<$ 28 m	0.203	0.178	0.061 – 0.477			4002	
Region							
North	0.022	0.015	0.003 – 0.085			4002	
South	1.000	1.000	1.000 – 1.000	3			
Season							
Autumn (Apr-Jun)	0.438	0.432	0.321 – 0.576			3847	
Spring (Oct-Dec)	0.834	0.813	0.564 – 1.202			3782	
Summer (Jan-Mar)	1.000	1.000	1.000 – 1.000	3			
Winter (Jul-Sep)	0.014	0.013	0.005 – 0.034			4002	
Fishery							
Albacore SLL	2.140	1.748	0.268 – 6.517			4002	
Bigeye SLL	1.107	0.868	0.129 – 3.558			4002	
Bluenose BLL	1.059	0.753	0.057 – 3.923			3329	
Deepwater trawl	0.030	0.024	0.003 – 0.096			4002	
Flatfish trawl	0.219	0.108	0.000 – 1.092			3618	
Hake trawl	0.244	0.201	0.044 – 0.708			4002	
Hāpuku BLL	0.606	0.301	0.001 – 2.965			4357	
Hoki trawl	0.581	0.539	0.192 – 1.193			4002	
Inshore trawl	0.578	0.428	0.040 – 2.034			3938	
Ling autoline BLL (no IWL)	2.604	2.248	0.434 – 6.827			3670	
Ling autoline BLL (IWL)	0.470	0.356	0.053 – 1.606			3902	
Ling manual-set BLL	1.444	1.167	0.165 – 4.347			3891	
Ling trawl	0.692	0.600	0.165 – 1.758			4002	
Mackerel trawl	0.941	0.835	0.262 – 2.232			4129	
Middle depths trawl	1.093	1.020	0.360 – 2.264			4002	
Minor targets BLL	0.783	0.581	0.074 – 2.705			4002	
Minor surface longline	0.698	0.372	0.002 – 3.077			4165	
Southern blue whiting trawl	0.352	0.177	0.001 – 1.681			4002	
Scampi trawl	2.924	2.658	0.966 – 6.548			4002	
Snapper BLL	0.186	0.077	0.000 – 1.036			3853	
Squid trawl	2.493	2.326	0.880 – 5.046			4002	
Southern bluefin SLL	0.163	0.102	0.011 – 0.648			4002	
Swordfish SLL	1.322	1.013	0.140 – 4.280			3813	
Area							
Auckland Islands	2.449	2.333	1.185 – 4.373			4033	
Cook Strait	0.390	0.326	0.077 – 1.032			3835	
East of North Island	1.108	0.959	0.210 – 2.855			3859	
Eastern Chatham Rise	0.942	0.892	0.412 – 1.764			4115	
East Subantarctic	0.976	0.869	0.284 – 2.255			3837	
Fiordland	0.676	0.619	0.247 – 1.434			4002	
Kermadec Islands	1.330	1.106	0.215 – 3.699			4426	
North East	0.811	0.692	0.125 – 2.206			4002	
South Subantarctic	0.812	0.736	0.270 – 1.798			4171	
Stewart Snares Shelf	2.009	1.942	0.995 – 3.487			4002	
Western Chatham Rise	0.829	0.791	0.372 – 1.536			4118	
West Coast North Island	0.665	0.552	0.097 – 1.886			4193	
West Coast South Island	0.094	0.080	0.019 – 0.250			4002	

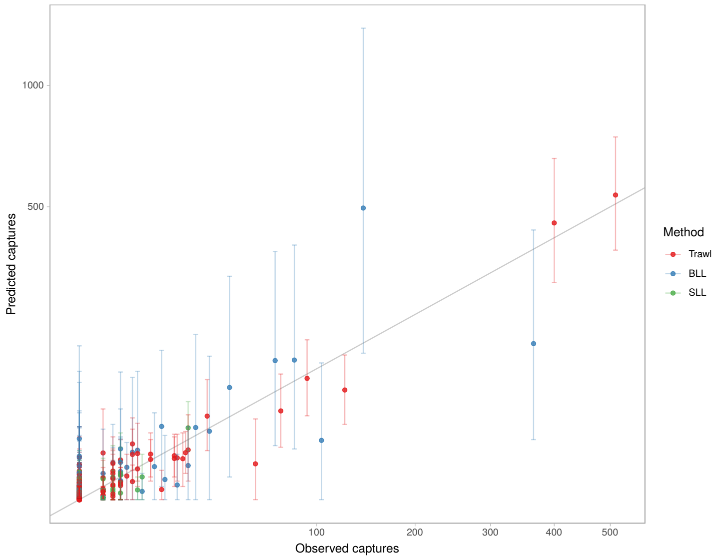


Figure D-36: Comparison between the observed and the predicted number of captures of white-chinned petrel (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points were coloured according to the fishing method (BLL, bottom longline; SLL, surface longline).

Table D-54: List of strata, defined as combinations of region, fishery, vessel size, area, and season, for which the number of observed captures of white-chinned petrel was outside the 95% credible interval (c.i.) of the estimated number of captures. There were twelve of these strata, representing 2.0% of all 602 strata. SLL, surface longline; BLL, bottom longline. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL.

Method	Fishery	Vessel size	Region	Area	Season	Observations	Captures	Mean	95% c.i.
Trawl	Squid trawl	Large	South	Stewart Snares Shelf	Autumn (Apr-Jun)	2605	125	70.09	33–122
Trawl	Scampi trawl	Large	South	Auckland Islands	Summer (Jan-Mar)	111	55	7.47	0–38
BLL	Minor targets BLL	Small	South	Eastern Chatham Rise	Spring (Oct-Dec)	8	17	1.25	0–12
Trawl	Scampi trawl	Small	South	Auckland Islands	Summer (Jan-Mar)	38	12	0.59	0–5
SLL	Southern bluefin SLL	Large	South	South Subantarctic	Autumn (Apr-Jun)	55	6	0.55	0–3
BLL	Ling manual-set BLL	Small	South	West Coast South Island	Summer (Jan-Mar)	12	7	0.40	0–4
SLL	Bigeye SLL	Small	North	West Coast North Island	Spring (Oct-Dec)	23	3	0.25	0–2
Trawl	Hoki trawl	Large	South	Fiordland	Spring (Oct-Dec)	33	2	0.06	0–1
BLL	Ling autoline BLL (no IWL)	Large	South	Stewart Snares Shelf	Winter (Jul-Sep)	4	1	0.03	0–0
SLL	Bigeye SLL	Small	North	North East	Winter (Jul-Sep)	100	1	0.03	0–0
BLL	Bluenose BLL	Small	North	North East	Spring (Oct-Dec)	9	1	0.02	0–0
SLL	Southern bluefin SLL	Small	North	North East	Winter (Jul-Sep)	311	1	0.01	0–0

D.6 Black petrel

Table D-55: Model strata with the highest number of estimated captures of black petrel in each of trawl, surface-longline (SLL), and bottom-longline (BLL) fisheries. Only the 15 strata with the most estimated captures are shown, sorted in decreasing order of mean estimated captures. The strata were defined as combinations of fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2015–16 for bottom- and surface-longline fisheries, and between 2002–03 and 2015–16 for trawl fisheries are shown, along with the number of fishing events observed, the proportion of fishing events observed (observer coverage), the associated ratio estimate of the total number of captures, and the mean and 95% credible interval of the total estimated number of captures.

