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Estimated capture of seabirds in New Zealand trawl and longline fisheries, 2002–03 to 2014–15

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

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In New Zealand, captures of seabirds and other protected species are recorded by government observers when they are on-board commercial fishing vessels. This report addresses the question of how many seabirds would be reported caught if every commercial trawl and longline vessel fishing within New Zealand's Exclusive Economic Zone carried an observer. Statistical models were used to scale up from observed captures, to estimate total captures across all commercial trawl and longline fisheries. Estimates were made for the 2002–03 to 2014–15 fishing years for trawl fisheries, and for the 1998–99 to 2014–15 fishing years for longline fisheries.

A consistent modelling framework was used to estimate the captures for ten species (and species groups): New Zealand white-capped albatross (*Thalassarche steadi*), Salvin's albatross (*Thalassarche salvini*), Buller's albatrosses (*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". A hierarchical mixed-effects generalised linear model (GLM) was used, fitted using Bayesian methods. For each model, the data were grouped by fishing method, target fishery, vessel class, spatial area, fishing year, and quarter of the year, and the capture rate was estimated within each of these strata from the observed captures. This capture rate was then applied to unobserved fishing effort to estimate total captures.

We estimated that a total of 4584 (95% c.i.: 3935–5477) seabirds were captured in trawl and longline fisheries during the 2014–15 fishing year, where the credible interval (c.i.) is the 95th quantile range of the posterior distribution. The total estimate included 2095 (95% c.i.: 1828–2414) seabirds captured in trawl fisheries, 1927 (95% c.i.: 1404–2746) seabirds captured in bottom-longline fisheries, and 561 (95% c.i.: 386–838) seabirds captured in surface-longline fisheries.

Among the seabird species, the highest number of total estimated captures duing the 2014–15 fishing year was of white-chinned petrel with 868 (95% c.i.: 578–1517) captures, followed by flesh-footed shearwater and Salvin's albatross, with 575 (95% c.i.: 357–958) and 559 (95% c.i.: 386–818) captures, respectively. Other estimates included 416 (95% c.i.: 294–589) captures of New Zealand white-capped albatross, 307 (95% c.i.: 171–558) captures of black petrel, 439 (95% c.i.: 321–641) captures of sooty shearwater, 260 (95% c.i.: 183–381) captures of Buller's albatrosses, and 239 (95% c.i.: 98–571) captures of grey petrel. In addition to the species estimates, there were 655 (95% c.i.: 475–912) and 561 (95% c.i.: 386–838) estimated captures for other birds and other albatrosses, respectively.

For seven of the ten modelled species groups, the total number of estimated captures decreased between 2002–03 and 2014–15. This decrease was primarily related to decreases in fishing effort over this period. Only Salvin's albatross, white-chinned petrel and grey petrel did not show a clear decrease in total captures over this time period, and it was only for white-chinned petrel that the mean estimated captures in 2014–15 were higher than the mean estimated captures in 2002–03. In the large-vessel fisheries with sufficient captures to evaluate trends, there were no clear decreases in the capture rate of either albatrosses or petrels and other birds over this period. In large-vessel squid trawl fisheries, there was an increase in the capture rate of petrels and other birds over the reporting period, and in hoki trawl fisheries there has been an increase in the capture rate of albatrosses since 2006–07.

In many fisheries, it appears from the observer data that it would be possible to improve the mitigation of seabird captures. For example, streamer lines could be used by all small-vessel surface-longline fisheries, and the use of integrated weight line in large-vessel bottom-longline fisheries could be increased. However, improvements to data collection by observers are necessary to understand the use of mitigation measures across New Zealand's fisheries.

1. INTRODUCTION

In New Zealand, captures of seabirds and other protected species are recorded by government observers when they are on-board fishing vessels. Any captured animals are identified and photographed. Dead animals are retained for necropsy, and any photographs of live-released animals are also identified. These consistently collected data provide a basis for evaluating the capture of seabirds in New Zealand fisheries.

New Zealand commercial fisheries are diverse, and their range includes deepwater orange roughy fisheries, offshore longline fisheries targeting a range of tuna species, bottom-longline fisheries targeting snapper in Hauraki Gulf, and coastal fisheries such as set-net fishing in North Island harbours and estuaries. A limitation of the observer data is that not all these fisheries are well observed, in particular small-vessel fisheries tend to have low observer coverage. For example, between 2002–03 and 2013–14, trawl fisheries targeting flatfish species had only 0.6% of all tows observed (Abraham & Richard 2017).

To monitor total seabird captures in New Zealand waters, estimation methods are applied to scale up capture rates from the observed fishing effort to all the fishing effort. This estimation has been periodically carried out for commercial trawl and longline fishing within the outer boundary of New Zealand's Exclusive Economic Zone (most recently by Abraham & Richard 2017). The current report updates this analysis by including observer records of seabird captures from the 2014–15 fishing year.

Specifically, the current study assessed how many seabirds would be reported caught if every trawl and longline vessel carried an observer. The impact of these captures on seabird populations was not considered. Furthermore, 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 are not considered in the present study.

The current estimation provides an assessment of the total number of seabird captures, without considering the post-capture survival of seabirds that were captured alive.

The methods used in this assessment were identical to methods used previously (Abraham & Richard 2017). Data were updated to include the 2014–15 fishing year (i.e., from 1 October 2014 to 30 September 2015). A generalised linear model (GLM) was used to estimate the total captures of ten seabird species (or species groups). These species (groups) included New Zealand white-capped albatross (*Thalassarche steadi*), Salvin's albatross (*Thalassarche salvini*), Buller's albatrosses (*Thalassarche bulleri*, combining both southern *T. b. bulleri* and northern *T. b. platei* subspecies), white-chinned petrel (*Procellaria aequinoctialis*), sooty shearwater (*Puffinus griseus*), black petrel (*Procellaria parkinsoni*), grey petrel (*Procellaria cinerea*), flesh-footed shearwater (*Puffinus carneipes*), other albatrosses (all other species in the Diomedeidae family), and all other birds. The species selected were those that have had the highest number of observed captures in trawl and longline fisheries over the period covered by the data. Any captures that could not be identified to the species level were included in the generic "other albatrosses" or "other birds" groups.

An independent statistical model was fitted to the captures of each species, and the captures were assumed to be drawn from an over-dispersed Poisson distribution (represented as a negative binomial distribution). The covariates included were the same in each model. They were based on a set of discrete strata (fishing year, area, fishery, season), so that the data could be aggregated before the modelling; covariates that reflected the distribution of seabirds (e.g., area and season) were shared across different fisheries. The identical model structure and parameters for each species allowed for direct comparisons between the models.

Captures that occurred in 2014–15 may influence estimates of captures in previous years, especially in poorly observed fisheries. In addition, the data preparation may result in changes to the data from throughout the study period. For these reasons, the results of the current analysis supersede findings from the previous analysis (Abraham & Richard 2017). Any exploration of changes in the number of captures over time needs to be based on the current findings.

2. METHODS

2.1 Data preparation

Ministry for Primary Industries (MPI) 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 MPI. Currently, data are housed in the Centralised Observer Database (COD; Sanders & Fisher 2010). This information of protected species captures information held 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).

During preparation of the captures data, three issues were found in the observer protected species captures data used by Abraham and 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 MPI. 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 issues were fixed, 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 MPI. 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 MPI (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 were during observations that could not be linked to fishing effort, and were not included in the modelling. From 2002–03 and 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 Statistical modelling

The methods used for the estimation of total captures followed those used by Abraham and Richard (2017), with the exception that the data range was extended to cover the period 1998–99 to 2014–15 for longline fisheries, and 2002–03 to 2014–15 for trawl fisheries. Earlier observer records of seabird captures in trawl fisheries were not considered complete, due to observers on trawl vessels not focusing on seabird captures, and so were not used for the estimation.

Generalised linear models (GLMs) were fitted to the observed fishing effort and captures data, and then used to estimate the observable captures on unobserved fishing effort. Bayesian methods were used to fit the models. Bayesian 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 for the modelling.

To standardise the models across species, a single model structure was used for all species groupings, combining all trawl, surface-longline, and bottom-longline fisheries.

Observed captures were assumed to follow a negative binomial distribution, similarly to other assessments (Baird & Smith 2008, Abraham & Thompson 2011), as 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, θ. The variance is given by $\mu + \mu^2/\theta$. As the overdispersion increases to infinity, the variance nears the mean, and the negative binomial distribution converges to a Poisson distribution. As θ gets small relative to the mean, the negative binomial distribution becomes increasingly peaked at zero and becomes skewed-right (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 $n\theta$. 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 negative binomial distribution may be generated by a Poisson mixture distribution, with a gamma-distributed mean. The seabird captures, y_i, during a group of n_i fishing events, were generated as

$$y_i \sim \text{Poisson}(n_i \mu_i \delta_i), \quad (1)$$
$$\delta_i \sim \text{Gamma}(n_i \theta, n_i \theta), \quad (2)$$

where μ_i is the mean capture rate for a single event in the group of fishing events i, δ_i is the overdispersion representing the effect of unknown processes on the variation of the mean capture rate, and $n_i\theta$ is both the shape and the rate of the gamma distribution, which has in this case a mean of 1.

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 areas in Figure 1),
- R: region ("north" or "south", with "north" being the region including the Kermadec Islands, West Coast North Island, east of North Island, and North East areas),
- S: season (period of four months, starting with January–April being considered as 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:

$$\mu_i = \alpha M_{m,v,i} F_i A_i R_i S_i Y_{m,v,y,i}, \quad (3)$$

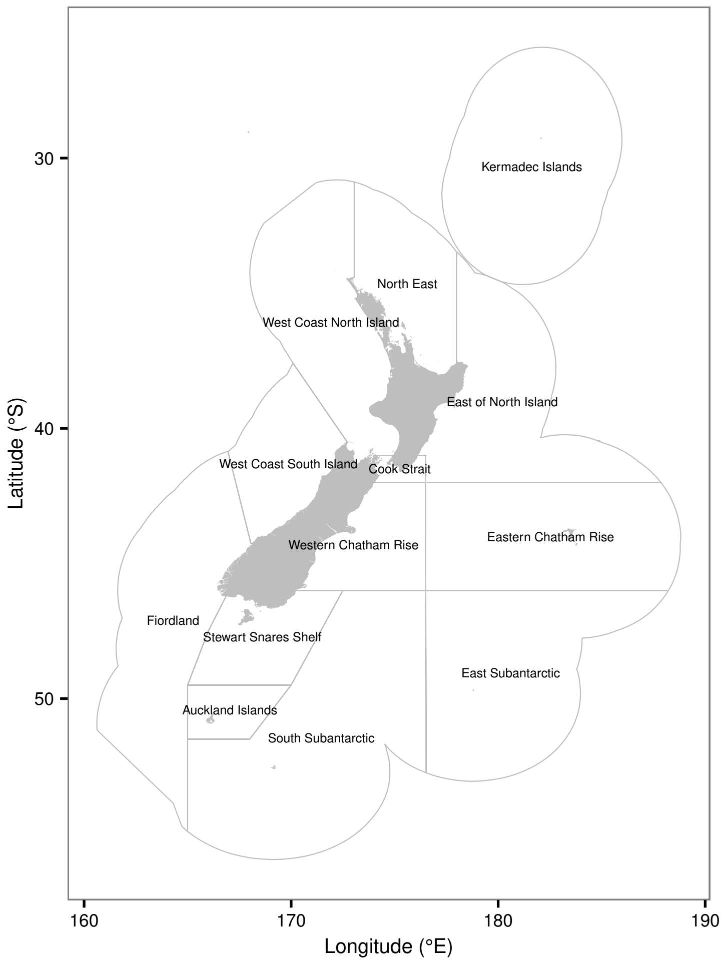
where α is the intercept, with a log-normal prior, defined with a mean of -3 and a standard deviation of 5 on the log scale.

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 1 for the base levels of these factors for each species). These fixed effects were assumed to follow a log-normal distribution, with a prior having a mean of 0 and a standard deviation of 5 on the log scale.

The effects of area, fishery, and year were modelled as random effects, assumed to follow 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 coefficient of variation (c.v.) of the random effect was drawn from an exponential distribution (the coefficient of variation of a gamma-distributed random variable with mean 1 is the inverse of the square-root of the shape). The rate of the exponential distribution was the same for all random effects, and had a uniform prior between 0.2 and 10.0. The exponential distribution was truncated at 5 to prevent extreme values and facilitate model stability.

Figure 1: Areas used for the estimation of the number of incidental captures of seabirds in New Zealand commercial fisheries.



A proportion of large-vessel bottom-longline fisheries used integrated weight lines as a mitigation measure to reduce the capture rate of seabirds. The integrated weight lines have an added lead core so that they sink faster, which minimises the time baited hooks are available to seabirds. The efficacy of line-weighting has been demonstrated during experimental trials (Robertson et al. 2006), and was previously found to significantly reduce capture rates in models used for estimating seabird captures (Abraham et al. 2016). To account for the use of integrated weight lines, the fisheries targeting ling were split into three different target fisheries, including small vessels, large vessels using integrated weight lines, and large vessels not using integrated weight lines. The other target fisheries were the same as those used by Abraham et al. (2016) in the previous assessment (see Table 2).