Fishery	Vessel size	Area	Season	Observations				Estimated captures	
				Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
Trawl									
Inshore trawl	Vessels < 28 m	North East	Autumn	19	1405	0.049	390	244	128–396
Inshore trawl	Vessels < 28 m	North East	Summer	1	935	0.028	35	132	59–247
Inshore trawl	Vessels < 28 m	East of North Island	Autumn	0	180	0.008	0	77	22–182
Inshore trawl	Vessels < 28 m	North East	Spring	0	745	0.025	0	65	21–138
Inshore trawl	Vessels < 28 m	East of North Island	Summer	0	237	0.009	0	40	10–99
Inshore trawl	Vessels < 28 m	East of North Island	Spring	0	19	0.001	0	28	4–83
Inshore trawl	Vessels < 28 m	West Coast North Island	Autumn	0	619	0.042	0	7	0–26
Inshore trawl	Vessels < 28 m	North East	Winter	0	746	0.028	0	6	0–26
Inshore trawl	Vessels < 28 m	West Coast North Island	Summer	0	955	0.047	0	4	0–17
Flatfish trawl	Vessels < 28 m	East of North Island	Autumn	0	70	0.022	0	3	0–22
Flatfish trawl	Vessels < 28 m	West Coast North Island	Autumn	0	1	0.000	0	3	0–23
Inshore trawl	Vessels < 28 m	East of North Island	Winter	0	100	0.004	0	3	0–13
Inshore trawl	Vessels < 28 m	West Coast North Island	Spring	0	492	0.021	0	3	0–13
Middle depths trawl	Vessels < 28 m	North East	Autumn	0	42	0.040	0	3	0–16
Flatfish trawl	Vessels < 28 m	East of North Island	Summer	0	110	0.026	0	2	0–14
Surface longline									
Bigeye SLL	Vessels < 43 m	North East	Autumn	0	54	0.012	0	1139	377–2991
Bigeye SLL	Vessels < 43 m	North East	Summer	7	144	0.027	258	577	221–1315
Albacore SLL	Vessels < 43 m	East of North Island	Autumn	0	23	0.015	0	425	16–2291
Bigeye SLL	Vessels < 43 m	East of North Island	Autumn	0	96	0.022	0	409	127–1042
Bigeye SLL	Vessels < 43 m	North East	Spring	17	188	0.028	616	389	166–805
Albacore SLL	Vessels < 43 m	North East	Autumn	0	1	0.002	0	311	11–1762
Bigeye SLL	Vessels < 43 m	East of North Island	Summer	13	174	0.028	456	246	98–528
Minor surface longline	Vessels < 43 m	North East	Summer	3	23	0.059	50	118	7–618
Albacore SLL	Vessels < 43 m	East of North Island	Summer	0	7	0.011	0	74	2–388
Minor surface longline	Vessels < 43 m	East of North Island	Summer	0	9	0.017	0	61	3–325
Swordfish SLL	Vessels < 43 m	North East	Autumn	0	16	0.065	0	59	2–316
Minor surface longline	Vessels < 43 m	East of North Island	Autumn	0	2	0.012	0	47	1–260
Bigeye SLL	Vessels < 43 m	North East	Winter	0	100	0.013	0	46	1–203
Swordfish SLL	Vessels < 43 m	North East	Summer	2	26	0.062	32	45	2–219
Albacore SLL	Vessels < 43 m	North East	Spring	2	1	0.004	564	43	1–229
Bottom longline									
Bluenose BLL	Vessels < 34 m	North East	Autumn	0	44	0.010	0	2517	489–8182
Bluenose BLL	Vessels < 34 m	North East	Summer	9	43	0.007	1308	1503	362–4292
Snapper BLL	Vessels < 34 m	North East	Autumn	21	521	0.015	1408	1150	576–2134
Bluenose BLL	Vessels < 34 m	North East	Spring	4	9	0.002	2218	657	138–2044
Snapper BLL	Vessels < 34 m	North East	Summer	14	1074	0.029	478	550	290–961
Hāpuku BLL	Vessels < 34 m	North East	Autumn	3	25	0.016	182	533	54–2207
Bluenose BLL	Vessels < 34 m	East of North Island	Autumn	0	11	0.004	0	522	96–1665
Snapper BLL	Vessels < 34 m	North East	Spring	2	493	0.012	165	345	125–714
Bluenose BLL	Vessels < 34 m	East of North Island	Summer	10	20	0.005	1938	342	83–1003
Hāpuku BLL	Vessels < 34 m	North East	Summer	0	2	0.001	0	306	33–1200
Bluenose BLL	Vessels < 34 m	East of North Island	Spring	0	0	0.000		254	42–805
Hāpuku BLL	Vessels < 34 m	North East	Spring	0	2	0.001	0	151	14–579
Hāpuku BLL	Vessels < 34 m	East of North Island	Autumn	0	9	0.016	0	74	5–316
Bluenose BLL	Vessels < 34 m	North East	Winter	0	15	0.004	0	56	1–264
Hāpuku BLL	Vessels < 34 m	East of North Island	Spring	0	0	0.000		46	3–206

Table D-56: Summary of model parameters, for black petrel capture in New Zealand commercial trawl, bottom-, and surface-longline fisheries. For each parameter, the table gives summary statistics of the posterior distribution (mean, median, and 95% credible interval, based on the 2.5% and 97.5% quantiles), and diagnostics (the number of chains that fail convergence and half-width tests (Heidelberger & Welch 1983), and the effective length of the chains (without autocorrelation). Trace plots of the chains are also shown. Base levels of the factor covariates are: Small BLL for method, North for region, and Summer (Jan-Mar) for season. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. IWL, integrated weight line.

Parameter	Statistic			Diagnostics			
	Mean	Median	95% c.i.	Conv.	H.W.	Effective length	Trace
S.d.(Year)							
BLL	0.963	0.827	0.144 – 2.375			1987	
SLL	0.846	0.723	0.135 – 2.202			2176	
Trawl	0.940	0.807	0.151 – 2.337			2547	
S.d.(Area)	1.249	1.178	0.586 – 2.260			3874	
S.d.(Fishery)	1.678	1.653	0.988 – 2.518			4369	
Overdispersion							
BLL	7.838	7.693	5.097 – 11.471			3813	
SLL	6.876	6.778	4.641 – 9.707			4702	
Trawl	2.350	1.401	0.413 – 11.381			4002	
Intercept	0.075	0.035	0.006 – 0.396			4002	
Method / Vessel class							
BLL / vessels $\geq$ 34 m	0.463	0.012	0.000 – 2.816			4227	
SLL / vessels $\geq$ 43 m	2.549	0.321	0.010 – 15.733			4125	
Trawl / vessels $\geq$ 28 m	0.008	0.001	0.000 – 0.055			3852	
BLL / vessels $<$ 34 m	1.000	1.000	1.000 – 1.000	3			
SLL / vessels $<$ 43 m	6.655	1.971	0.199 – 34.632			4274	
Trawl / vessels $<$ 28 m	0.056	0.027	0.003 – 0.289			3775	
Region							
North	1.000	1.000	1.000 – 1.000	3			
South	0.014	0.002	0.000 – 0.109			4357	
Season							
Autumn (Apr-Jun)	2.328	2.188	1.089 – 4.550			3854	
Spring (Oct-Dec)	0.587	0.538	0.226 – 1.222			4300	
Summer (Jan-Mar)	1.000	1.000	1.000 – 1.000	3			
Winter (Jul-Sep)	0.061	0.038	0.002 – 0.272			4002	
Fishery							
Albacore SLL	1.455	0.976	0.060 – 5.628			4002	
Bigeye SLL	0.998	0.707	0.052 – 3.656			3631	
Bluenose BLL	3.307	2.800	0.479 – 8.520			4002	
Deepwater trawl	0.492	0.140	0.000 – 3.059			4157	
Flatfish trawl	0.615	0.195	0.000 – 3.832			4002	
Hake trawl	0.963	0.348	0.000 – 5.229			3856	
Hāpuku BLL	1.926	1.459	0.190 – 6.287			3539	
Hoki trawl	0.620	0.189	0.000 – 3.708			4110	
Inshore trawl	2.525	2.027	0.240 – 7.620			4133	
Ling autoline BLL (no IWL)	0.883	0.329	0.000 – 5.251			3646	
Ling autoline BLL (IWL)	0.774	0.233	0.000 – 4.705			3677	
Ling manual-set BLL	0.251	0.053	0.000 – 1.658			4002	
Ling trawl	0.778	0.302	0.000 – 4.327			3754	
Mackerel trawl	0.783	0.260	0.000 – 4.780			4002	
Middle depths trawl	0.516	0.164	0.000 – 2.982			3962	
Minor targets BLL	0.108	0.018	0.000 – 0.788			3846	
Minor surface longline	1.591	1.149	0.072 – 5.946			4002	
Southern blue whiting trawl	0.962	0.339	0.000 – 5.401			4002	
Scampi trawl	0.159	0.039	0.000 – 0.978			4002	
Snapper BLL	0.268	0.202	0.031 – 0.899			3892	
Squid trawl	0.879	0.296	0.000 – 5.329			4002	
Southern bluefin SLL	0.014	0.002	0.000 – 0.098			4167	
Swordfish SLL	0.790	0.453	0.019 – 3.593			3741	
Area							
Auckland Islands	0.929	0.576	0.000 – 4.077			4002	
Cook Strait	0.945	0.568	0.001 – 4.239			4002	
East of North Island	0.966	0.801	0.136 – 2.710			4002	
Eastern Chatham Rise	0.902	0.563	0.001 – 3.777			4219	
East Subantarctic	0.944	0.587	0.000 – 4.161			4002	
Fiordland	0.963	0.581	0.001 – 4.531			3899	
Kermadec Islands	0.693	0.441	0.020 – 2.788			3847	
North East	2.479	2.133	0.406 – 6.637			4635	
South Subantarctic	0.975	0.584	0.000 – 4.211			4074	
Stewart Snares Shelf	0.957	0.570	0.000 – 4.286			4500	
Western Chatham Rise	0.928	0.564	0.000 – 4.234			3732	
West Coast North Island	0.128	0.082	0.003 – 0.515			4108	
West Coast South Island	0.889	0.546	0.001 – 3.818	1		4150	

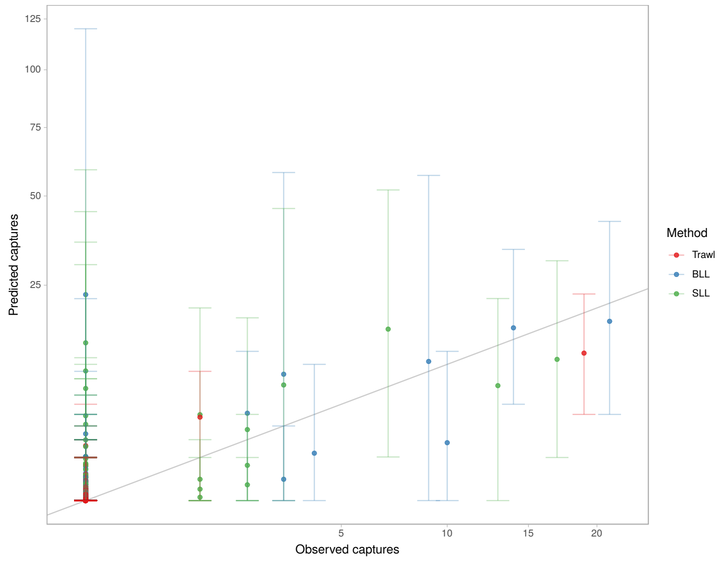


Figure D-37: Comparison between the observed and the predicted number of captures of black petrel (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points were coloured according to the fishing method (BLL, bottom longline; SLL, surface longline).

Table D-57: List of strata, defined as combinations of region, fishery, vessel size, area, and season, for which the number of observed captures of black petrel was outside the 95% credible interval (c.i.) of the estimated number of captures. There were two of these strata, representing 0.3% of all 602 strata. SLL, surface longline; BLL, bottom longline. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL.

Method	Fishery	Vessel size	Region	Area	Season	Observations	Captures	Mean	95% c.i.
SLL	Albacore SLL	Small	North	North East	Spring (Oct-Dec)	1	2	0.13	0–1
SLL	Albacore SLL	Large	North	North East	Winter (Jul-Sep)	2	1	0.01	0–0

D.7 Grey petrel

Table D-58: Model strata with the highest number of estimated captures of grey petrel in each of trawl, surface-longline (SLL), and bottom-longline (BLL) fisheries. Only the 15 strata with the most estimated captures are shown, sorted in decreasing order of mean estimated captures. The strata were defined as combinations of fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2015–16 for bottom- and surface-longline fisheries, and between 2002–03 and 2015–16 for trawl fisheries are shown, along with the number of fishing events observed, the proportion of fishing events observed (observer coverage), the associated ratio estimate of the total number of captures, and the mean and 95% credible interval of the total estimated number of captures. IWL: Integrated weight line.

Fishery	Vessel size	Area	Season	Observations				Estimated captures	
				Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
Trawl									
Southern blue whiting trawl	Vessels $\geq$ 28 m	South Subantarctic	Winter	35	5041	0.549	63	66	42–96
Southern blue whiting trawl	Vessels $\geq$ 28 m	East Subantarctic	Winter	14	958	0.484	28	19	7–36
Inshore trawl	Vessels $\geq$ 28 m	East of North Island	Winter	0	0	0.000		9	0–42
Hoki trawl	Vessels $\geq$ 28 m	Western Chatham Rise	Autumn	1	2234	0.156	6	8	1–20
Hoki trawl	Vessels $\geq$ 28 m	Western Chatham Rise	Winter	0	1049	0.156	0	7	1–19
Inshore trawl	Vessels $<$ 28 m	East of North Island	Winter	0	100	0.004	0	7	0–51
Deepwater trawl	Vessels $\geq$ 28 m	East of North Island	Autumn	0	391	0.108	0	4	0–12
Squid trawl	Vessels $\geq$ 28 m	Auckland Islands	Autumn	0	2734	0.362	0	4	0–12
Inshore trawl	Vessels $\geq$ 28 m	East of North Island	Autumn	0	6	0.006	0	3	0–15
Inshore trawl	Vessels $<$ 28 m	East of North Island	Autumn	0	180	0.008	0	3	0–20
Ling trawl	Vessels $\geq$ 28 m	East of North Island	Winter	0	0	0.000		3	0–13
Middle depths trawl	Vessels $\geq$ 28 m	East of North Island	Winter	0	3	0.004	0	3	0–13
Deepwater trawl	Vessels $\geq$ 28 m	East of North Island	Winter	0	32	0.034	0	2	0–8
Deepwater trawl	Vessels $\geq$ 28 m	South Subantarctic	Winter	0	601	0.251	0	2	0–8
Hoki trawl	Vessels $\geq$ 28 m	Eastern Chatham Rise	Autumn	0	801	0.139	0	2	0–7
Surface longline									
Southern bluefin SLL	Vessels $<$ 43 m	East of North Island	Autumn	12	333	0.042	288	224	111–396
Southern bluefin SLL	Vessels $<$ 43 m	East of North Island	Winter	7	195	0.111	63	108	52–212
Southern bluefin SLL	Vessels $<$ 43 m	North East	Winter	3	311	0.095	31	49	16–106
Bigeye SLL	Vessels $<$ 43 m	East of North Island	Autumn	0	96	0.022	0	40	4–127
Albacore SLL	Vessels $<$ 43 m	East of North Island	Autumn	0	23	0.015	0	38	5–132
Bigeye SLL	Vessels $<$ 43 m	North East	Winter	0	100	0.013	0	36	2–125
Southern bluefin SLL	Vessels $\geq$ 43 m	East of North Island	Winter	25	146	0.764	32	26	7–59
Swordfish SLL	Vessels $<$ 43 m	East of North Island	Autumn	0	12	0.061	0	11	0–46
Bigeye SLL	Vessels $<$ 43 m	North East	Autumn	0	54	0.012	0	10	0–34
Minor surface longline	Vessels $<$ 43 m	East of North Island	Autumn	0	2	0.012	0	6	0–31
Albacore SLL	Vessels $<$ 43 m	North East	Winter	0	0	0.000		5	0–21
Southern bluefin SLL	Vessels $<$ 43 m	North East	Autumn	2	41	0.059	33	5	0–13
Bigeye SLL	Vessels $<$ 43 m	North East	Spring	0	188	0.028	0	4	0–15
Albacore SLL	Vessels $\geq$ 43 m	East of North Island	Autumn	3	65	0.942	3	3	0–11
Albacore SLL	Vessels $<$ 43 m	North East	Autumn	0	1	0.002	0	3	0–11
Bottom longline									
Snapper BLL	Vessels $<$ 34 m	North East	Winter	0	0	0.000		1134	326–3007
Ling manual-set BLL	Vessels $<$ 34 m	East of North Island	Winter	0	92	0.017	0	617	75–2385
Snapper BLL	Vessels $<$ 34 m	North East	Autumn	11	521	0.015	737	550	170–1418
Ling autoline BLL (no IWL)	Vessels $\geq$ 34 m	South Subantarctic	Autumn	105	355	0.202	519	324	74–863
Ling autoline BLL (no IWL)	Vessels $\geq$ 34 m	Eastern Chatham Rise	Winter	9	1011	0.145	62	304	74–862
Bluenose BLL	Vessels $<$ 34 m	East of North Island	Winter	0	14	0.005	0	229	3–1218
Ling autoline BLL (no IWL)	Vessels $\geq$ 34 m	Auckland Islands	Winter	98	165	0.359	273	164	9–637
Ling autoline BLL (no IWL)	Vessels $\geq$ 34 m	Western Chatham Rise	Winter	10	47	0.027	373	153	20–543
Snapper BLL	Vessels $<$ 34 m	North East	Spring	0	493	0.012	0	147	24–500
Ling autoline BLL (no IWL)	Vessels $\geq$ 34 m	East Subantarctic	Autumn	0	8	0.013	0	133	12–472
Ling autoline BLL (no IWL)	Vessels $\geq$ 34 m	South Subantarctic	Winter	103	55	0.185	556	120	3–474
Hāpuku BLL	Vessels $<$ 34 m	East of North Island	Winter	0	1	0.001	0	91	0–507
Bluenose BLL	Vessels $<$ 34 m	East of North Island	Autumn	0	11	0.004	0	89	1–460
Ling manual-set BLL	Vessels $<$ 34 m	East of North Island	Autumn	0	0	0.000		83	8–355
Hāpuku BLL	Vessels $<$ 34 m	North East	Winter	0	20	0.006	0	76	0–349

Table D-59: Summary of model parameters, for grey petrel capture in New Zealand commercial trawl, bottom-, and surface-longline fisheries. For each parameter, the table gives summary statistics of the posterior distribution (mean, median, and 95% credible interval, based on the 2.5% and 97.5% quantiles), and diagnostics (the number of chains that fail convergence and half-width tests (Heidelberger & Welch 1983), and the effective length of the chains (without autocorrelation). Trace plots of the chains are also shown. Base levels of the factor covariates are: Large BLL for method, South for region, and Winter (Jul-Sep) for season. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. IWL, integrated weight line.