The models were coded in the BUGS (Bayesian inference Using Gibbs Sampling) language (Spiegelhalter et al. 2003), a domain-specific language for describing Bayesian models. Each model was fitted with the software package JAGS (Just Another Gibbs Sampler) (Plummer 2016), using Markov chain Monte Carlo(MCMC) methods (see Appendix A 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 and Welch (1983) and Geweke (1992). The models were run for 200 000 updates during burn-in, and then run for up to a further 540 000 updates, with every 400th sample retained for analysis (i.e., 1350 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, so that estimates may be unreliable. 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 1: 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	Summer
Buller's albatrosses	SLL - Large vessels	South	Summer
Other albatrosses	SLL - Large vessels	North	Summer
White-chinned petrel	Trawl - Large vessels	South	Summer
Black petrel	BLL - Small vessels	North	Summer
Grey petrel	BLL - Large vessels	South	Summer
Sooty shearwater	Trawl - Large vessels	South	Summer
Flesh-footed shearwater	SLL - Small vessels	North	Summer
Other birds	Trawl - Large vessels	South	Summer

Table 2: 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	2015	72 237	18 782	26.0
		Flatfish	2003	2012	136	0	0.0
		Hake	2003	2015	14 660	4 377	29.9
		Hoki	2003	2015	157 860	31 939	20.2
		Inshore	2003	2015	30 920	588	1.9
		Ling	2003	2015	10 100	1 693	16.8
		Mackerel	2003	2015	30 932	12 718	41.1
		Middle depths	2003	2015	40 429	8 822	21.8
		S. blue whiting	2003	2015	11 024	5 678	51.5
		Scampi	2003	2015	8 553	968	11.3
		Squid	2003	2015	63 642	20 387	32.0
	Small vessels	Deepwater	2003	2015	5 894	148	2.5
		Flatfish	2003	2015	263 376	1 612	0.6
		Hake	2003	2015	590	0	0.0
		Hoki	2003	2015	16 054	725	4.5
		Inshore	2003	2015	424 564	6 124	1.4
		Ling	2003	2015	5 421	106	2.0
		Mackerel	2003	2015	90	1	1.1
		Middle depths	2003	2015	60 621	657	1.1
		Scampi	2003	2015	50 373	3 922	7.8
		Squid	2003	2015	4 328	8	0.2
SLL	Large vessels	Albacore	2003	2003	231	225	97.4
		Bigeye	1999	2013	138	113	81.9
		Bluefin	1999	2015	4 357	3 827	87.8
	Small vessels	Albacore	1999	2014	4 017	32	0.8
		Bigeye	1999	2015	42 810	904	2.1
		Bluefin	1999	2015	16 927	893	5.3
		Minor species	1999	2015	1 558	41	2.6
		Swordfish	1999	2015	2 394	183	7.6
BLL	Large vessels	Minor species	1999	2015	356	135	37.9
		Bluenose	1999	2006	384	40	10.4
		Hāpuku	1999	2004	14	0	0.0
		Ling, with IWL	2003	2015	9 475	2 580	27.2
		Ling, no IWL	1999	2015	32 207	4 651	14.4
	Small vessels	Ling	1999	2015	48 284	781	1.6
		Minor species	1999	2015	28 187	329	1.2
		Bluenose	1999	2015	49 372	257	0.5
		Hāpuku	1999	2015	33 801	136	0.4
		Snapper	1999	2015	143 793	1 322	0.9

3. RESULTS

3.1 Observed seabird captures during the 2014–15 fishing year

During the 2014–15 fishing year, there were 684 observed seabird captures in trawl and longline fisheries that were included in the model dataset (Table 3). Of these captures, 345 were of dead birds, i.e., the seabirds were dead when they were brought onboard the vessel. The other captured birds were released alive, but their post-capture survival was unknown. Around half (50.4%) of the captured birds had their identity confirmed by a specialist, either from necropsy or from a photograph. The species that was most frequently observed caught was white-chinned petrel with 295 recorded captures, 43.1% of all observed seabird captures. Of the observed captures of white-chinned petrel, 219 captures were in squid trawl fisheries. Other species with more than ten observed captures were sooty shearwater, New Zealand white-capped albatross, Southern Buller's albatross, Salvin's albatross, and flesh-footed shearwater (Table 3).

Observed captures of these species (and the other 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*.

Table 3: Number of observed seabird captures during the 2014–15 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 on-board the vessel.

Common name	Scientific name	Captures	Confirmed	Dead
White-chinned petrel	*Procellaria aequinoctialis*	295	153	150
Sooty shearwater	*Puffinus griseus*	135	67	66
New Zealand white-capped albatross	*Thalassarche cauta steadi*	81	40	40
Southern Buller's albatross	*Thalassarche bulleri bulleri*	55	28	31
Salvin's albatross	*Thalassarche salvini*	46	27	26
Flesh-footed shearwater	*Puffinus carneipes*	17	8	9
Grey petrel	*Procellaria cinerea*	8	5	8
Mid-sized petrels & shearwaters	*Pterodroma*, *Procellaria*, and *Puffinus* spp.	6	0	0
Giant petrels	*Macronectes* spp.	5	0	0
Westland petrel	*Procellaria westlandica*	5	5	5
Common diving petrel	*Pelecanoides urinatrix*	5	3	1
Northern giant petrel	*Macronectes halli*	4	0	0
Black petrel	*Procellaria parkinsoni*	3	2	1
Grey-faced petrel	*Pterodroma macroptera gouldi*	3	0	0
Black-browed albatross	*Thalassarche melanophris*	3	3	3
Gibson's albatross	*Diomedea antipodensis gibsoni*	2	1	1
Fairy prion	*Pachyptila turtur*	2	0	0
Campbell black-browed albatross	*Thalassarche impavida*	2	1	1
Antarctic prion	*Pachyptila desolata*	2	0	0
New Zealand white-faced storm petrel	*Pelagodroma marina maoriana*	1	1	1
Buller's albatross	*Thalassarche bulleri*	1	0	0
Shearwaters	*Puffinus* spp.	1	0	0
Royal albatrosses	*Diomedea sanfordi* and *D. epomophora*	1	0	1
Cape petrel	*Daption capense*	1	1	1
Total		684	345	345

3.2 Estimation model fitting

Model diagnostics showed that there were occasional single chains that failed the convergence diagnostics, but there were no parameters where all chains failed this test (see Appendix C for diagnostics for each of the ten models, and details of each model by region, fishery, vessel size, area, and season strata). The half-width and autocorrelation tests showed that some parameters were poorly estimated in

* https://psc.dragonfly.co.nz/

some models, with some parameters failing the half-width test in all three chains. This outcome indicated that the mean values of these parameters were not accurately estimated by the model (an estimated accuracy in the mean value of two significant digits was required to pass the test). For example, for white-capped albatross, the estimated mean effect of small-vessel trawl was 1.05 (95% credible interval, c.i.: 0.53–2.07), and all three chains failed the half-width test (Appendix C, Table C-33). There was little autocorrelation in these chains; however, with a loss in the effective number of samples of 5.3% from autocorrelation.

The parameters that were most frequently poorly estimated in many of the models were the overdispersion parameters, particularly for species and fishing methods where there were few observed captures. For example, for grey petrel, the overdispersion parameter for trawl fisheries had poorly converged chains, with all three chains failing the half-width test (Appendix C, Table C-51), and a 98.1% reduction in the number of effective samples due to autocorrelation. In other cases, for example, sooty shearwater in trawl fisheries (Appendix C, Table C-54), the distribution of the overdispersion parameter was constrained by the prior, which had a uniform distribution between 0 and 10 on the coefficient of variation. In this case, the posterior distribution had a 95% credible interval of 9.62 to 9.95, at the top of the range permitted by the prior, and indicating there was evidence from the data that the overdispersion was outside the range of the prior.

Another diagnostic was the comparison between captures estimated on observed fishing and the observed captures (Appendix C). In general, the models fitted the observed data closely. For example, for white-capped albatross there were four strata (out of a total 577 strata) where the observed captures were outside the 95% credible interval of the estimated captures (see Appendix C, Figure C-33 and Table C-34). One of these strata was the large-vessel southern bluefin tuna fishery on the Stewart-Snares Shelf during the autumn quarter. In this stratum, there were 20 observed captures of white-capped albatross during 98 sets, compared with a model estimate of 5.05 (95% c.i.: 0–17) (Appendix C, Table C-34). The model with the highest number of strata with observed captures outside the 95% credible interval of the estimated captures was that of flesh-footed shearwater, with 15 such strata (Table C-56).

3.3 Estimated seabird captures

There was an estimated total of 4584 (95% c.i.: 3 935–5 477) seabirds captured during the 2014–15 fishing year, including 2095 (95% c.i.: 1 828–2 414) seabirds in trawl fisheries, 1927 (95% c.i.: 1 404–2 746) seabirds in bottom-longline fisheries, and 561 (95% c.i.: 386–838) 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 2014–15). White-chinned petrel had 868 (95% c.i.: 578–1 517) estimated captures during the 2014–15 fishing year, 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 estimated captures of over 500 birds during the 2014–15 fishing year were flesh-footed shearwater, Salvin's albatross, and the "other birds" group.

During the 2014–15 fishing year, seabird captures occurred in a wide range of fisheries – 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 year were: squid trawl fisheries, with 427 (95% c.i.: 396–489) estimated seabird captures; ling bottom-longline fisheries, with 690 (95% c.i.: 399–1268) estimated seabird captures; and southern bluefin tuna surface-longline fisheries, with 268 (95% c.i.: 167–465) estimated seabird captures.

For seven of the ten modelled species groups, the total number of estimated captures decreased between 2002–03 and 2014–15 (where the decrease was sufficient for the 95% c.i. of the estimated captures in 2014–15 to be below the mean estimated captures in 2002–03) (Figure 2). Only Salvin's albatross, white-chinned petrel and grey petrel did not show a clear decrease in total captures over this time period, and it was only for white-chinned petrel that the mean estimated captures in 2014–15 were higher than the mean estimated captures in 2002–03.

Table 4: Number of estimated captures (mean and 95% credible interval, c.i.) for each seabird species group in trawl, surface-longline (SLL), and bottom-longline (BLL) fisheries for the 2014–15 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	279	206–382	105	34–254	30	8–72	416	294–589
Salvin's albatross	412	287–590	5	1–13	140	44–345	559	386–818
Buller's albatrosses	110	76–164	111	55–219	39	14–81	260	183–381
Other albatrosses	34	15–64	110	58–200	116	51–228	262	170–397
White-chinned petrel	408	358–476	36	9–111	424	149–1 048	868	578–1 517
Black petrel	18	6–38	48	10–146	240	121–467	307	171–558
Grey petrel	8	5–19	26	8–66	204	67–531	239	98–571
Sooty shearwater	414	302–613	0	0–5	24	4–65	439	321–641
Flesh-footed shearwater	104	59–177	100	26–270	370	195–707	575	357–958
Other birds	303	202–461	16	5–35	335	203–548	655	475–912
All birds	2 095	1 828–2 414	561	386–838	1 927	1 404–2 746	4 584	3 935–5 477

Table 5: Number of estimated seabird captures in different trawl, bottom-longline (BLL), and surface-longline (SLL) target fisheries for the 2014–15 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	Squid	427	396–489
	Hoki	415	335–518
	Inshore	403	287–556
	Middle depths	360	256–538
	Flatfish	252	145–411
	Scampi	151	102–220
	Ling	43	22–74
	Mackerel	14	12–21
	Deepwater	13	5–24
	S. blue whiting	7	7–10
	Hake	5	3–10
BLL	Ling	690	399–1 268
	Snapper	559	387–801
	Minor species	289	129–620
	Hāpuku	210	76–548
	Bluenose	177	72–396
SLL	Bluefin	268	167–435
	Bigeye	146	68–303
	Swordfish	143	63–302
	Minor species	2	0–14

White-capped albatross and sooty shearwater had a high proportion of captures in large-vessel trawl fisheries, while white-chinned petrel had a high proportion of captures in both large-vessel trawl and large-vessel bottom-longline fisheries.

For many other species, the captures were predominantly in small-vessel fisheries. In the small-vessel fisheries, the models had no year effect. There were large declines in fishing effort in New Zealand trawl and surface-longline fisheries over the reporting period, and the declines in estimated captures largely followed 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 2014–15 was 69.8% and 47.3% of the effort in 2002–03, for small-vessel and large-vessel trawl fisheries, respectively. The number of hooks set in surface-longline fisheries in 2014–15 was 20.1% and 30% of the number of hooks set in 2014–15 for small-vessel and large-vessel fisheries, respectively (the decrease for surface-longline fisheries is only approximate, due to data confidentiality requirements). In bottom-longline fisheries, the change in effort was not as distinct, and the number of hooks set during 2014–15 was 127.5% and 78.2% 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 seabird captures, changes in capture rate (birds per unit effort) showed different patterns over time (Figure 3). Each of the species group models included random-year effects for fishing by large vessels. In large-vessel squid trawl fisheries, a decrease in albatross captures was evident following the introduction of mandatory warp mitigation. In these fisheries, the capture rate decreased by around 50%, from 7.6 (95% c.i.: 6.1–9.6) albatrosses per 100 tows in 2004–05 to 3.7 (95% c.i.: 3.5–4.2) albatrosses per 100 tows in 2014–15. In contrast, there was a considerable increase in the capture rate of petrels and other birds in the squid trawl fishery over the same period – from 5.1 (95% c.i.: 3.9–6.6) to 18.7 (95% c.i.: 21.1–17.4) birds per 100 tows. This increase was largely associated with an increase in the capture of white-chinned petrel, with the estimated capture rate of this species increasing from 1.89 (95% c.i.: 1.23–2.7) to 12.9 (95% c.i.: 11.9–15.3) birds per 100 tows over this period. White-chinned petrel were primarily caught in the net, and many were released alive. For example, during the 2014–15 fishing year, 55.2% of the 218 observed captures of white-chinned petrel in large-vessel squid trawl fisheries were released alive.