Parameter	Statistic			Diagnostics			
	Mean	Median	95% c.i.	Conv.	H.W.	Effective length	Trace
S.d.(Year)							
BLL	1.709	1.698	0.842 – 2.605			3900	
SLL	0.532	0.461	0.097 – 1.377			3063	
Trawl	0.647	0.626	0.233 – 1.194			3900	
S.d.(Area)	1.672	1.636	1.093 – 2.474			4230	
S.d.(Fishery)	0.932	0.906	0.469 – 1.538			3765	
Overdispersion							
BLL	13.982	13.905	8.637 – 19.267			4002	
SLL	3.797	3.750	0.795 – 7.280			4301	
Trawl	1.341	1.109	0.420 – 3.703			3679	
Intercept	0.112	0.059	0.011 – 0.525			3827	
Method / Vessel class							
BLL / vessels $\geq$ 34 m	1.000	1.000	1.000 – 1.000	3			
SLL / vessels $\geq$ 43 m	1.049	0.504	0.049 – 5.418			4002	
Trawl / vessels $\geq$ 28 m	0.038	0.026	0.004 – 0.138			4002	
BLL / vessels $<$ 34 m	0.686	0.363	0.036 – 3.211			4002	
SLL / vessels $<$ 43 m	0.542	0.237	0.022 – 2.797			4221	
Trawl / vessels $<$ 28 m	0.003	0.001	0.000 – 0.017			4161	
Region							
North	7.567	2.221	0.228 – 37.780			3889	
South	1.000	1.000	1.000 – 1.000	3			
Season							
Autumn (Apr-Jun)	0.482	0.462	0.248 – 0.842			3898	
Spring (Oct-Dec)	0.113	0.094	0.023 – 0.319			3835	
Summer (Jan-Mar)	0.017	0.012	0.002 – 0.061			4002	
Winter (Jul-Sep)	1.000	1.000	1.000 – 1.000	3			
Fishery							
Albacore SLL	0.841	0.696	0.103 – 2.450			4002	
Bigeye SLL	0.345	0.255	0.019 – 1.177			4002	
Bluenose BLL	0.631	0.441	0.017 – 2.342			3531	
Deepwater trawl	0.309	0.254	0.038 – 0.903			4188	
Flatfish trawl	0.965	0.739	0.018 – 3.310			4002	
Hake trawl	0.869	0.660	0.015 – 2.993			3876	
Hāpuku BLL	0.805	0.591	0.010 – 2.787			4002	
Hoki trawl	1.167	1.017	0.269 – 2.841			4253	
Inshore trawl	0.749	0.560	0.010 – 2.679			4002	
Ling autoline BLL (no IWL)	1.344	1.156	0.267 – 3.548			4230	
Ling autoline BLL (IWL)	1.174	0.964	0.200 – 3.390			3819	
Ling manual-set BLL	1.079	0.842	0.142 – 3.405			3734	
Ling trawl	1.478	1.221	0.193 – 4.382			3966	
Mackerel trawl	0.686	0.515	0.008 – 2.359			3892	
Middle depths trawl	0.447	0.322	0.003 – 1.622			4002	
Minor targets BLL	0.852	0.651	0.055 – 2.878			3884	
Minor surface longline	0.915	0.699	0.016 – 3.159			4127	
Southern blue whiting trawl	2.657	2.351	0.904 – 6.024			4421	
Scampi trawl	0.640	0.485	0.005 – 2.172			3792	
Snapper BLL	1.644	1.395	0.318 – 4.433			4217	
Squid trawl	0.486	0.372	0.035 – 1.538			3968	
Southern bluefin SLL	1.134	0.986	0.190 – 2.977			4110	
Swordfish SLL	1.660	1.408	0.307 – 4.664			4002	
Area							
Auckland Islands	2.059	1.687	0.304 – 6.151			4002	
Cook Strait	0.080	0.015	0.000 – 0.586			4002	
East of North Island	2.501	2.041	0.159 – 7.421			3823	
Eastern Chatham Rise	0.547	0.437	0.074 – 1.697			3676	
East Subantarctic	2.768	2.431	0.518 – 6.921			3997	
Fiordland	0.047	0.024	0.001 – 0.227			3841	
Kermadec Islands	0.668	0.406	0.022 – 2.806			3813	
North East	0.627	0.474	0.031 – 2.102			3540	
South Subantarctic	2.263	1.994	0.419 – 5.733			4112	
Stewart Snares Shelf	0.122	0.073	0.003 – 0.537			4002	
Western Chatham Rise	0.913	0.739	0.120 – 2.786			4002	
West Coast North Island	0.041	0.008	0.000 – 0.280			3393	
West Coast South Island	0.013	0.003	0.000 – 0.086			4002	

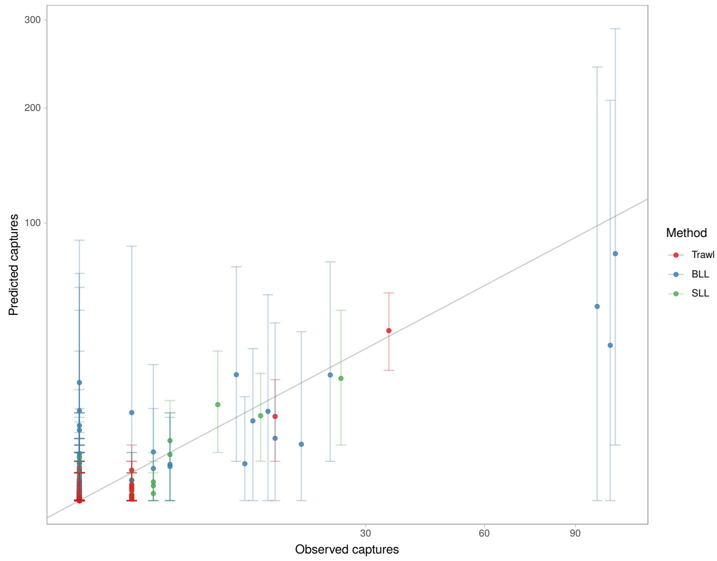


Figure D-38: Comparison between the observed and the predicted number of captures of grey petrel (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points were coloured according to the fishing method (BLL, bottom longline; SLL, surface longline).

Table D-60: List of strata, defined as combinations of region, fishery, vessel size, area, and season, for which the number of observed captures of grey petrel was outside the 95% credible interval (c.i.) of the estimated number of captures. There were four of these strata, representing 0.7% of all 602 strata. SLL, surface longline; BLL, bottom longline. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL.

Method	Fishery	Vessel size	Region	Area	Season	Observations	Captures	Mean	95% c.i.
SLL	Swordfish SLL	Small	North	Kermadec Islands	Spring (Oct-Dec)	21	2	0.06	0–1
Trawl	Hoki trawl	Large	South	Stewart Snares Shelf	Spring (Oct-Dec)	1507	1	0.02	0–0
Trawl	Hoki trawl	Large	South	Fiordland	Winter (Jul-Sep)	147	1	0.01	0–0
Trawl	Squid trawl	Large	South	Western Chatham Rise	Winter (Jul-Sep)	5	1	0.00	0–0

D.8 Sooty shearwater

Table D-61: Model strata with the highest number of estimated captures of sooty shearwater in each of trawl, surface-longline (SLL), and bottom-longline (BLL) fisheries. Only the 15 strata with the most estimated captures are shown, sorted in decreasing order of mean estimated captures. The strata were defined as combinations of fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2015–16 for bottom- and surface-longline fisheries, and between 2002–03 and 2015–16 for trawl fisheries are shown, along with the number of fishing events observed, the proportion of fishing events observed (observer coverage), the associated ratio estimate of the total number of captures, and the mean and 95% credible interval of the total estimated number of captures. IWL: Integrated weight line.

Fishery	Vessel size	Area	Season	Observations				Estimated captures	
				Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
Trawl									
Squid trawl	Vessels ≥ 28 m	Stewart Snares Shelf	Summer	341	9573	0.364	935	1072	742–1505
Squid trawl	Vessels ≥ 28 m	Stewart Snares Shelf	Autumn	274	2605	0.303	903	636	371–1005
Hoki trawl	Vessels ≥ 28 m	Western Chatham Rise	Autumn	104	2234	0.156	665	429	257–667
Hoki trawl	Vessels ≥ 28 m	Western Chatham Rise	Spring	54	2403	0.195	277	300	171–489
Middle depths trawl	Vessels < 28 m	Western Chatham Rise	Autumn	0	6	0.001	0	277	69–785
Middle depths trawl	Vessels < 28 m	Western Chatham Rise	Spring	0	38	0.007	0	273	67–765
Squid trawl	Vessels ≥ 28 m	Auckland Islands	Summer	108	6591	0.475	227	242	149–371
Hoki trawl	Vessels ≥ 28 m	Stewart Snares Shelf	Autumn	29	1771	0.269	107	235	122–400
Squid trawl	Vessels ≥ 28 m	Auckland Islands	Autumn	69	2734	0.362	190	228	125–371
Middle depths trawl	Vessels < 28 m	Western Chatham Rise	Summer	10	256	0.037	267	221	60–609
Hoki trawl	Vessels ≥ 28 m	Western Chatham Rise	Summer	38	1606	0.127	299	210	122–345
Middle depths trawl	Vessels ≥ 28 m	Stewart Snares Shelf	Spring	31	1465	0.276	112	198	97–370
Squid trawl	Vessels ≥ 28 m	Western Chatham Rise	Autumn	18	336	0.121	148	184	74–367
Hoki trawl	Vessels ≥ 28 m	Stewart Snares Shelf	Spring	14	1507	0.242	57	180	86–323
Squid trawl	Vessels < 28 m	Western Chatham Rise	Autumn	0	0	0.000		163	31–493
Surface longline									
Albacore SLL	Vessels < 43 m	East of North Island	Autumn	0	23	0.015	0	12	0–62
Albacore SLL	Vessels ≥ 43 m	East of North Island	Autumn	7	65	0.942	7	5	0–13
Southern bluefin SLL	Vessels ≥ 43 m	Fiordland	Autumn	0	3055	0.900	0	4	0–12
Albacore SLL	Vessels < 43 m	East of North Island	Summer	0	7	0.011	0	3	0–14
Bigeye SLL	Vessels < 43 m	East of North Island	Autumn	0	96	0.022	0	3	0–20
Bigeye SLL	Vessels < 43 m	East of North Island	Summer	0	174	0.028	0	2	0–15
Albacore SLL	Vessels ≥ 43 m	North East	Autumn	0	43	0.977	0	1	0–4
Albacore SLL	Vessels < 43 m	North East	Autumn	0	1	0.002	0	1	0–7
Albacore SLL	Vessels < 43 m	North East	Spring	0	1	0.004	0	1	0–4
Bigeye SLL	Vessels < 43 m	North East	Autumn	0	54	0.012	0	1	0–7
Bigeye SLL	Vessels < 43 m	North East	Spring	0	188	0.028	0	1	0–8
Bigeye SLL	Vessels < 43 m	North East	Summer	0	144	0.027	0	1	0–5
Minor surface longline	Vessels < 43 m	East of North Island	Autumn	0	2	0.012	0	1	0–5
Minor surface longline	Vessels < 43 m	East of North Island	Summer	0	9	0.017	0	1	0–8
Southern bluefin SLL	Vessels ≥ 43 m	Stewart Snares Shelf	Autumn	2	98	0.797	2	1	0–3
Bottom longline									
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Stewart Snares Shelf	Spring	69	909	0.464	148	123	71–192
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Western Chatham Rise	Spring	0	57	0.024	0	110	53–207
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Western Chatham Rise	Autumn	0	61	0.034	0	94	34–210
Ling autoline BLL (IWL)	Vessels ≥ 34 m	Stewart Snares Shelf	Spring	12	118	0.084	142	69	24–149
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Western Chatham Rise	Summer	1	65	0.048	20	45	18–94
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Eastern Chatham Rise	Spring	1	464	0.143	6	14	4–28
Ling autoline BLL (IWL)	Vessels ≥ 34 m	Fiordland	Spring	3	154	0.218	13	14	3–35
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Eastern Chatham Rise	Autumn	0	157	0.070	0	13	3–30
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Fiordland	Spring	5	78	0.139	35	12	2–28
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Auckland Islands	Autumn	0	20	0.061	0	11	2–29
Hāpuku BLL	Vessels < 34 m	Western Chatham Rise	Summer	0	5	0.009	0	8	0–47
Bluenose BLL	Vessels < 34 m	East of North Island	Spring	0	0	0.000		7	0–41
Bluenose BLL	Vessels < 34 m	Western Chatham Rise	Autumn	0	9	0.021	0	7	0–36
Hāpuku BLL	Vessels < 34 m	Western Chatham Rise	Spring	0	1	0.003	0	6	0–37
Ling manual-set BLL	Vessels < 34 m	Western Chatham Rise	Spring	0	59	0.020	0	6	0–35

Table D-62: Summary of model parameters, for sooty shearwater capture in New Zealand commercial trawl, bottom-, and surface-longline fisheries. For each parameter, the table gives summary statistics of the posterior distribution (mean, median, and 95% credible interval, based on the 2.5% and 97.5% quantiles), and diagnostics (the number of chains that fail convergence and half-width tests (Heidelberger & Welch 1983), and the effective length of the chains (without autocorrelation). Trace plots of the chains are also shown. Base levels of the factor covariates are: Large trawl for method, South for region, and Autumn (Apr-Jun) for season. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. IWL, integrated weight line.

Parameter	Statistic			Diagnostics			
	Mean	Median	95% c.i.	Conv.	H.W.	Effective length	Trace
S.d.(Year)							
BLL	0.746	0.717	0.185 – 1.471			3878	
SLL	0.708	0.593	0.114 – 1.901			2690	
Trawl	0.373	0.362	0.170 – 0.651			4002	
S.d.(Area)	1.276	1.247	0.849 – 1.852			3722	
S.d.(Fishery)	1.407	1.376	0.961 – 2.003			4140	
Overdispersion							
BLL	3.757	3.448	0.601 – 8.651			3749	
SLL	1.325	1.122	0.396 – 3.469			4002	
Trawl	14.570	14.549	12.856 – 16.451			4002	
Intercept	0.015	0.011	0.004 – 0.047			4208	
Method / Vessel class							
BLL / vessels $\geq$ 34 m	11.307	3.216	0.474 – 47.218			4002	
SLL / vessels $\geq$ 43 m	73.990	16.015	1.206 – 439.619			4117	
Trawl / vessels $\geq$ 28 m	1.000	1.000	1.000 – 1.000	3			
BLL / vessels $<$ 34 m	0.614	0.239	0.011 – 3.493			4069	
SLL / vessels $<$ 43 m	2.560	0.810	0.021 – 14.458			4246	
Trawl / vessels $<$ 28 m	1.590	1.341	0.465 – 4.115			4133	
Region							
North	0.502	0.211	0.027 – 2.454			4002	
South	1.000	1.000	1.000 – 1.000	3			
Season							
Autumn (Apr-Jun)	1.000	1.000	1.000 – 1.000	3			
Spring (Oct-Dec)	0.828	0.808	0.515 – 1.270			3748	
Summer (Jan-Mar)	0.564	0.555	0.400 – 0.774			3938	
Winter (Jul-Sep)	0.013	0.011	0.002 – 0.039			3662	
Fishery							
Albacore SLL	2.083	1.632	0.125 – 6.699			3895	
Bigeye SLL	0.275	0.097	0.000 – 1.702			4002	
Bluenose BLL	1.407	1.016	0.063 – 5.056			3833	
Deepwater trawl	0.063	0.049	0.009 – 0.196			4002	
Flatfish trawl	0.027	0.009	0.000 – 0.159			3891	
Hake trawl	1.657	1.425	0.384 – 4.209			4002	
Hāpuku BLL	2.324	1.815	0.155 – 7.330			3948	
Hoki trawl	1.182	1.081	0.341 – 2.546			4002	
Inshore trawl	0.150	0.098	0.010 – 0.580			3829	
Ling autoline BLL (no IWL)	0.898	0.647	0.047 – 3.281			4002	
Ling autoline BLL (IWL)	0.927	0.670	0.041 – 3.410			3895	
Ling manual-set BLL	0.437	0.156	0.000 – 2.497			3749	
Ling trawl	1.313	1.113	0.287 – 3.548			3899	
Mackerel trawl	0.331	0.273	0.065 – 0.945			4171	
Middle depths trawl	1.512	1.391	0.434 – 3.205			4002	
Minor targets BLL	0.275	0.091	0.000 – 1.637			3802	
Minor surface longline	0.888	0.389	0.000 – 4.565			4449	
Southern blue whiting trawl	0.720	0.302	0.000 – 3.811			3962	
Scampi trawl	1.220	1.028	0.235 – 3.401			4430	
Snapper BLL	0.600	0.251	0.000 – 3.168			3964	
Squid trawl	2.461	2.258	0.737 – 5.275			4002	
Southern bluefin SLL	0.015	0.006	0.000 – 0.083			4002	
Swordfish SLL	1.871	1.335	0.106 – 6.665			3898	
Area							
Auckland Islands	1.324	1.223	0.410 – 2.859			4002	
Cook Strait	0.245	0.185	0.025 – 0.835			4002	
East of North Island	1.568	1.241	0.155 – 4.895			3861	
Eastern Chatham Rise	0.251	0.224	0.068 – 0.575			4183	
East Subantarctic	0.091	0.071	0.010 – 0.288			4134	
Fiordland	1.100	0.978	0.300 – 2.620			3765	
Kermadec Islands	1.574	1.178	0.099 – 5.323			3743	
North East	0.499	0.342	0.030 – 1.829			3879	
South Subantarctic	0.074	0.051	0.004 – 0.273			3798	
Stewart Snares Shelf	3.155	2.973	1.035 – 6.464			4002	
Western Chatham Rise	2.630	2.469	0.844 – 5.495			3650	
West Coast North Island	0.228	0.123	0.004 – 1.073			4143	
West Coast South Island	0.122	0.097	0.020 – 0.371			4110	

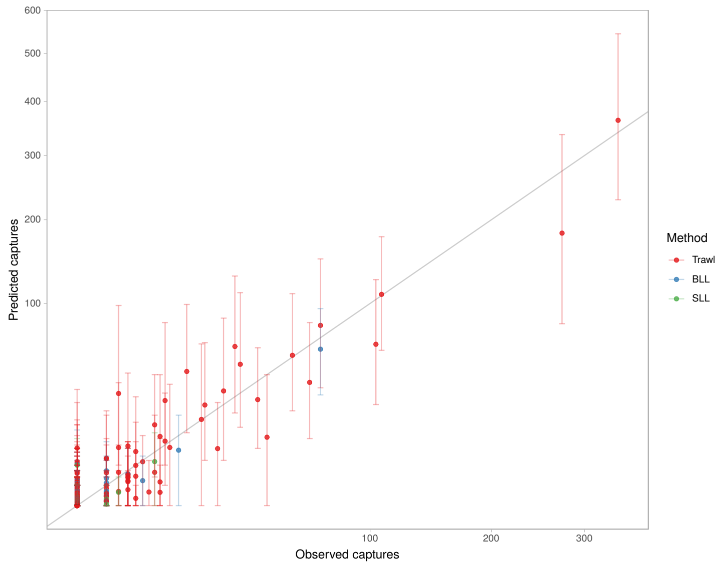


Figure D-39: Comparison between the observed and the predicted number of captures of sooty shearwater (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points were coloured according to the fishing method (BLL, bottom longline; SLL, surface longline).

Table D-63: List of strata, defined as combinations of region, fishery, vessel size, area, and season, for which the number of observed captures of sooty shearwater was outside the 95% credible interval (c.i.) of the estimated number of captures. There were six of these strata, representing 1.0% of all 602 strata. SLL, surface longline; BLL, bottom longline. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL.