In hoki trawl fisheries, there was a marked decrease in the capture rate of albatrosses following the introduction of warp mitigation; however, since 2006–07 the estimated capture rate has increased (Figure 3). Since 2010–11, both the mean estimated capture rate and the observed capture rate of albatrosses in large-vessel hoki trawl fisheries have been over one bird per 100 tows. In large-vessel ling bottom-longline fisheries, there was a marked decrease in the capture rate of petrels and other birds in the years following the introduction of integrated weight line around 2001–02. Since then, the capture rate of petrels and other birds has fluctuated, with marked increases in 2012–13 and 2014–15 in both the observed and the estimated capture rates. Observer coverage in this fishery was extremely low during the 2014–15 fishing year, when only 2.5% of 14 million hooks were observed (see Appendix B, Table B-5). Capture rates in the large-vessel surface-longline fishery were variable. The lowest capture rate in this fishery was in 2012–13, before it increased again in 2013–14 and 2014–15. There were no clear trends in capture rates in the other fisheries.

Comparison of capture estimates across target fisheries (for fisheries with an annual mean number of 50 or more estimated captures) highlighted differences in the capture of individual species between fisheries (Figure 4). During 2014–15, white-chinned petrel was the species with the highest mean estimated captures in ling bottom-longline and squid trawl fisheries; flesh-footed shearwater had the highest estimated captures in snapper bottom-longline, minor-species bottom-longline and bigeye surface-longline fisheries; Salvin's albatross and sooty shearwater were the two species with the highest mean estimated captures in hoki trawl and middle-depths species trawl fisheries; Salvin's albatross was the species with highest mean estimated captures in inshore trawl fisheries; Buller's albatrosses (*Thalassarche bulleri*, combining both southern *T. b. bulleri* and northern *T. b. platei* subspecies) had the highest mean estimated captures in southern bluefin surface-longline fisheries; other birds was the species group with

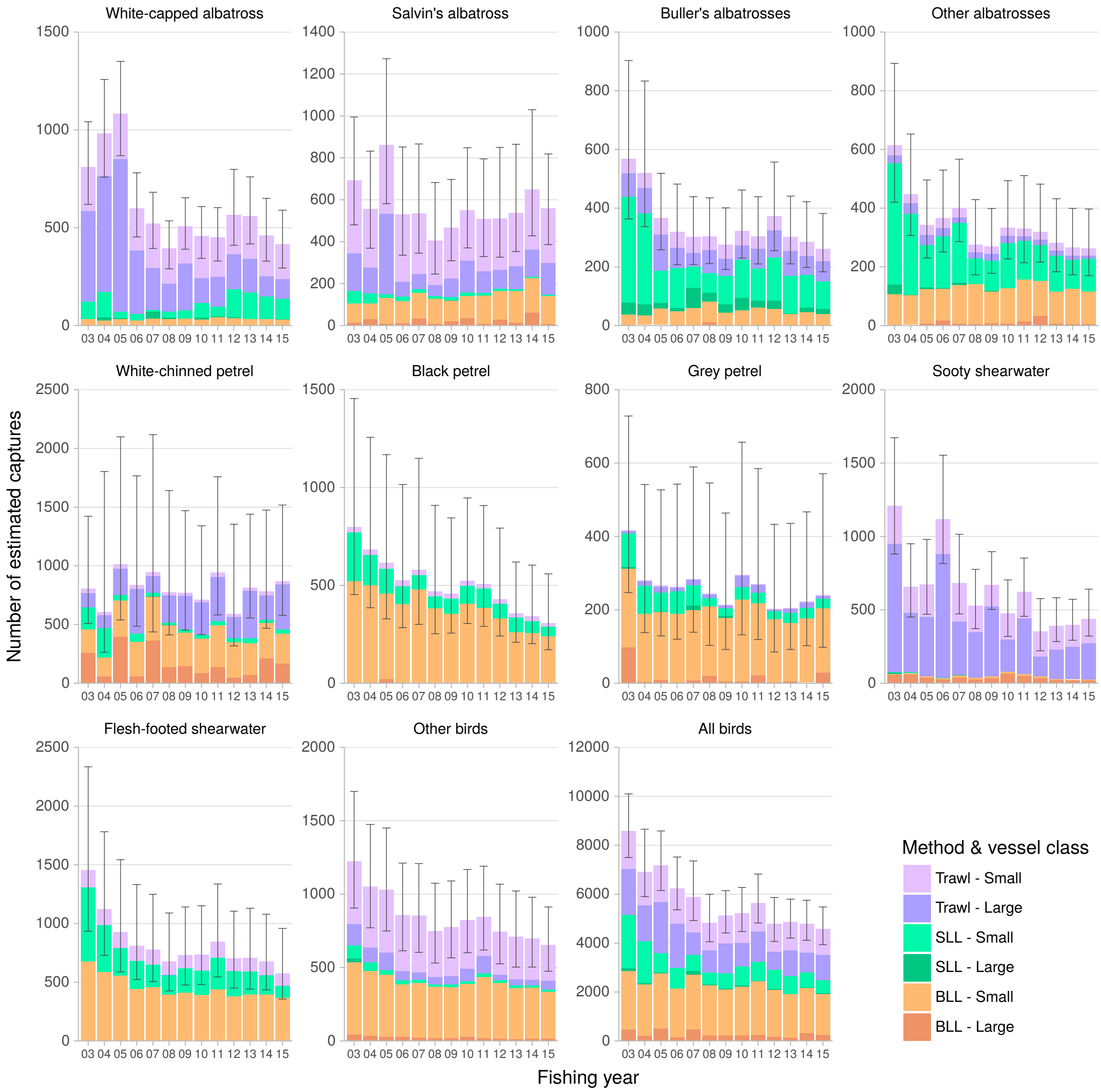


Figure 2: Time series of the number of estimated captures for the seabird species groups and for all birds for the 2002–03 to 2014–15 fishing years. Estimates are shown by fishing method and vessel size class. Cut-off lengths for small and large vessel size classes were 45 m, 34 m, and 28 m, for surface-longline (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.)

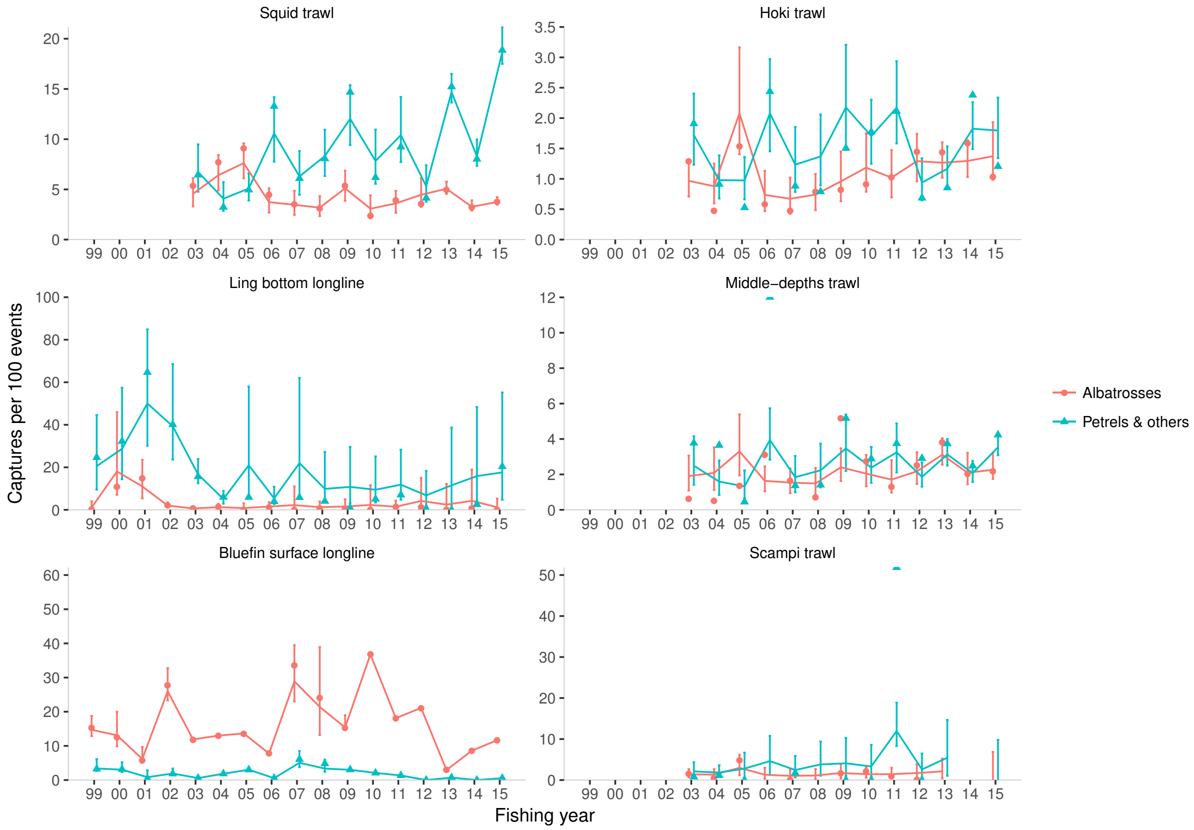


Figure 3: Capture rates (captures per 100 fishing events) of two seabird groupings in selected large-vessel fisheries, for fishing years between 2002–03 and 2014–15 for trawling, and between 1998–99 and 2014–15 for bottom and surface longlining. Cut-off lengths for the large vessel size class were 45 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, and symbols mark observed capture rates. Observed captures are not shown in years with fewer than ten capture events. (Note different y-axis scales.)

the highest estimated captures in flatfish trawl fisheries (observed seabird captures in flatfish trawl fisheries were of 32 spotted shags caught during a single tow, and four white-capped albatross); and black petrel was the species with the highest mean estimated captures in bluenose bottom-longline fisheries. Estimated captures of black petrel were also high in snapper bottom-longline fisheries.

The spatial distribution of estimated captures in 2014–15 also showed distinct patterns for each seabird species group across the different model areas (Figure 5). 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. Across all species, estimated seabird captures were highest in the north-eastern, Stewart-Snares, and Chatham Rise areas (Table 6). Captures in the north-eastern area were primarily in bottom-longline and, to a lesser extent, surface-longline fisheries, whereas captures at the Stewart-Snares Shelf were primarily in trawl fisheries, and captures in the Chatham Rise areas were in both trawl and bottom-longline fisheries.

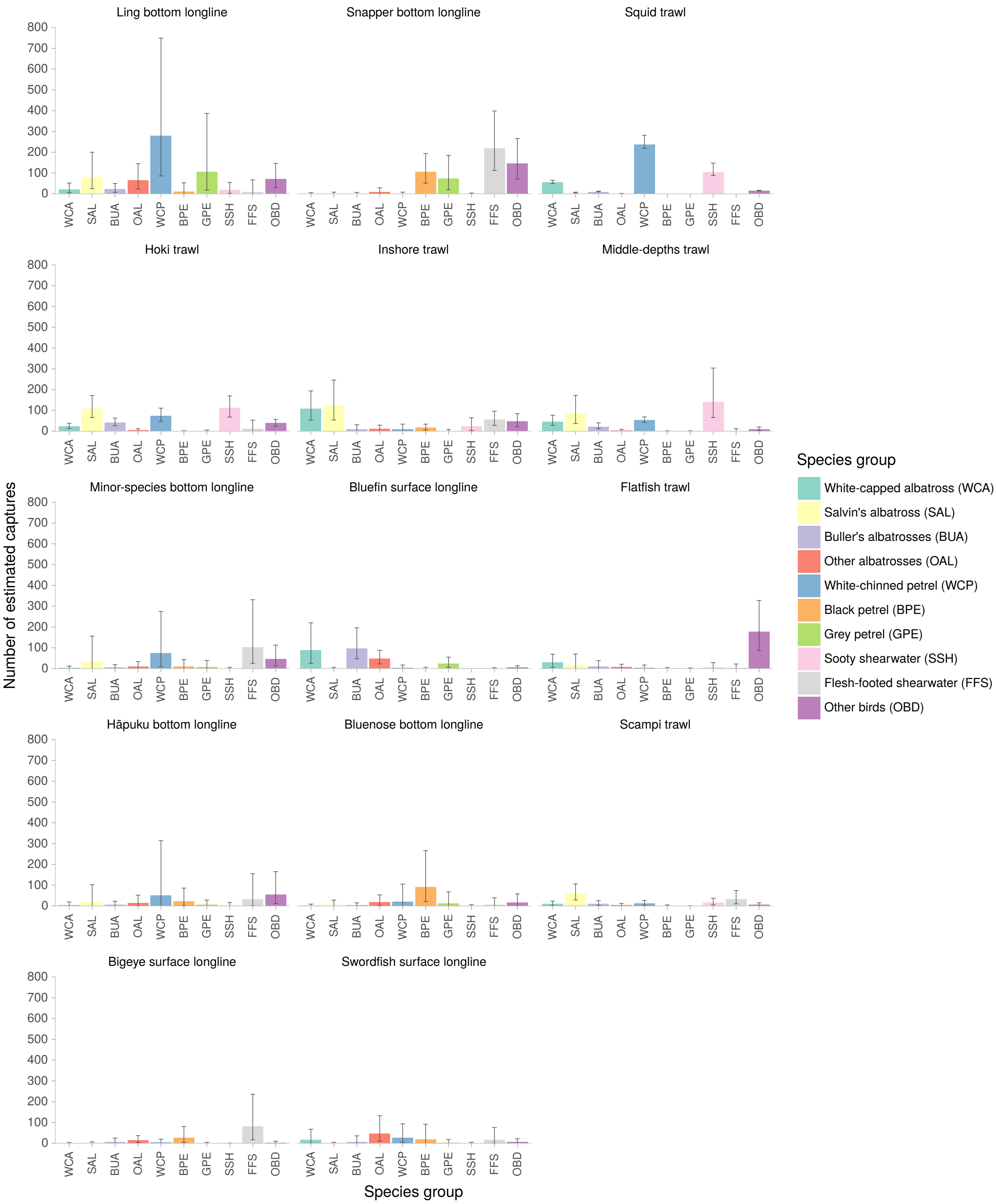


Figure 4: Number of estimated captures for the modelled seabird species groups for the 2014–15 fishing year. For each species group and fishery, the bars show mean captures and the 95% credible interval. Shown are only fisheries that were estimated to have caught a mean of more than 50 birds.