Method	Fishery	Vessel size	Region	Area	Season	Observations	Captures	Mean	95% c.i.
Trawl	Hake trawl	Large	South	Stewart Snares Shelf	Spring (Oct-Dec)	742	2	30.76	4–98
Trawl	Middle depths trawl	Large	South	Western Chatham Rise	Autumn (Apr-Jun)	324	42	11.44	0–42
Trawl	Hoki trawl	Large	South	Fiordland	Spring (Oct-Dec)	33	6	0.45	0–5
Trawl	Scampi trawl	Small	South	Auckland Islands	Summer (Jan-Mar)	38	8	0.43	0–4
Trawl	Hake trawl	Large	South	Eastern Chatham Rise	Summer (Jan-Mar)	69	4	0.13	0–1
SLL	Southern bluefin SLL	Large	South	South Subantarctic	Autumn (Apr-Jun)	55	1	0.00	0–0

D.9 Flesh-footed shearwater

Table D-64: Model strata with the highest number of estimated captures of flesh-footed shearwater in each of trawl, surface-longline (SLL), and bottom-longline (BLL) fisheries. Only the 15 strata with the most estimated captures are shown, sorted in decreasing order of mean estimated captures. The strata were defined as combinations of fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2015–16 for bottom- and surface-longline fisheries, and between 2002–03 and 2015–16 for trawl fisheries are shown, along with the number of fishing events observed, the proportion of fishing events observed (observer coverage), the associated ratio estimate of the total number of captures, and the mean and 95% credible interval of the total estimated number of captures.

Fishery	Vessel size	Area	Season	Observations				Estimated captures	
				Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
Trawl									
Inshore trawl	Vessels < 28 m	North East	Summer	7	935	0.028	248	208	98–377
Scampi trawl	Vessels < 28 m	North East	Summer	4	172	0.055	72	156	55–356
Inshore trawl	Vessels < 28 m	North East	Autumn	9	1405	0.049	185	134	62–245
Scampi trawl	Vessels < 28 m	East of North Island	Summer	0	11	0.003	0	118	29–315
Scampi trawl	Vessels < 28 m	North East	Spring	31	447	0.105	294	106	47–198
Inshore trawl	Vessels < 28 m	East of North Island	Summer	1	237	0.009	106	100	31–236
Inshore trawl	Vessels < 28 m	North East	Spring	2	745	0.025	78	99	37–203
Scampi trawl	Vessels < 28 m	North East	Autumn	2	379	0.187	10	75	24–185
Inshore trawl	Vessels < 28 m	East of North Island	Autumn	0	180	0.008	0	66	18–161
Inshore trawl	Vessels < 28 m	East of North Island	Spring	0	19	0.001	0	63	16–161
Scampi trawl	Vessels < 28 m	East of North Island	Spring	0	272	0.094	0	46	12–115
Hoki trawl	Vessels < 28 m	North East	Autumn	2	33	0.061	32	34	1–161
Inshore trawl	Vessels < 28 m	West Coast North Island	Summer	0	955	0.047	0	31	7–76
Hoki trawl	Vessels < 28 m	North East	Summer	0	6	0.018	0	29	1–139
Hoki trawl	Vessels < 28 m	North East	Spring	0	21	0.041	0	22	1–102
Surface longline									
Bigeye SLL	Vessels < 43 m	North East	Summer	17	144	0.027	626	1600	617–3647
Bigeye SLL	Vessels < 43 m	North East	Spring	14	188	0.028	507	1104	374–2724
Bigeye SLL	Vessels < 43 m	North East	Autumn	9	54	0.012	767	1056	361–2533
Bigeye SLL	Vessels < 43 m	East of North Island	Summer	87	174	0.028	3057	1055	477–2111
Bigeye SLL	Vessels < 43 m	East of North Island	Autumn	0	96	0.022	0	590	198–1368
Bigeye SLL	Vessels < 43 m	West Coast North Island	Summer	0	60	0.023	0	196	42–547
Albacore SLL	Vessels < 43 m	East of North Island	Autumn	0	23	0.015	0	173	15–743
Albacore SLL	Vessels < 43 m	East of North Island	Summer	5	7	0.011	440	89	7–404
Albacore SLL	Vessels < 43 m	North East	Autumn	0	1	0.002	0	86	5–417
Bigeye SLL	Vessels < 43 m	East of North Island	Spring	1	13	0.015	67	82	22–214
Bigeye SLL	Vessels < 43 m	West Coast North Island	Autumn	0	11	0.009	0	73	11–235
Minor surface longline	Vessels < 43 m	North East	Summer	3	23	0.059	50	71	2–399
Bigeye SLL	Vessels < 43 m	North East	Winter	0	100	0.013	0	59	1–254
Minor surface longline	Vessels < 43 m	East of North Island	Summer	0	9	0.017	0	59	2–318
Albacore SLL	Vessels < 43 m	North East	Spring	0	1	0.004	0	39	1–190
Bottom longline									
Snapper BLL	Vessels < 34 m	North East	Summer	44	1074	0.029	1503	1872	1111–3078
Snapper BLL	Vessels < 34 m	North East	Autumn	32	521	0.015	2146	1326	738–2244
Snapper BLL	Vessels < 34 m	North East	Spring	6	493	0.012	497	1124	509–2177
Hāpuku BLL	Vessels < 34 m	North East	Summer	0	2	0.001	0	355	31–1580
Minor targets BLL	Vessels < 34 m	North East	Summer	4	34	0.024	167	342	70–1127
Minor targets BLL	Vessels < 34 m	West Coast North Island	Summer	10	179	0.034	292	256	85–643
Minor targets BLL	Vessels < 34 m	North East	Autumn	2	35	0.026	75	243	50–788
Hāpuku BLL	Vessels < 34 m	North East	Autumn	1	25	0.016	60	197	18–834
Hāpuku BLL	Vessels < 34 m	North East	Spring	0	2	0.001	0	178	13–831
Minor targets BLL	Vessels < 34 m	North East	Spring	0	26	0.021	0	162	28–571
Hāpuku BLL	Vessels < 34 m	West Coast North Island	Summer	0	18	0.006	0	115	11–462
Minor targets BLL	Vessels < 34 m	West Coast North Island	Spring	2	51	0.012	163	109	29–306
Hāpuku BLL	Vessels < 34 m	East of North Island	Summer	0	4	0.005	0	87	5–404
Hāpuku BLL	Vessels < 34 m	East of North Island	Spring	0	0	0.000		86	5–399
Minor targets BLL	Vessels < 34 m	West Coast North Island	Autumn	0	43	0.021	0	77	19–208

Table D-65: Summary of model parameters, for flesh-footed shearwater capture in New Zealand commercial trawl, bottom-, and surface-longline fisheries. For each parameter, the table gives summary statistics of the posterior distribution (mean, median, and 95% credible interval, based on the 2.5% and 97.5% quantiles), and diagnostics (the number of chains that fail convergence and half-width tests (Heidelberger & Welch 1983), and the effective length of the chains (without autocorrelation). Trace plots of the chains are also shown. Base levels of the factor covariates are: Small SLL for method, North for region, and Summer (Jan-Mar) for season. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. IWL, integrated weight line.