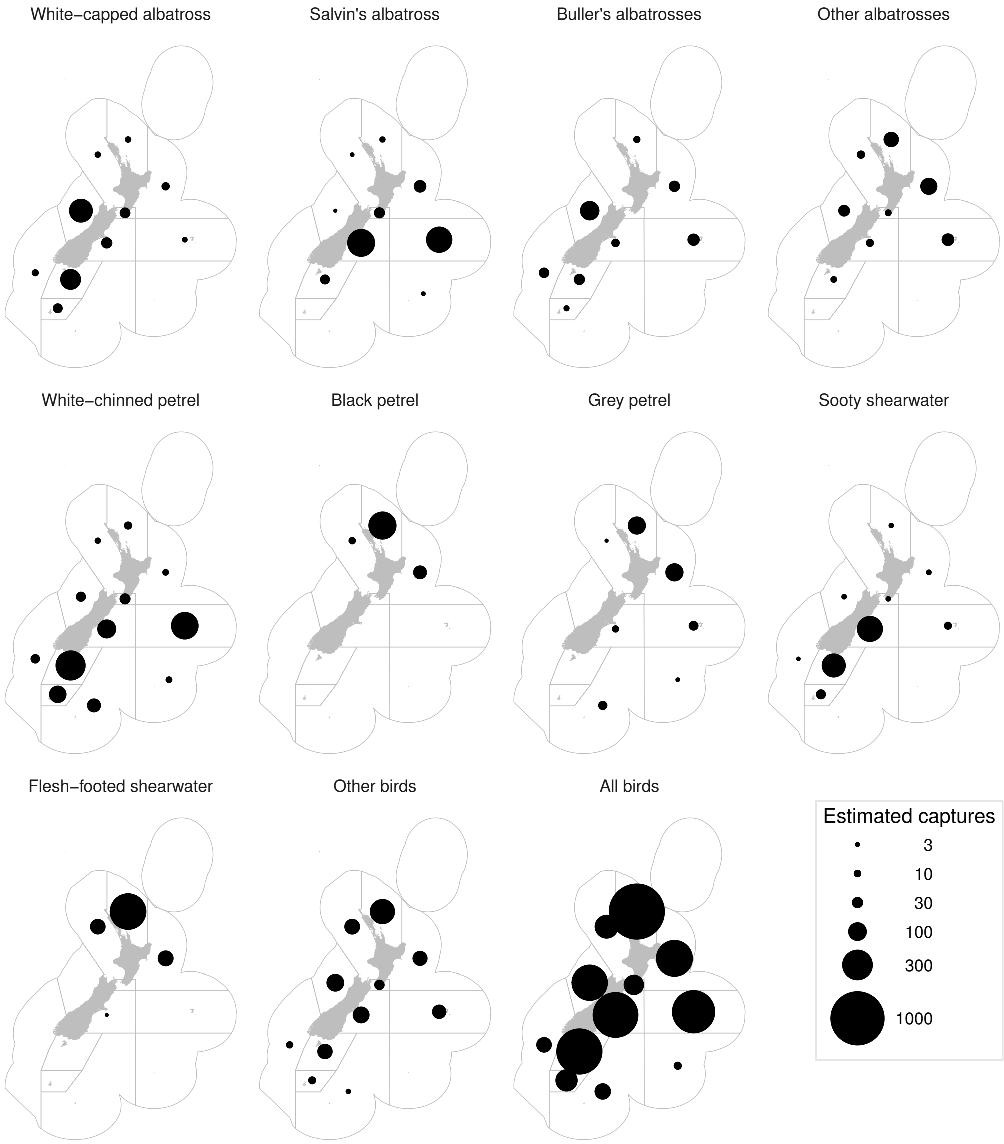


Figure 5: Estimated captures of seabird species groups by model area in the 2014–15 fishing year. For each of the modelled species groups, the size of the circles is proportional to the mean number of estimated captures in each of the model areas (mean estimated captures of fewer than one bird are not shown).

Table 6: Number of estimated seabird captures by model area and fishing method in the 2014–15 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	99	64–154	197	102–386	776	545–1 139	1 073	791–1 504
Stewart-Snares Shelf	668	596–759	0	0	45	5–205	714	617–889
Western Chatham Rise	548	398–770	0	0	152	69–318	700	510–959
Eastern Chatham Rise	213	157–291	0	0	407	220–804	621	414–1 011
East of North Island	109	66–172	109	63–180	229	113–461	447	295–694
West Coast South Island	169	120–236	205	103–390	55	28–99	431	300–630
West Coast North Island	52	26–91	24	7–65	95	48–187	173	102–287
Auckland Islands	148	124–190	0	0	0	0	148	124–190
Cook Strait	66	37–108	0	0	54	19–137	120	66–215
South Subantarctic	5	5–8	0	0	68	8–273	73	14–279
Fiordland	10	5–20	23	21–40	31	8–98	65	38–136
East Subantarctic	2	2–2	0	0	10	0–64	12	2–66
Kermadec Islands	0	0	0	0–5	0	0–1	0	0–6

4. DISCUSSION

4.1 Model framework

The modelling approach in the present study followed the framework developed by Abraham and 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 modelling approach simplified previous seabird capture 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 study, the models developed by Abraham and Richard (2017) were updated with data for the 2014–15 fishing year. For most species groups, the addition of new data did not substantially change the mean total capture estimates (Figure 6). An exception was the estimated captures of seabirds in small-vessel trawl fisheries. In all years, the mean estimates based on data to the 2014–15 fishing year were lower than (or close to) the lower credible interval of estimates from the model with data to the end of the 2013–14 year.

This reduction was in part due to changes in the classification of seabird captures, which resulted in a reduction in the number of observed captures of seabirds in the other birds species group in small-vessel trawl fisheries from 53 observed captures included in the analysis by Abraham and Richard (2017) to 40 observed captures of other birds in the current study (over the period from 2002–03 to 2013–14). There was focused observer effort on inshore trawl fisheries during 2014–15, with 2087 observed tows targeting inshore or flatfish fish species. This was an increase of 30% over the observed effort between 2002–03 and 2013–14. Year effects were not included in the models for small-vessel trawl fisheries, so adding observed fishing data from 2014–15 affected estimated captures across the entire time series.

When compared with the earlier modelling approach used by Abraham et al. (2016), the most notable change in estimates was in small-vessel bottom-longline fisheries. This change resulted from black petrel, flesh-footed shearwater, and grey petrel being separated from the other birds group. For grey petrel and other birds, the stratum with the highest number of estimated captures was snapper bottom-longline fishing in the north-eastern shelf during the winter quarter (July to September). There have been no observations in snapper bottom-longline fisheries during this period, so estimated captures depended strongly on the assumptions implied by the model structure.

The small-vessel bottom-longline fisheries also showed the largest discrepancy with the estimates of observable captures from the seabird risk assessment (Figure 6), reflecting the sensitivity of estimates of captures in poorly observed fisheries to the model assumptions. Overall, observer coverage in small-vessel bottom-longline fisheries has been low: a maximum observer coverage of 5% was achieved in 2013–14; however, in 2014–15, this coverage reduced to 1.5%. There were no observations of snapper bottom-longline fisheries during 2014–15. Improving observer coverage in the poorly-observed, small-vessel fisheries is essential for improving understanding of seabird captures in New Zealand fisheries.

There were some limitations in the model fitting; most notably, the convergence of the overdispersion parameters was poor. Ideally, there would be some sharing of information between the models for the different species so that the overdispersion for species and methods with few captures could be parameterised using information from species with more captures. The model framework, with independent species, does not allow for any correlation in the year effects between different species. It is possible that changes in fishing practice affect multiple species in the same way, or that environmental changes similarly affect multiple seabird species. Sharing information between the models may improve the estimation of the year effects, particularly for fishing methods and vessel size classes with low numbers of observations. The current model makes the assumption that all fishing by large vessels of each method within the same model have the same year effects. If any further model development is undertaken, it is recommended that the correlation of the year effects (between species, fisheries, and years) is explored. Ideally, this correlation structure could be learned within the model, rather than imposed as an assumption.

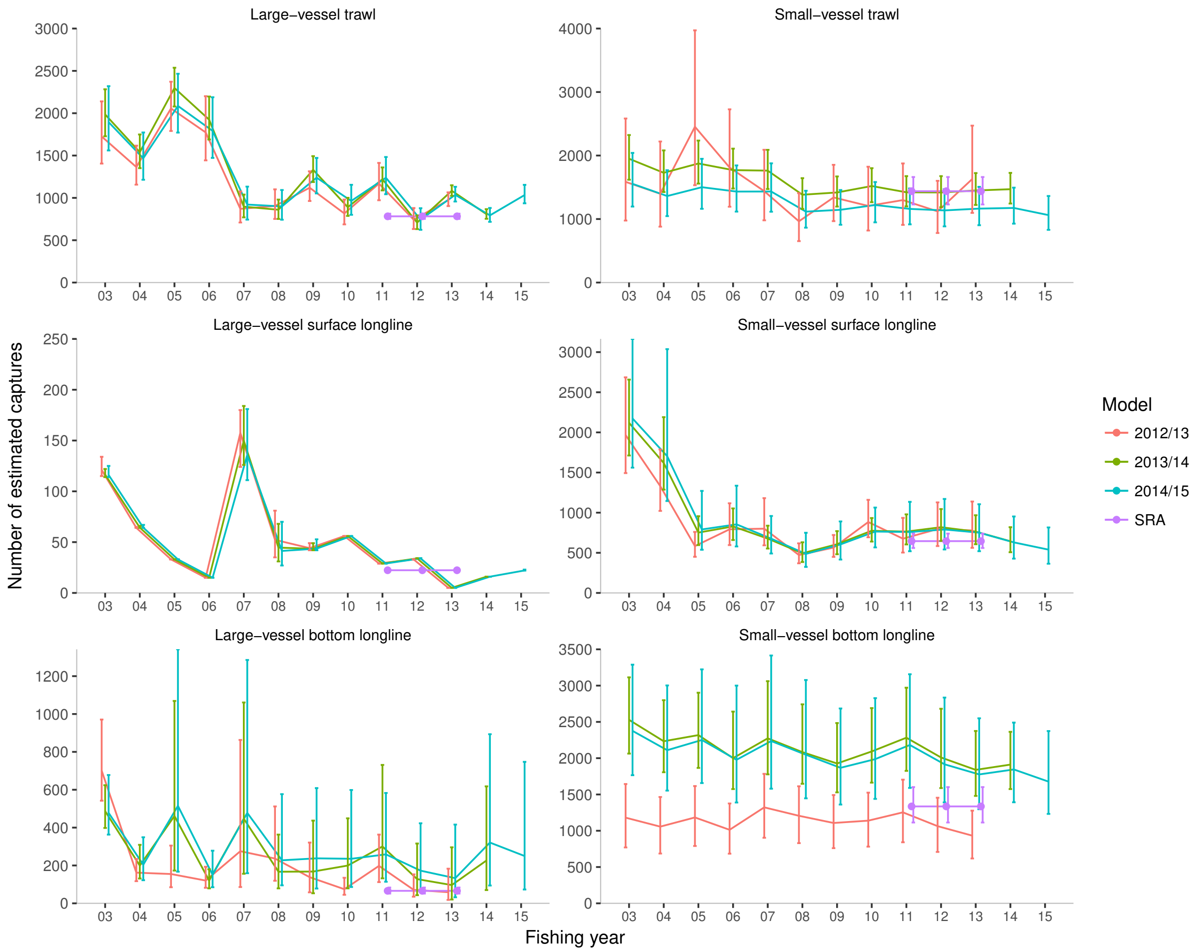


Figure 6: Comparison of the number of seabird captures estimated with four different statistical models. For each fishing method (trawl, surface longline, bottom longline) and vessel class, estimated captures are from the previous assessments of 2012–13 (Abraham et al. 2016), 2013–14 (Abraham & Richard 2017), this study (2014–15), and the seabird risk assessment (SRA; Richard & Abraham 2015). Estimates for the risk assessment were an average over the three fishing years 2010–11 to 2012–13. 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.)