Parameter	Statistic			Diagnostics			
	Mean	Median	95% c.i.	Conv.	H.W.	Effective length	Trace
S.d.(Year)							
BLL	0.911	0.777	0.135 – 2.316			2189	
SLL	0.997	0.876	0.145 – 2.422			2051	
Trawl	0.934	0.801	0.135 – 2.377			2271	
S.d.(Area)	0.909	0.821	0.300 – 1.987			3760	
S.d.(Fishery)	1.503	1.477	0.898 – 2.273			3890	
Overdispersion							
BLL	7.662	7.551	5.278 – 10.587			4002	
SLL	8.538	8.422	6.337 – 11.269			4129	
Trawl	9.337	9.206	5.574 – 13.902			4002	
Intercept	0.142	0.080	0.016 – 0.642			3864	
Method / Vessel class							
BLL / vessels $\geq$ 34 m	0.843	0.015	0.000 – 3.023			4326	
SLL / vessels $\geq$ 43 m	0.210	0.007	0.000 – 0.939			3698	
Trawl / vessels $\geq$ 28 m	0.025	0.007	0.000 – 0.160			3822	
BLL / vessels $<$ 34 m	1.910	0.781	0.088 – 10.614			3882	
SLL / vessels $<$ 43 m	1.000	1.000	1.000 – 1.000	3			
Trawl / vessels $<$ 28 m	0.457	0.205	0.025 – 2.001			4111	
Region							
North	1.000	1.000	1.000 – 1.000	3			
South	0.016	0.008	0.000 – 0.078			4002	
Season							
Autumn (Apr-Jun)	0.777	0.742	0.396 – 1.358			3896	
Spring (Oct-Dec)	0.556	0.521	0.254 – 1.057			3874	
Summer (Jan-Mar)	1.000	1.000	1.000 – 1.000	3			
Winter (Jul-Sep)	0.028	0.018	0.001 – 0.110			4002	
Fishery							
Albacore SLL	1.669	1.191	0.149 – 6.105			4002	
Bigeye SLL	2.542	2.147	0.368 – 7.073			4002	
Bluenose BLL	0.108	0.023	0.000 – 0.749			4002	
Deepwater trawl	0.256	0.071	0.000 – 1.500			4002	
Flatfish trawl	0.175	0.050	0.000 – 1.079			4002	
Hake trawl	0.932	0.424	0.000 – 4.789			4002	
Hāpuku BLL	1.494	1.068	0.095 – 5.519			4235	
Hoki trawl	2.328	1.916	0.264 – 6.916			3877	
Inshore trawl	0.280	0.222	0.032 – 0.852			4002	
Ling autoline BLL (no IWL)	0.878	0.365	0.000 – 4.726			4002	
Ling autoline BLL (IWL)	0.796	0.315	0.000 – 4.270			4002	
Ling manual-set BLL	0.217	0.058	0.000 – 1.430			3710	
Ling trawl	1.475	1.006	0.050 – 5.792			4137	
Mackerel trawl	0.344	0.096	0.000 – 2.129			4002	
Middle depths trawl	0.550	0.342	0.016 – 2.326			4002	
Minor targets BLL	2.280	1.839	0.211 – 6.729			4122	
Minor surface longline	1.179	0.733	0.061 – 5.057			4429	
Southern blue whiting trawl	0.931	0.410	0.000 – 4.766			4213	
Scampi trawl	2.070	1.711	0.268 – 5.957			4002	
Snapper BLL	0.644	0.481	0.049 – 2.284			4002	
Squid trawl	0.752	0.334	0.000 – 4.004			4002	
Southern bluefin SLL	0.033	0.008	0.000 – 0.218			4002	
Swordfish SLL	0.549	0.319	0.024 – 2.439			3940	
Area							
Auckland Islands	0.844	0.691	0.002 – 2.773			4002	
Cook Strait	0.934	0.754	0.006 – 3.143			4002	
East of North Island	1.147	0.991	0.235 – 2.981			4002	
Eastern Chatham Rise	0.807	0.653	0.004 – 2.598			3899	
East Subantarctic	0.961	0.770	0.004 – 3.333			4002	
Fiordland	0.947	0.764	0.004 – 3.410			4262	
Kermadec Islands	0.700	0.568	0.001 – 2.328			4152	
North East	1.895	1.658	0.490 – 4.849			4132	
South Subantarctic	0.919	0.747	0.005 – 2.967			4002	
Stewart Snares Shelf	0.874	0.706	0.003 – 3.016			4159	
Western Chatham Rise	1.492	1.188	0.183 – 4.828			4063	
West Coast North Island	0.457	0.391	0.066 – 1.195			3899	
West Coast South Island	0.882	0.718	0.005 – 2.957			3660	

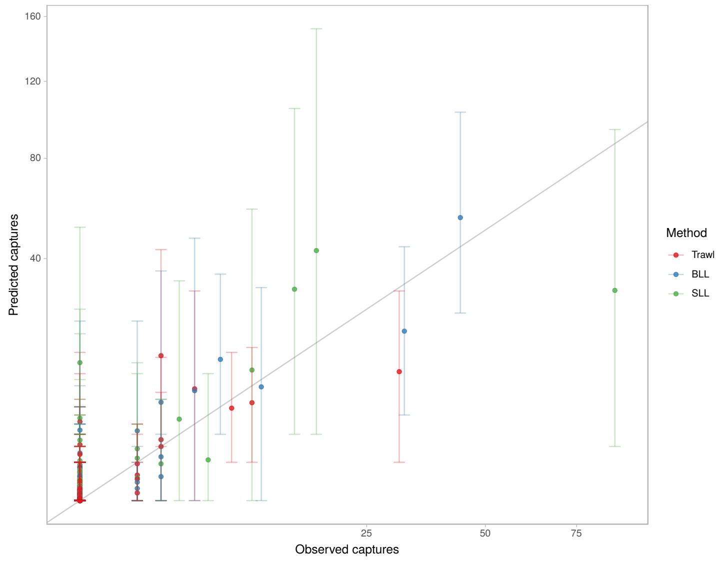


Figure D-40: Comparison between the observed and the predicted number of captures of flesh-footed shearwater (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points were coloured according to the fishing method (BLL, bottom longline; SLL, surface longline).

Table D-66: List of strata, defined as combinations of region, fishery, vessel size, area, and season, for which the number of observed captures of flesh-footed shearwater was outside the 95% credible interval (c.i.) of the estimated number of captures. There was one of these strata, representing 0.2% of all 602 strata. SLL, surface longline; BLL, bottom longline. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL.

Method	Fishery	Vessel size	Region	Area	Season	Observations	Captures	Mean	95% c.i.
Trawl	Scampi trawl	Small	North	North East	Spring (Oct-Dec)	447	31	11.35	1–30

D.10 Other birds

Table D-67: Model strata with the highest number of estimated captures of other birds in each of trawl, surface-longline (SLL), and bottom-longline (BLL) fisheries. Only the 15 strata with the most estimated captures are shown, sorted in decreasing order of mean estimated captures. The strata were defined as combinations of fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2015–16 for bottom- and surface-longline fisheries, and between 2002–03 and 2015–16 for trawl fisheries are shown, along with the number of fishing events observed, the proportion of fishing events observed (observer coverage), the associated ratio estimate of the total number of captures, and the mean and 95% credible interval of the total estimated number of captures. IWL: Integrated weight line.

Fishery	Vessel size	Area	Season	Observations				Estimated captures	
				Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
Trawl									
Flatfish trawl	Vessels < 28 m	Stewart Snares Shelf	Summer	0	581	0.024	0	237	84–571
Flatfish trawl	Vessels < 28 m	West Coast South Island	Autumn	0	14	0.001	0	231	71–570
Flatfish trawl	Vessels < 28 m	Stewart Snares Shelf	Spring	0	7	0.000	0	214	69–517
Flatfish trawl	Vessels < 28 m	Western Chatham Rise	Summer	32	307	0.014	2278	209	90–440
Flatfish trawl	Vessels < 28 m	West Coast South Island	Winter	0	23	0.002	0	187	57–455
Flatfish trawl	Vessels < 28 m	Western Chatham Rise	Autumn	0	184	0.009	0	185	70–413
Flatfish trawl	Vessels < 28 m	West Coast South Island	Spring	0	155	0.015	0	182	50–473
Flatfish trawl	Vessels < 28 m	Western Chatham Rise	Spring	0	69	0.004	0	175	64–405
Flatfish trawl	Vessels < 28 m	Stewart Snares Shelf	Autumn	0	47	0.003	0	158	48–391
Flatfish trawl	Vessels < 28 m	Stewart Snares Shelf	Winter	0	0	0.000		151	44–372
Flatfish trawl	Vessels < 28 m	West Coast South Island	Summer	0	162	0.020	0	140	43–351
Flatfish trawl	Vessels < 28 m	Western Chatham Rise	Winter	0	73	0.005	0	134	47–313
Hoki trawl	Vessels ≥ 28 m	West Coast South Island	Winter	34	13112	0.328	103	125	74–194
Flatfish trawl	Vessels < 28 m	West Coast North Island	Autumn	0	1	0.000	0	124	36–309
Flatfish trawl	Vessels < 28 m	West Coast North Island	Winter	0	0	0.000		102	28–253
Surface longline									
Albacore SLL	Vessels < 43 m	East of North Island	Autumn	0	23	0.015	0	124	24–388
Southern bluefin SLL	Vessels < 43 m	East of North Island	Autumn	1	333	0.042	24	69	28–136
Southern bluefin SLL	Vessels < 43 m	West Coast South Island	Autumn	15	205	0.084	178	58	24–110
Bigeye SLL	Vessels < 43 m	North East	Spring	4	188	0.028	144	56	17–117
Bigeye SLL	Vessels < 43 m	North East	Winter	0	100	0.013	0	56	17–118
Albacore SLL	Vessels < 43 m	East of North Island	Summer	0	7	0.011	0	51	8–162
Bigeye SLL	Vessels < 43 m	North East	Summer	1	144	0.027	36	45	14–93
Bigeye SLL	Vessels < 43 m	East of North Island	Summer	0	174	0.028	0	44	12–98
Albacore SLL	Vessels < 43 m	North East	Autumn	0	1	0.002	0	42	6–139
Bigeye SLL	Vessels < 43 m	North East	Autumn	0	54	0.012	0	38	11–81
Albacore SLL	Vessels < 43 m	North East	Winter	0	0	0.000		35	5–112
Bigeye SLL	Vessels < 43 m	East of North Island	Autumn	0	96	0.022	0	31	8–72
Southern bluefin SLL	Vessels < 43 m	North East	Winter	1	311	0.095	10	31	11–64
Albacore SLL	Vessels < 43 m	North East	Spring	0	1	0.004	0	28	3–91
Albacore SLL	Vessels < 43 m	West Coast North Island	Summer	0	0	0.000		22	2–75
Bottom longline									
Snapper BLL	Vessels < 34 m	North East	Spring	9	493	0.012	745	850	428–1596
Snapper BLL	Vessels < 34 m	North East	Summer	23	1074	0.029	785	770	418–1327
Snapper BLL	Vessels < 34 m	North East	Autumn	9	521	0.015	603	720	375–1315
Snapper BLL	Vessels < 34 m	North East	Winter	0	0	0.000		609	294–1175
Minor targets BLL	Vessels < 34 m	West Coast North Island	Summer	4	179	0.034	117	98	29–246
Hāpuku BLL	Vessels < 34 m	North East	Winter	0	20	0.006	0	84	17–248
Ling autoline BLL (no IWL)	Vessels ≥ 34 m	Eastern Chatham Rise	Winter	15	1011	0.145	103	84	39–159
Bluenose BLL	Vessels < 34 m	North East	Summer	0	43	0.007	0	83	7–291
Hāpuku BLL	Vessels < 34 m	Eastern Chatham Rise	Summer	0	0	0.000		81	14–275
Ling manual-set BLL	Vessels < 34 m	West Coast South Island	Spring	0	1	0.000	0	78	18–218
Minor targets BLL	Vessels < 34 m	West Coast North Island	Spring	3	51	0.012	244	77	21–199
Hāpuku BLL	Vessels < 34 m	Eastern Chatham Rise	Autumn	0	0	0.000		76	13–265
Ling manual-set BLL	Vessels < 34 m	West Coast South Island	Winter	0	6	0.002	0	76	19–197
Hāpuku BLL	Vessels < 34 m	West Coast North Island	Summer	0	18	0.006	0	74	14–234
Minor targets BLL	Vessels < 34 m	Cook Strait	Summer	0	0	0.000		68	13–205

Table D-68: Summary of model parameters, for other birds capture in New Zealand commercial trawl, bottom-, and surface-longline fisheries. For each parameter, the table gives summary statistics of the posterior distribution (mean, median, and 95% credible interval, based on the 2.5% and 97.5% quantiles), and diagnostics (the number of chains that fail convergence and half-width tests (Heidelberger & Welch 1983), and the effective length of the chains (without autocorrelation). Trace plots of the chains are also shown. Base levels of the factor covariates are: Large trawl for method, South for region, and Summer (Jan-Mar) for season. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. IWL, integrated weight line.

Parameter	Statistic			Diagnostics			
	Mean	Median	95% c.i.	Conv.	H.W.	Effective length	Trace
S.d.(Year)							
BLL	0.557	0.518	0.113 – 1.230			3661	
SLL	0.814	0.772	0.160 – 1.782			3086	
Trawl	0.387	0.374	0.151 – 0.687			4149	
S.d.(Area)	0.459	0.441	0.195 – 0.833			3837	
S.d.(Fishery)	0.759	0.747	0.428 – 1.176			3887	
Overdispersion							
BLL	11.136	11.053	8.449 – 14.239			4002	
SLL	4.116	3.966	0.620 – 9.296			3452	
Trawl	19.468	19.604	18.198 – 19.987			4002	
Intercept	0.004	0.004	0.002 – 0.009			3450	
Method / Vessel class							
BLL / vessels $\geq$ 34 m	5.780	4.526	1.168 – 17.918			3723	
SLL / vessels $\geq$ 43 m	5.126	3.985	1.062 – 15.922			4002	
Trawl / vessels $\geq$ 28 m	1.000	1.000	1.000 – 1.000	3			
BLL / vessels $<$ 34 m	11.057	9.137	2.826 – 30.967			4202	
SLL / vessels $<$ 43 m	17.189	13.100	3.750 – 53.457			3825	
Trawl / vessels $<$ 28 m	1.345	1.193	0.477 – 3.057			3759	
Region							
North	0.768	0.678	0.302 – 1.795			3717	
South	1.000	1.000	1.000 – 1.000	3			
Season							
Autumn (Apr-Jun)	0.997	0.975	0.642 – 1.477			3982	
Spring (Oct-Dec)	1.009	0.980	0.621 – 1.574			4002	
Summer (Jan-Mar)	1.000	1.000	1.000 – 1.000	3			
Winter (Jul-Sep)	0.909	0.879	0.536 – 1.437			4050	
Fishery							
Albacore SLL	3.009	2.754	1.146 – 6.335			3396	
Bigeye SLL	0.332	0.281	0.060 – 0.862			4178	
Bluenose BLL	0.632	0.525	0.070 – 1.831			4002	
Deepwater trawl	0.402	0.372	0.136 – 0.837			4402	
Flatfish trawl	2.853	2.630	1.163 – 5.919			4517	
Hake trawl	0.539	0.484	0.144 – 1.224			4240	
Hāpuku BLL	1.422	1.237	0.391 – 3.527			3901	
Hoki trawl	0.754	0.729	0.314 – 1.360			4009	
Inshore trawl	0.710	0.645	0.244 – 1.637			4253	
Ling autoline BLL (no IWL)	1.218	1.104	0.305 – 2.779			4002	
Ling autoline BLL (IWL)	0.865	0.772	0.199 – 2.111			4002	
Ling manual-set BLL	0.643	0.565	0.137 – 1.583			4180	
Ling trawl	1.383	1.272	0.438 – 2.986			4008	
Mackerel trawl	1.070	1.003	0.386 – 2.096			3712	
Middle depths trawl	0.738	0.693	0.274 – 1.446			4388	
Minor targets BLL	1.175	1.053	0.345 – 2.759			3817	
Minor surface longline	0.690	0.560	0.030 – 2.151			3078	
Southern blue whiting trawl	0.947	0.859	0.271 – 2.095			4111	
Scampi trawl	0.517	0.457	0.147 – 1.207			4002	
Snapper BLL	1.148	1.059	0.367 – 2.464			3996	
Squid trawl	0.776	0.732	0.291 – 1.492			4163	
Southern bluefin SLL	0.409	0.358	0.094 – 0.986	1		3981	
Swordfish SLL	0.640	0.547	0.111 – 1.658			3890	
Area							
Auckland Islands	1.738	1.657	1.004 – 2.903			4239	
Cook Strait	1.039	0.993	0.497 – 1.873			4002	
East of North Island	0.764	0.741	0.293 – 1.384			3890	
Eastern Chatham Rise	0.733	0.719	0.386 – 1.172			4002	
East Subantarctic	0.703	0.672	0.262 – 1.271			4002	
Fiordland	1.006	0.971	0.515 – 1.717			4214	
Kermadec Islands	1.591	1.459	0.759 – 3.156			3794	
North East	0.903	0.887	0.376 – 1.574			3861	
South Subantarctic	0.726	0.703	0.309 – 1.270			3847	
Stewart Snares Shelf	0.783	0.769	0.437 – 1.227			4086	
Western Chatham Rise	0.808	0.794	0.419 – 1.320			4002	
West Coast North Island	0.750	0.734	0.275 – 1.334			4002	
West Coast South Island	1.417	1.367	0.856 – 2.265			4338	

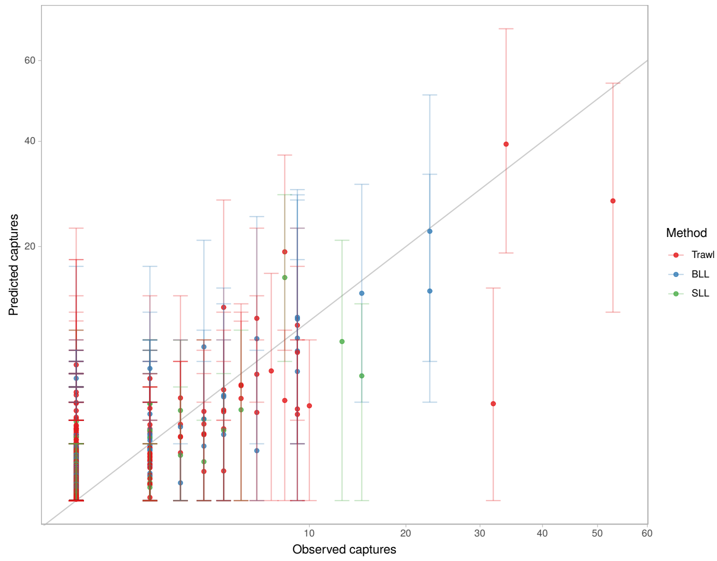


Figure D-41: Comparison between the observed and the predicted number of captures of other birds (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points were coloured according to the fishing method (BLL, bottom longline; SLL, surface longline).

Table D-69: List of strata, defined as combinations of region, fishery, vessel size, area, and season, for which the number of observed captures of other birds was outside the 95% credible interval (c.i.) of the estimated number of captures. There were nine of these strata, representing 1.5% of all 602 strata. SLL, surface longline; BLL, bottom longline. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL.

Method	Fishery	Vessel size	Region	Area	Season	Observations	Captures	Mean	95% c.i.
SLL	Southern bluefin SLL	Small	South	West Coast South Island	Autumn (Apr-Jun)	205	15	4.82	0–12
Trawl	Flatfish trawl	Small	South	Western Chatham Rise	Summer (Jan-Mar)	307	32	2.91	0–14
Trawl	Deepwater trawl	Large	South	Eastern Chatham Rise	Autumn (Apr-Jun)	2946	10	2.79	0–8
Trawl	Mackerel trawl	Large	North	West Coast North Island	Summer (Jan-Mar)	1731	9	2.60	0–8
Trawl	Hoki trawl	Large	South	Cook Strait	Winter (Jul-Sep)	1000	9	2.30	0–8
SLL	Southern bluefin SLL	Large	North	East of North Island	Winter (Jul-Sep)	146	3	0.47	0–2
Trawl	Hoki trawl	Large	South	Fiordland	Autumn (Apr-Jun)	137	4	0.27	0–2
BLL	Ling manual-set BLL	Small	South	Cook Strait	Summer (Jan-Mar)	4	2	0.10	0–1
Trawl	Ling trawl	Large	South	South Subantarctic	Summer (Jan-Mar)	1	1	0.00	0–0