The model framework used here was appropriate for estimating total seabird captures across trawl and longline fisheries and across all species. A different modelling approach could be used to explore the factors that are associated with seabird captures during observed fishing, as more data are available for observed fishing than for all fishing events. These data could be used, for example, to explore the effectiveness of warp mitigation in trawl fisheries, fishing by the full moon in surface-longline fisheries, or the seasonality of incidental captures of specific seabirds of interest. This modelling approach was taken previously (e.g., see Abraham et al. 2016), but the application of a consistent model structure across fisheries and species was considered preferable by MPI.

4.2 Reducing seabird captures

Mitigation measures are used to reduce seabird captures in fisheries. For longline fisheries, best-practice measures include the use of: line-weighting (to increase the sink rate of hooks so that the bait is available to seabirds for a shorter time); night-setting (when albatrosses are less active); and streamer lines that keep birds away from the area immediately behind the vessel (Agreement on the Conservation of Albatrosses and Petrels 2016b, 2016a). In New Zealand longline fisheries, streamer lines are currently required on all sets, and night-setting is required (unless the lines are weighted) (New Zealand Government 2010, Department of Internal Affairs 2014). On bottom-longline vessels, the discharge of offal is prohibited during setting and hauling, as during these times discharge is likely to attract seabirds to the fishing operation.

Integrated weight line (IWL) has been used by some large New Zealand bottom longliners from around 2003, following experiments by Robertson et al. (2006). Using observer data for the period between 2005–06 and 2014–15, the observed capture rate of all seabirds in large-vessel bottom-longline fisheries without IWL was 0.016 birds per 1000 hooks, compared with the observed capture of 0.003 birds per 1000 hooks in large-vessel bottom-longline fisheries using IWL.

For large-vessel bottom-longline fisheries targeting ling, the use of IWL was included in the estimation models by separating fishing with and without IWL into separate fisheries. For white-chinned petrel, large-vessel bottom-longline fishing without IWL had a relative effect of 2.82 (95% c.i.: 0.57–7.54), while fishing with IWL had a relative effect of 0.60 (95% c.i.: 0.09–1.79) (see Appendix C, Table C-45). From the mean effects, the capture rate of white-chinned petrel in large-vessel bottom longlining with IWL was estimated to be around 20% of the capture rate without the use of IWL. While IWL is effective, the use of IWL has not been made mandatory for large bottom-longline vessels fishing within New Zealand waters. In the years between 2005–06 and 2014–15, between 38% and 53% of hooks set by large bottom-longline vessels were set without IWL. In 2014–15, 47.5% of hooks in large-vessel bottom-longline fisheries were set without IWL. While line-weighting is also important for reducing seabird capture rates in small-vessel bottom-longline fisheries, there have been no data on line-weighting collected by observers on forms. Some information may be available from observer diaries, but these are not routinely entered into the observer database. A recent review of observer forms related to protected species captures recommended the use of new forms to collect detailed information on all mitigation, including line-weighting (Pierre et al. 2015), but these forms have not been implemented to date. For surface-longline fisheries, changes to observer forms are currently being implemented, including the recording of line-weighting (N. Walker, MPI, pers. comm.).

During 2014–15, no large surface-longline vessels began setting during the day (after nautical dawn and before nautical dusk). For small surface-longline vessels, 23.3% of the sets in the 2014–15 fishing year started during the day, at a time when albatrosses are expected to be active. A further 19.3% of sets were made during full moon (defined here as more than 90% illumination of the moon's disk), when albatrosses may still be active. For small- and large-vessel bottom-longline fishing in 2014–15, 48% and 56.8% of sets, respectively, were set during the day. Day-setting is permitted in surface-longline fisheries, provided that line-weighting is used. No information on line-weighting in surface-longline fisheries was available from the observer database.

Streamer lines are currently mandatory across all New Zealand longline fishing. Information on the use of streamer lines was recorded by observers on surface-longline vessels. During 2015, 57.7% of observed sets made by small-vessel surface longliners were recorded as not using streamer lines. In contrast, only one of 181 observed surface-longline sets made by large vessels were recorded as not using streamer lines.

During the 2014–15 fishing year, most observed seabird captures in large-vessel (28 m and over) trawl fisheries were net captures (81.2% of albatross and 97.5% of other bird captures, see https://data.dragonfly.co.nz/psc/). No effective mitigation of seabird net captures is generally available, although a net restrictor has been developed to reduce net captures in scampi trawl fisheries (Pierre et al. 2012).

In trawl fisheries a focus of seabird capture reduction has been on reducing birds captured on the trawl warps. During 2014–15 only 19 out of a total of 596 (3.0%) observed seabird captures in large-vessel trawl fisheries were on the warps. Large vessels (28 m or longer) must use one of three devices to reduce the number of seabirds that strike vessel warps: streamer lines, bird bafflers, or warp scarers (Department of Internal Affairs 2006). Experiments and observations in the squid trawl fishery found that streamer lines were the most effective of the three devices at reducing the number of birds striking the warps (Middleton & Abraham 2007, Abraham 2010). During the 2014–15 fishing year, 72.2% of observed tows by large vessels were made using a bird baffler only; 18.1% were made using both a streamer line and a bird baffler; 8.4% were made with streamer lines only; and 1.2% of observed tows were made with no warp mitigation recorded by the observers. The advantage of bird bafflers to fishers is that they can be set at the start of the trip, without needing to be set and deployed during each tow.

In small-vessel trawl fisheries, warp mitigation is not mandatory, and 44.8% of observed tows during 2014–15 were made without any warp mitigation. During the 2014–15 fishing year there were seven observed captures of albatrosses in small-vessel trawl fisheries, with three of those captures on trawl warps and four captures on tori lines. Between 2002–03 and 2014–15 there were 127 observed captures of albatross species in small-vessel trawl fisheries. Of these captures, 62.2% were on trawl warps, 27.6% were in the net, and 11 captures (8.6%) were on tori lines. Warp captures remain a significant source of seabird mortality during fishing by small trawl vessels, and it appears that there are risks associated with the tori lines themselves on these smaller vessels.

In trawl fisheries, the discharge of offal during fishing attracts birds to the vessel (Abraham et al. 2009). No routine information on offal discharge was available from the observer database, and the sporadic nature of offal discharge makes it difficult for observers to quantify this discharge.

Across New Zealand trawl and longline fisheries, the total number of captures of seabirds decreased between 2002–03 and 2014–15. This decrease was associated with a decline in fishing effort. Since the introduction of IWL in large-vessel bottom-longline fisheries (from 2002–03) and of mandatory warp mitigation in large-vessel trawl fisheries (from 2005–06 onwards), there has not been a consistent decrease in seabird capture rates in any of the large-vessel fisheries where a time series of capture rates was monitored. An increase in albatross capture rates was evident in hoki trawl fisheries, and there was an increase in the capture rate of petrels and other birds in squid trawl fisheries.

It is clear from data on mitigation use, that there are improvements that could be made to reduce seabird captures across all fishing methods. One of the challenges for increasing the uptake of mitigation measures is consideration of safety concerns for crew; for example, when line-weighting is implemented in longline fisheries. Furthermore, improvements to data collection by observers are necessary to understand the use of mitigation measures across New Zealand's fisheries. For example, there is no consistent recording of line-weighting, no recording of offal discharge during fishing by trawl vessels, or during setting and hauling by longline vessels, and no recording of the characteristics of streamer lines that could be used to determine how they conform to regulations. Detailed recommendations on improving observer data collection have been made previously (Pierre et al. 2015). Implementing these recommendations would provide much improved data on the use of mitigation, which in turn would support the management of seabird captures in New Zealand fisheries.

5. ACKNOWLEDGMENTS

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APPENDIX A: SEABIRD ESTIMATION MODEL JAGS CODE

Code for Bayesian estimation of seabird bycatch from fishing-effort data and observed captures. This code works with Just Another Gibbs Sampler (JAGS) version 4.2.0 (Plummer 2016).

```
model {
    # INTERCEPT
    log.beta.0 ~ dnorm(-3, 1/25)

    ## METHOD / VCLASS fixed effect
    log.beta.method[1,1] <-  0
    log.beta.method[1,2] ~  dnorm(0, 1/25)
    log.beta.method[2,1] ~  dnorm(0, 1/25)
    log.beta.method[2,2] ~  dnorm(0, 1/25)
    log.beta.method[3,1] ~  dnorm(0, 1/25)
    log.beta.method[3,2] ~  dnorm(0, 1/25)

    for (i in 1:3) {
        for (j in 1:2) {
            beta.method[i,j] <- exp(log.beta.method[i,j])
        }
    }

    ##  REGION fixed effect
    log.beta.region[1] <- 0
    log.beta.region[2] ~ dnorm(0, 1/25)
    for (i in 1:2){
        beta.region[i] <- exp(log.beta.region[i])
    }

    ##  SEASON fixed effect
    log.beta.season[1] <- 0
    for (s in 2 : 4) {
        log.beta.season[s] ~  dnorm(0, 1/25)
    }
    for (i in 1:4){
        beta.season[i] <- exp(log.beta.season[i])
    }

    # HYPERPRIOR
    alpha ~ dunif(0.2, 10)
    upper.cv <- 5

    ##  YEAR random effect for large vessels
    ##  YEAR constant for small vessels
    for (m in 1 : 3) {
        cv.eta.y[m] ~ dexp(alpha) T(, upper.cv)
        shape.eta.y[m] <- pow(cv.eta.y[m], -2)
        for (y in 1 : YEARS) {
            eta.y[m, y, 2-LARGEFIRST ] ~ dgamma(shape.eta.y[m], shape.eta.y[m])
            eta.y[m, y, LARGEFIRST+1 ] <- 1
        }
    }

    ##  FISHERY random effect
    cv.eta.f ~ dexp(alpha) T(, upper.cv)
    shape.eta.f <- pow(cv.eta.f, -2)
    for (f in 1 : FISHERIES) {
        eta.f[f] ~ dgamma(shape.eta.f, shape.eta.f)
    }

    ##  AREA random effect
    cv.eta.a ~ dexp(alpha) T(, upper.cv)
    shape.eta.a <- pow(cv.eta.a, -2)
    for (a in 1 : AREAS) {
        eta.a[a] ~ dgamma(shape.eta.a, shape.eta.a)
    }

    ##  EXAMPLE PRIOR random effect
    cv.eta.p ~ dexp(alpha) T(, upper.cv)
    shape.eta.p <- pow(cv.eta.p, -2)
    eta.p ~ dgamma(shape.eta.p, shape.eta.p)

    ##  OVERDISPERSION
    for (t in 1:3) {
        uniform.theta[t] ~ dunif(0.01, 0.99)
        theta[t] <- (1.0 / (1.0 - uniform.theta[t])) - 1.0
        cv.theta[t] <- pow(theta[t], -0.5)
    }
    for (k in 1: ROWS) {
        overdispersion[k] ~ dgamma(events[k] * theta[method[k]], events[k] * theta[method[k]]) T(1E-10,)
    }

    ##  COUNT predicted captures on groups of fishing events
    for (k in 1 : ROWS) {
        beta.method.k[k] <- beta.method[method[k], vclass[k]]
        beta.region.k[k] <- beta.region[nzhalf[k]]
        beta.season.k[k] <- beta.season[season[k]]
        eta.a.k[k] <- eta.a[area[k]]
        eta.f.k[k] <- eta.f[fishery[k]]
        eta.y.k[k] <- eta.y[method[k], year[k], vclass[k]]
        beta[k] <-  exp(log.beta.0) * beta.method.k[k] * beta.region.k[k] * beta.season.k[k]
        mustar[k] <- beta[k] * eta.y.k[k] * eta.f.k[k] * eta.a.k[k]
        count[k] ~ dpois(events[k] * overdispersion[k] * mustar[k])
    }
}
```

APPENDIX B: SUMMARIES OF CAPTURES BY SPECIES AND FISHERY

B.1 All bird captures

B.1.1 All bird captures in small-vessel bottom-longline fisheries

Table B-1: Annual fishing effort and number of hooks observed in small-vessel 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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	19 830 969	0.0	3	5.46	2 256	1 674–3 109	1.14	0.84–1.57
2003–04	19 879 853	1.1	11	0.50	2 011	1 484–2 832	1.01	0.75–1.42
2004–05	22 904 862	1.3	13	0.45	2 111	1 554–2 995	0.92	0.68–1.31
2005–06	22 257 310	0.7	12	0.76	1 859	1 329–2 717	0.84	0.60–1.22
2006–07	25 370 452	1.9	44	0.89	2 148	1 535–3 142	0.85	0.61–1.24
2007–08	27 377 199	1.7	18	0.38	1 925	1 371–2 826	0.70	0.50–1.03
2008–09	24 572 815	3.5	34	0.39	1 819	1 328–2 601	0.74	0.54–1.06
2009–10	26 835 631	3.7	48	0.48	1 893	1 381–2 661	0.71	0.51–0.99
2010–11	28 008 099	0.8	2	0.09	2 094	1 542–2 959	0.75	0.55–1.06
2011–12	26 313 256	0.3	6	0.71	1 874	1 361–2 777	0.71	0.52–1.06
2012–13	24 268 384	2.2	7	0.13	1 667	1 219–2 393	0.69	0.50–0.99
2013–14	24 417 104	5.0	57	0.47	1 563	1 173–2 103	0.64	0.48–0.86
2014–15	25 279 789	1.5	16	0.43	1 509	1 106–2 134	0.60	0.44–0.84

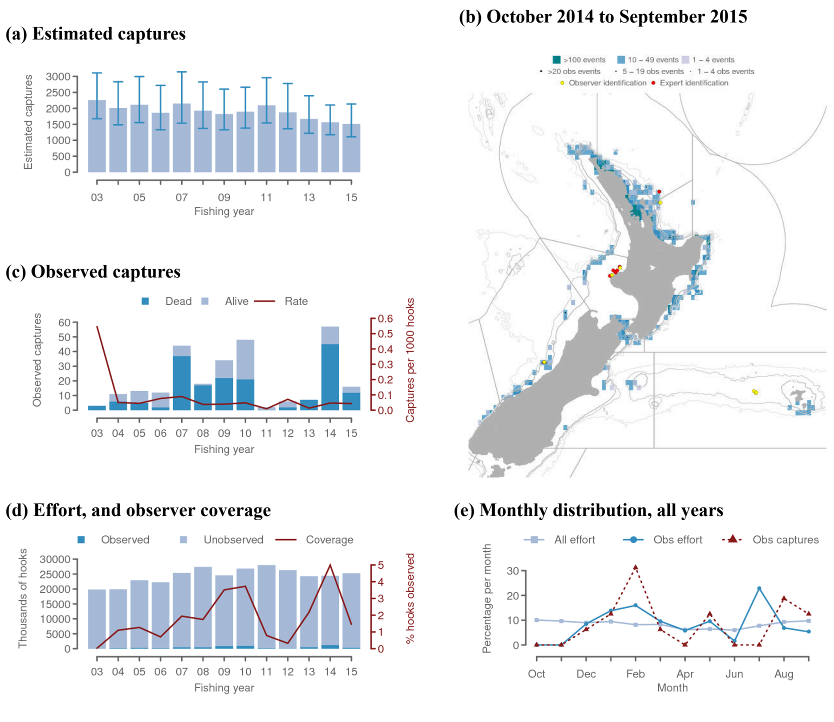


Figure B-1: Captures of all birds in small-vessel bottom-longline fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 97.9% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.1.2 All bird captures in small-vessel trawl fisheries

Table B-2: Annual fishing effort and number of tows observed in small-vessel 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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	75 956	0.5	1	0.26	1 554	1 196–2 042	2.05	1.57–2.69
2003–04	73 498	0.3	3	1.62	1 362	1 046–1 769	1.85	1.42–2.41
2004–05	76 275	0.2	6	4.72	1 501	1 161–1 949	1.97	1.52–2.56
2005–06	70 823	0.6	12	2.75	1 433	1 117–1 845	2.02	1.58–2.61
2006–07	68 109	1.0	32	4.66	1 434	1 115–1 878	2.11	1.64–2.76
2007–08	56 761	1.3	11	1.46	1 117	864–1 446	1.97	1.52–2.55
2008–09	57 572	4.5	87	3.34	1 146	910–1 457	1.99	1.58–2.53
2009–10	63 383	2.9	23	1.24	1 221	948–1 583	1.93	1.50–2.50
2010–11	58 693	2.3	53	3.88	1 160	916–1 482	1.98	1.56–2.53
2011–12	58 828	1.6	21	2.22	1 136	884–1 470	1.93	1.50–2.50
2012–13	59 870	1.0	7	1.20	1 164	903–1 507	1.94	1.51–2.52
2013–14	59 454	3.3	25	1.26	1 175	927–1 495	1.98	1.56–2.51
2014–15	53 075	4.3	22	0.96	1 062	830–1 363	2.00	1.56–2.57

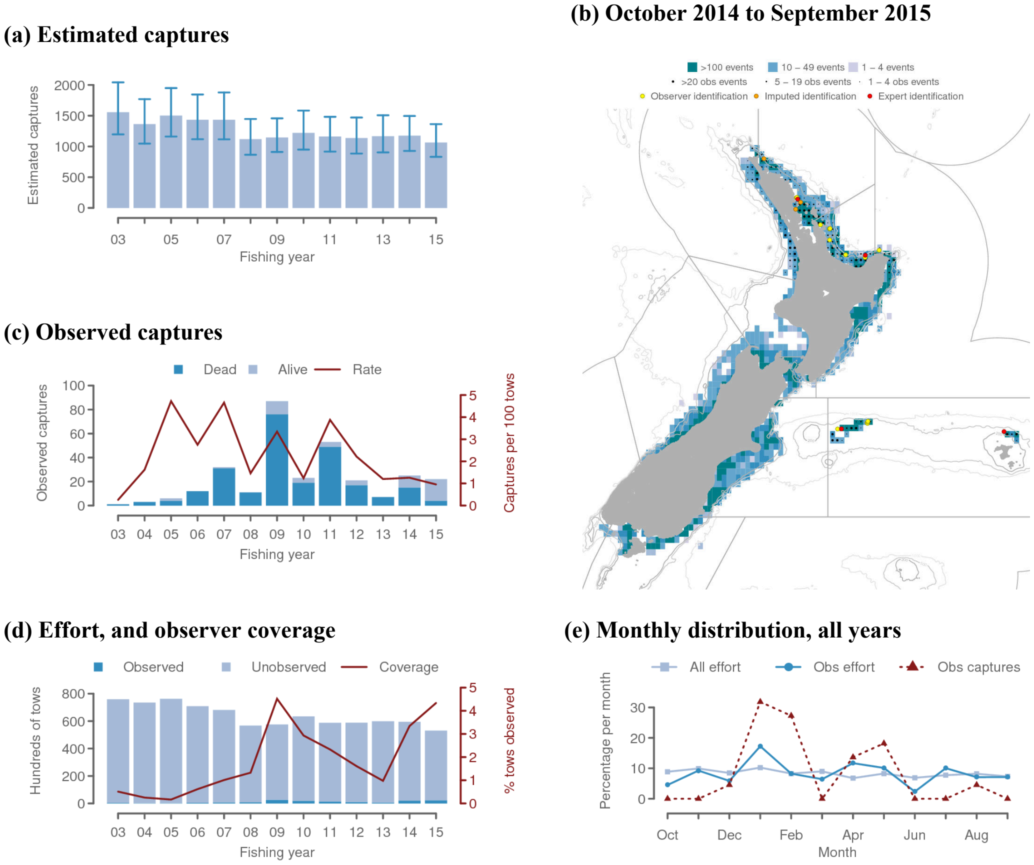


Figure B-2: Captures of all birds in small-vessel trawl fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.1.3 All bird captures in large-vessel trawl fisheries

Table B-3: Annual fishing effort and number of tows observed in large-vessel 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, c.i.).

		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	1 895	1 560–2 320	3.50	2.88–4.28
2003–04	47 339	13.4	248	3.90	1 468	1 214–1 773	3.10	2.56–3.75
2004–05	44 156	17.2	428	5.64	2 086	1 771–2 466	4.72	4.01–5.58
2005–06	39 121	15.8	333	5.39	1 792	1 472–2 189	4.58	3.76–5.60
2006–07	35 188	20.6	176	2.43	921	743–1 133	2.62	2.11–3.22
2007–08	32 766	25.3	221	2.66	899	742–1 093	2.74	2.26–3.34
2008–09	29 978	24.7	373	5.04	1 239	1 053–1 472	4.13	3.51–4.91
2009–10	29 506	26.0	241	3.14	964	800–1 155	3.27	2.71–3.91
2010–11	27 393	22.7	332	5.34	1 238	1 043–1 483	4.52	3.81–5.41
2011–12	25 593	32.8	226	2.69	744	623–878	2.91	2.43–3.43
2012–13	23 972	49.3	710	6.01	1 036	957–1 131	4.32	3.99–4.72
2013–14	25 660	43.7	455	4.06	793	717–881	3.09	2.79–3.43
2014–15	25 621	44.1	597	5.29	1 033	936–1 154	4.03	3.65–4.50

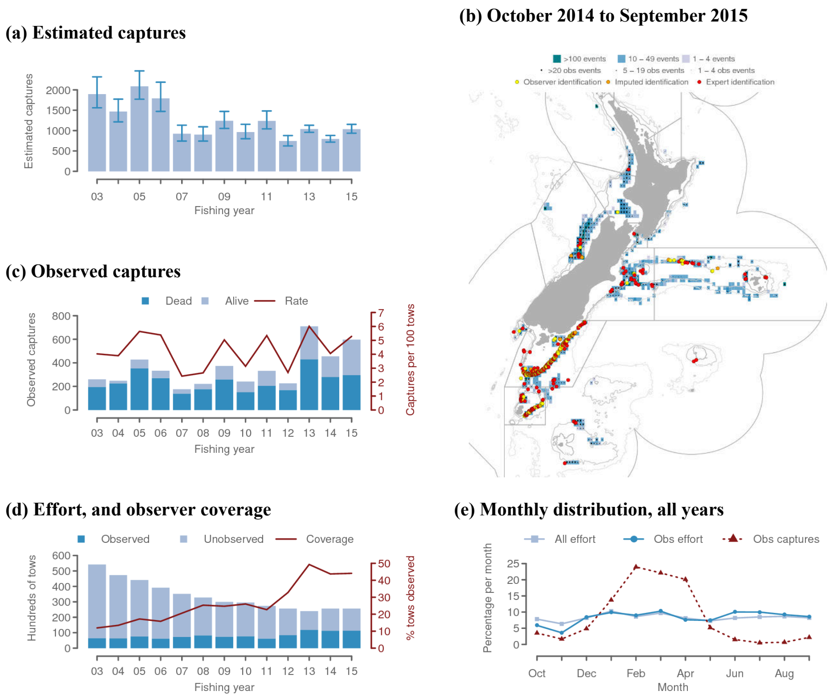


Figure B-3: Captures of all birds in large-vessel trawl fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 97.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.1.4 All bird captures in small-vessel surface-longline fisheries

Table B-4: Annual fishing effort and number of hooks observed in small-vessel 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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	8 572 516	0.0	0	.	2 147	1 541–3 129	2.50	1.80–3.65
2003–04	5 730 239	2.4	7	0.52	1 562	1 092–2 443	2.73	1.91–4.26
2004–05	3 041 381	4.7	8	0.56	791	538–1 271	2.60	1.77–4.18
2005–06	3 027 229	3.2	22	2.26	841	571–1 321	2.78	1.89–4.36
2006–07	2 332 813	8.1	76	4.04	660	477–941	2.83	2.04–4.03
2007–08	1 677 854	8.1	13	0.95	486	324–750	2.90	1.93–4.47
2008–09	2 306 403	6.5	15	0.99	605	416–891	2.62	1.80–3.86
2009–10	2 516 706	7.7	89	4.57	765	567–1 064	3.04	2.25–4.23
2010–11	2 684 809	6.4	18	1.05	759	519–1 135	2.83	1.93–4.23
2011–12	2 548 837	6.8	31	1.79	790	541–1 171	3.10	2.12–4.59
2012–13	2 389 412	3.0	22	3.02	751	520–1 105	3.14	2.18–4.62
2013–14	1 896 434	6.8	20	1.55	630	427–953	3.32	2.25–5.03
2014–15	1 784 936	6.0	16	1.50	539	364–816	3.02	2.04–4.57

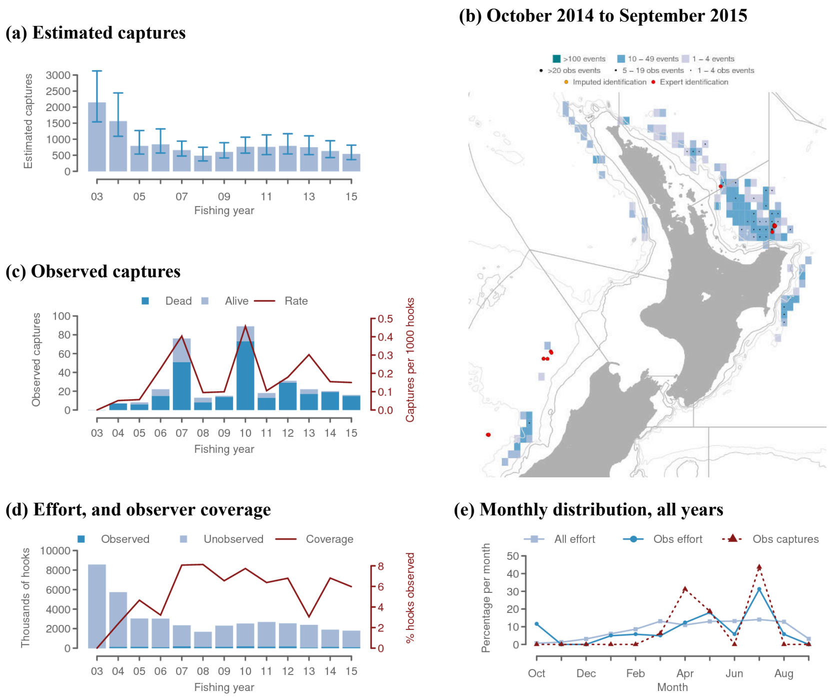


Figure B-4: Captures of all birds in small-vessel surface-longline fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 95.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.1.5 All bird captures in large-vessel bottom-longline fisheries

Table B-5: Annual fishing effort and number of hooks observed in large-vessel 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, c.i.).

		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	594	445–860	0.331	0.248–0.480
2003–04	23 347 151	20.7	46	0.095	303	189–526	0.130	0.081–0.225
2004–05	18 932 296	13.7	17	0.066	655	275–1 487	0.346	0.145–0.785
2005–06	14 888 123	24.5	29	0.080	270	147–539	0.181	0.099–0.362
2006–07	12 759 288	14.3	14	0.077	566	219–1 409	0.444	0.172–1.104
2007–08	14 123 096	21.9	22	0.071	350	167–804	0.248	0.118–0.569
2008–09	12 870 071	24.8	5	0.016	286	113–668	0.222	0.088–0.519
2009–10	13 607 740	12.6	10	0.058	328	148–738	0.241	0.109–0.542
2010–11	12 914 717	11.8	18	0.118	346	173–718	0.268	0.134–0.556
2011–12	11 560 277	17.5	4	0.020	214	93–476	0.185	0.080–0.412
2012–13	8 240 515	3.3	0	0.000	242	115–550	0.294	0.140–0.667
2013–14	16 482 357	11.6	46	0.240	603	317–1 219	0.366	0.192–0.740
2014–15	14 021 683	2.5	11	0.308	418	196–938	0.298	0.140–0.669

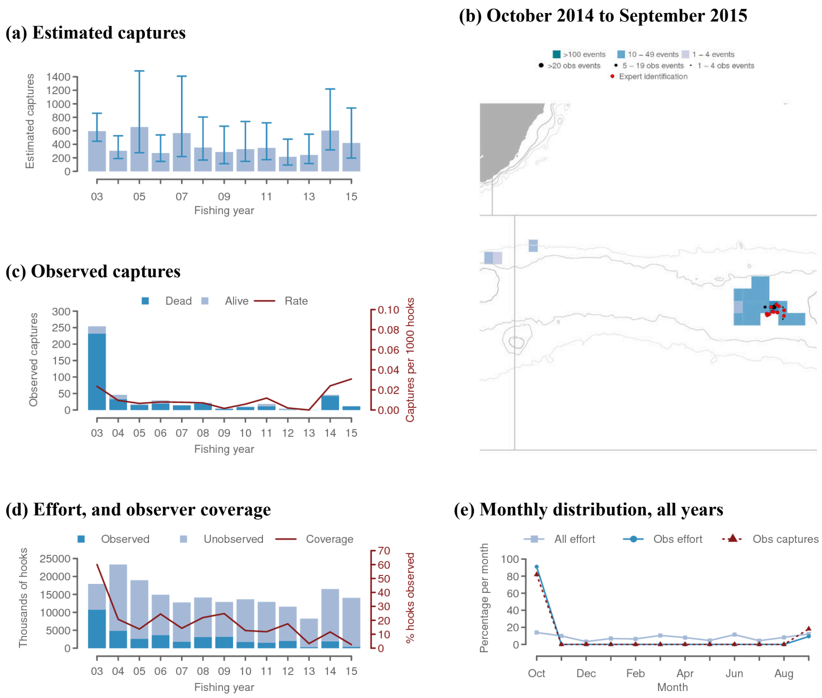


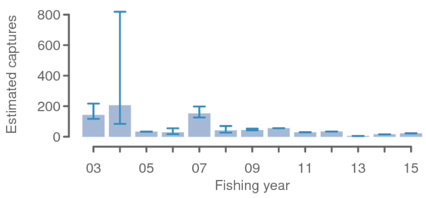
Figure B-5: Captures of all birds in large-vessel bottom-longline fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 75.1% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.1.6 All bird captures in large-vessel surface-longline fisheries

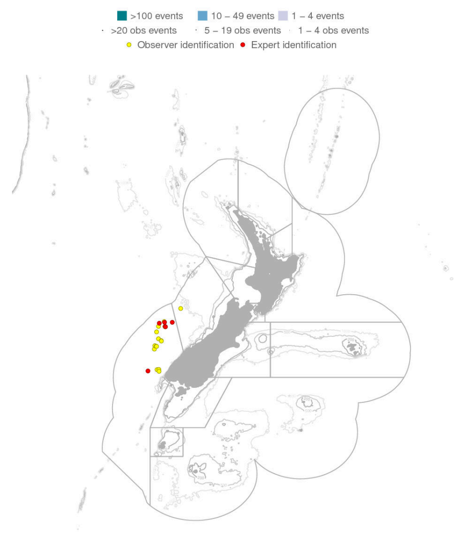
Table B-6: Annual fishing effort and number of hooks observed in large-vessel surface-longline fisheries, number of observed captures of all birds and observed capture rate (captures per thousand hooks), estimated captures and capture rate of all birds (mean and 95% credible interval, c.i.). Dots indicate values that are not shown following confidentiality rules.

		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	143	117–217	0.65	0.53–0.99
2003–04	1 655 920	88.9	64	0.43	206	84–819	1.24	0.51–4.95
2004–05	.	.	33	0.51	33	33–33	.	.
2005–06	.	.	15	0.25	28	17–55	.	.
2006–07	1 407 149	60.6	111	1.30	153	126–198	1.09	0.90–1.41
2007–08	.	.	24	0.84	41	27–70	.	.
2008–09	.	.	42	0.53	44	42–53	.	.
2009–10	.	.	56	1.17	56	56–56	.	.
2010–11	.	.	29	0.58	29	29–29	.	.
2011–12	.	.	34	0.61	34	34–34	.	.
2012–13	.	.	5	0.10	5	5–5	.	.
2013–14	.	.	16	0.24	16	16–16	.	.
2014–15	.	.	22	0.36	22	22–23	.	.

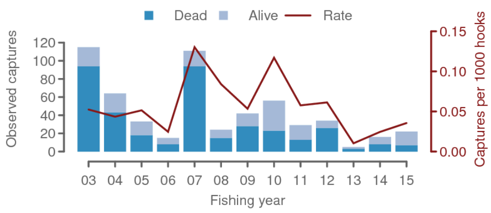
(a) Estimated captures



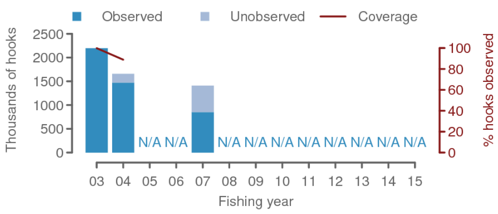
(b) October 2014 to September 2015



(c) Observed captures



(d) Effort, and observer coverage



(e) Monthly distribution, all years

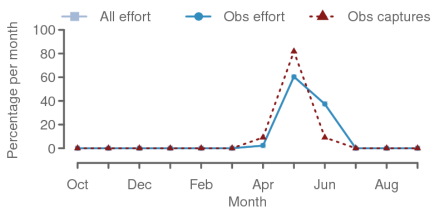


Figure B-6: Captures of all birds in large-vessel surface-longline fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 0.5% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, values that are not shown following confidentiality rules are indicated by 'N/A', 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 trawl fisheries

Table B-7: Annual fishing effort and number of tows observed in large-vessel 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, c.i.).

		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	80	1.24	463	334–635	0.85	0.62–1.17
2003–04	47 339	13.4	138	2.17	593	443–788	1.25	0.94–1.66
2004–05	44 156	17.2	213	2.81	782	606–1 006	1.77	1.37–2.28
2005–06	39 121	15.8	64	1.04	323	228–450	0.83	0.58–1.15
2006–07	35 188	20.6	48	0.66	212	148–303	0.60	0.42–0.86
2007–08	32 766	25.3	42	0.51	141	98–202	0.43	0.30–0.62
2008–09	29 978	24.7	80	1.08	241	179–323	0.80	0.60–1.08
2009–10	29 506	26.0	32	0.42	127	85–185	0.43	0.29–0.63
2010–11	27 393	22.7	41	0.66	153	105–216	0.56	0.38–0.79
2011–12	25 593	32.8	59	0.70	177	128–243	0.69	0.50–0.95
2012–13	23 972	49.3	131	1.11	171	152–195	0.71	0.63–0.81
2013–14	25 660	43.7	70	0.62	104	87–125	0.41	0.34–0.49
2014–15	25 621	44.1	73	0.65	102	88–122	0.40	0.34–0.48

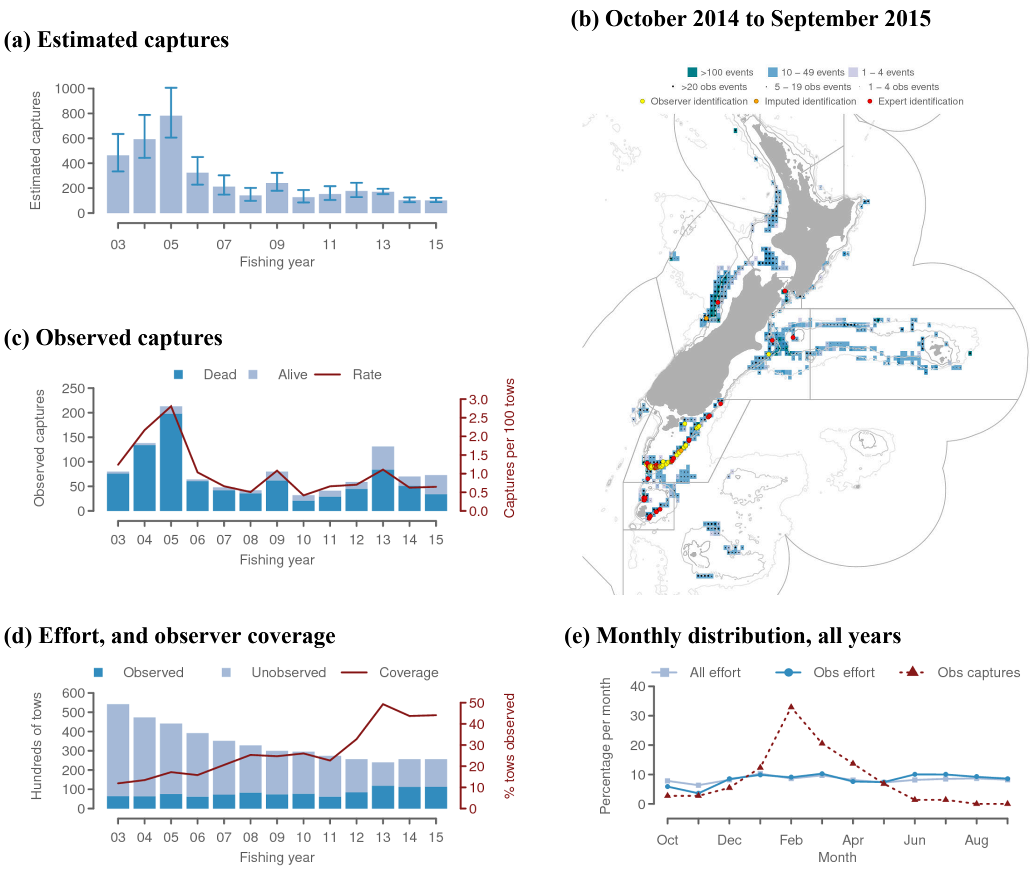


Figure B-7: White-capped albatross captures in large-vessel trawl fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 97.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.2.2 White-capped albatross captures in small-vessel trawl fisheries

Table B-8: Annual fishing effort and number of tows observed in small-vessel 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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	75 956	0.5	0	0.00	225	136–348	0.30	0.18–0.46
2003–04	73 498	0.3	0	0.00	218	129–342	0.30	0.18–0.47
2004–05	76 275	0.2	0	0.00	231	138–358	0.30	0.18–0.47
2005–06	70 823	0.6	0	0.00	216	129–333	0.30	0.18–0.47
2006–07	68 109	1.0	6	0.87	227	136–349	0.33	0.20–0.51
2007–08	56 761	1.3	0	0.00	180	106–281	0.32	0.19–0.50
2008–09	57 572	4.5	10	0.38	188	117–285	0.33	0.20–0.50
2009–10	63 383	2.9	9	0.48	216	133–332	0.34	0.21–0.52
2010–11	58 693	2.3	2	0.15	201	121–313	0.34	0.21–0.53
2011–12	58 828	1.6	10	1.06	202	124–312	0.34	0.21–0.53
2012–13	59 870	1.0	5	0.86	218	132–337	0.36	0.22–0.56
2013–14	59 454	3.3	4	0.20	209	127–322	0.35	0.21–0.54
2014–15	53 075	4.3	0	0.00	178	106–280	0.34	0.20–0.53

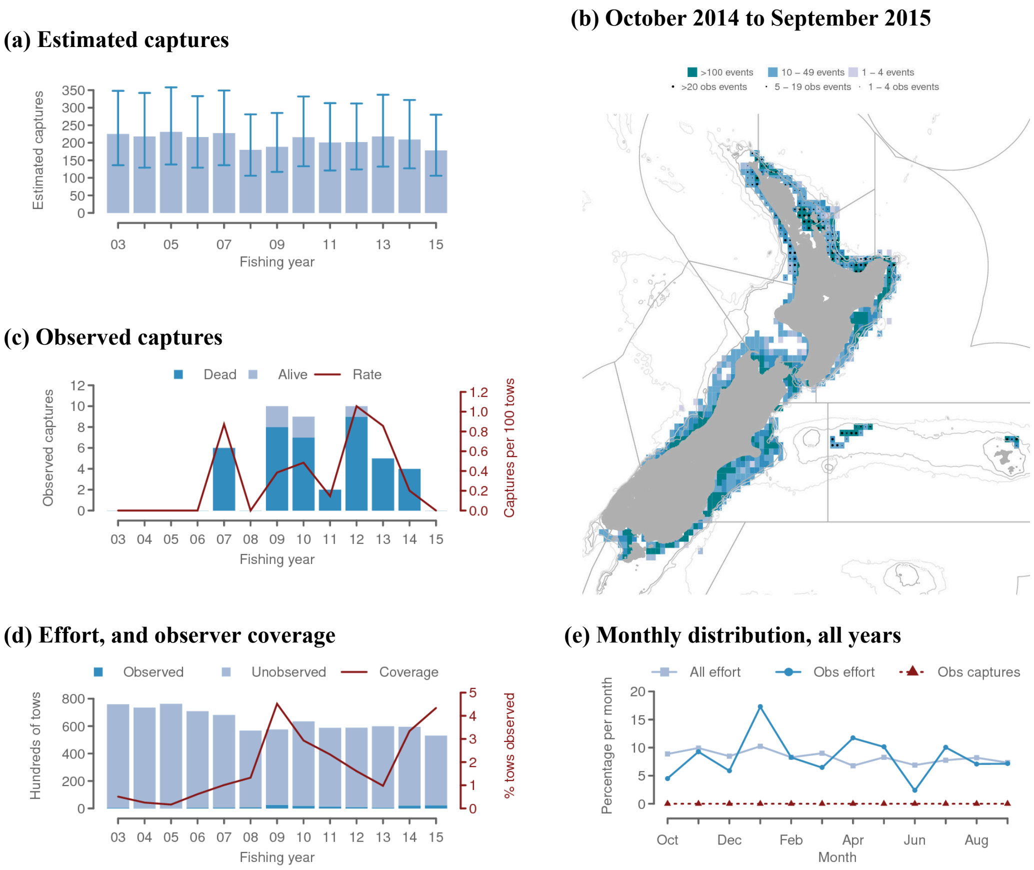


Figure B-8: White-capped albatross captures in small-vessel trawl fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.2.3 White-capped albatross captures in small-vessel surface-longline fisheries

Table B-9: Annual fishing effort and number of hooks observed in small-vessel 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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	8 572 516	0.0	0	.	80	28–189	0.09	0.03–0.22
2003–04	5 730 239	2.4	1	0.07	121	41–284	0.21	0.07–0.50
2004–05	3 041 381	4.7	0	0.00	32	7–88	0.11	0.02–0.29
2005–06	3 027 229	3.2	1	0.10	32	8–91	0.11	0.03–0.30
2006–07	2 332 813	8.1	1	0.05	9	2–24	0.04	0.01–0.10
2007–08	1 677 854	8.1	1	0.07	33	6–96	0.20	0.04–0.57
2008–09	2 306 403	6.5	1	0.07	41	10–116	0.18	0.04–0.50
2009–10	2 516 706	7.7	23	1.18	74	37–149	0.29	0.15–0.59
2010–11	2 684 809	6.4	0	0.00	50	12–131	0.19	0.04–0.49
2011–12	2 548 837	6.8	1	0.06	144	44–355	0.56	0.17–1.39
2012–13	2 389 412	3.0	10	1.37	135	49–302	0.56	0.21–1.26
2013–14	1 896 434	6.8	7	0.54	113	37–269	0.60	0.20–1.42
2014–15	1 784 936	6.0	4	0.37	103	31–252	0.58	0.17–1.41

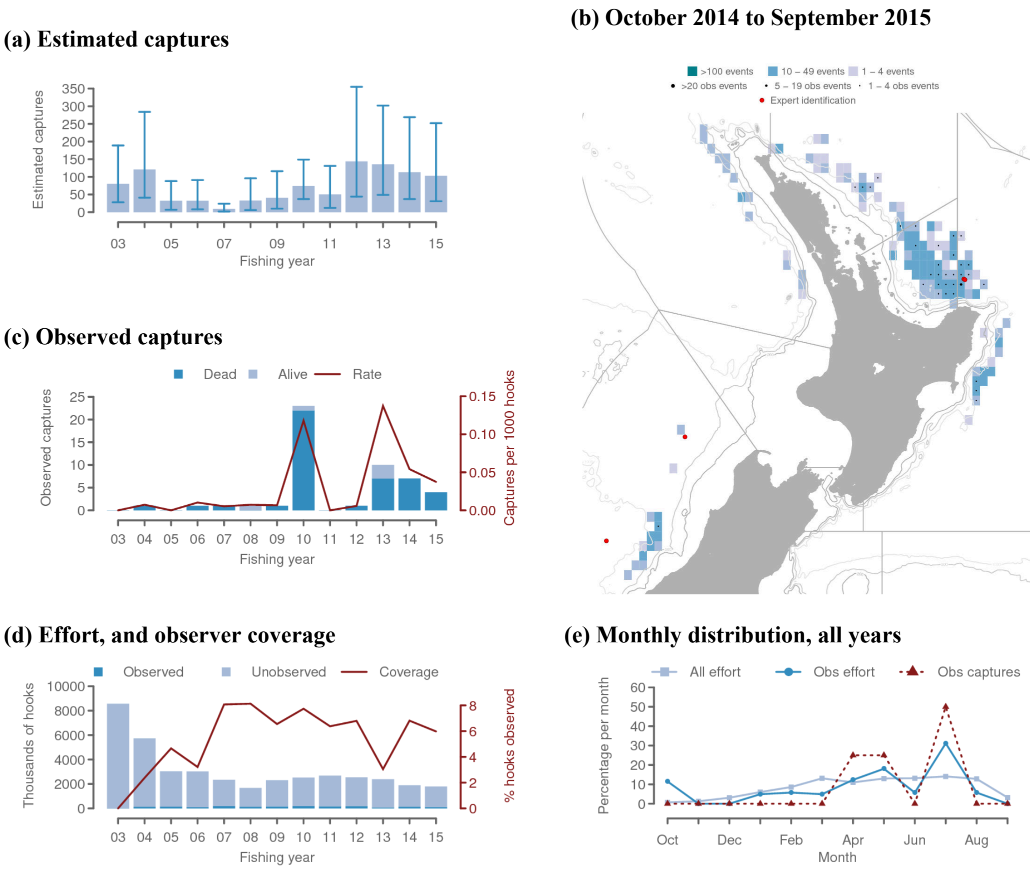


Figure B-9: White-capped albatross captures in small-vessel surface-longline fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 95.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.3 Salvin's albatross captures

B.3.1 Salvin's albatross captures in small-vessel trawl fisheries

Table B-10: Annual fishing effort and number of tows observed in small-vessel 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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	75 956	0.5	1	0.26	348	190–589	0.46	0.25–0.78
2003–04	73 498	0.3	3	1.62	279	148–483	0.38	0.20–0.66
2004–05	76 275	0.2	2	1.57	328	184–554	0.43	0.24–0.73
2005–06	70 823	0.6	1	0.23	320	178–537	0.45	0.25–0.76
2006–07	68 109	1.0	2	0.29	288	164–479	0.42	0.24–0.70
2007–08	56 761	1.3	4	0.53	211	117–354	0.37	0.21–0.62
2008–09	57 572	4.5	24	0.92	242	144–393	0.42	0.25–0.68
2009–10	63 383	2.9	10	0.54	240	134–400	0.38	0.21–0.63
2010–11	58 693	2.3	4	0.29	249	140–417	0.42	0.24–0.71
2011–12	58 828	1.6	4	0.42	244	138–407	0.41	0.23–0.69
2012–13	59 870	1.0	1	0.17	253	141–416	0.42	0.24–0.69
2013–14	59 454	3.3	3	0.15	286	164–464	0.48	0.28–0.78
2014–15	53 075	4.3	6	0.26	259	154–422	0.49	0.29–0.80

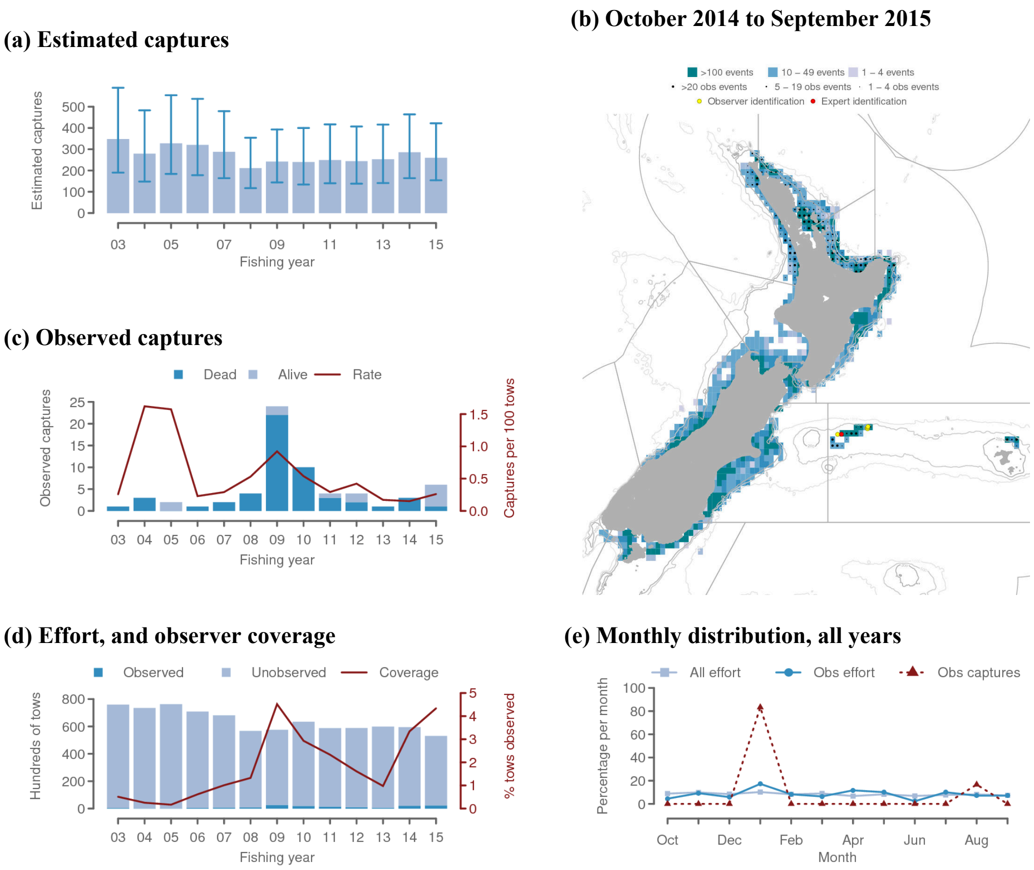


Figure B-10: Salvin's albatross captures in small-vessel trawl fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.3.2 Salvin's albatross captures in large-vessel trawl fisheries

Table B-11: Annual fishing effort and number of tows observed in large-vessel 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, c.i.).

		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	180	99–297	0.332	0.183–0.548
2003–04	47 339	13.4	7	0.110	124	49–247	0.262	0.104–0.522
2004–05	44 156	17.2	33	0.435	382	217–641	0.865	0.491–1.452
2005–06	39 121	15.8	5	0.081	71	25–147	0.181	0.064–0.376
2006–07	35 188	20.6	9	0.124	71	33–133	0.202	0.094–0.378
2007–08	32 766	25.3	5	0.060	53	19–111	0.162	0.058–0.339
2008–09	29 978	24.7	12	0.162	88	43–155	0.294	0.143–0.517
2009–10	29 506	26.0	34	0.443	150	96–234	0.508	0.325–0.793
2010–11	27 393	22.7	17	0.274	103	56–176	0.376	0.204–0.642
2011–12	25 593	32.8	22	0.262	91	55–146	0.356	0.215–0.570
2012–13	23 972	49.3	47	0.398	108	76–153	0.451	0.317–0.638
2013–14	25 660	43.7	48	0.428	128	90–182	0.499	0.351–0.709
2014–15	25 621	44.1	40	0.354	153	100–235	0.597	0.390–0.917

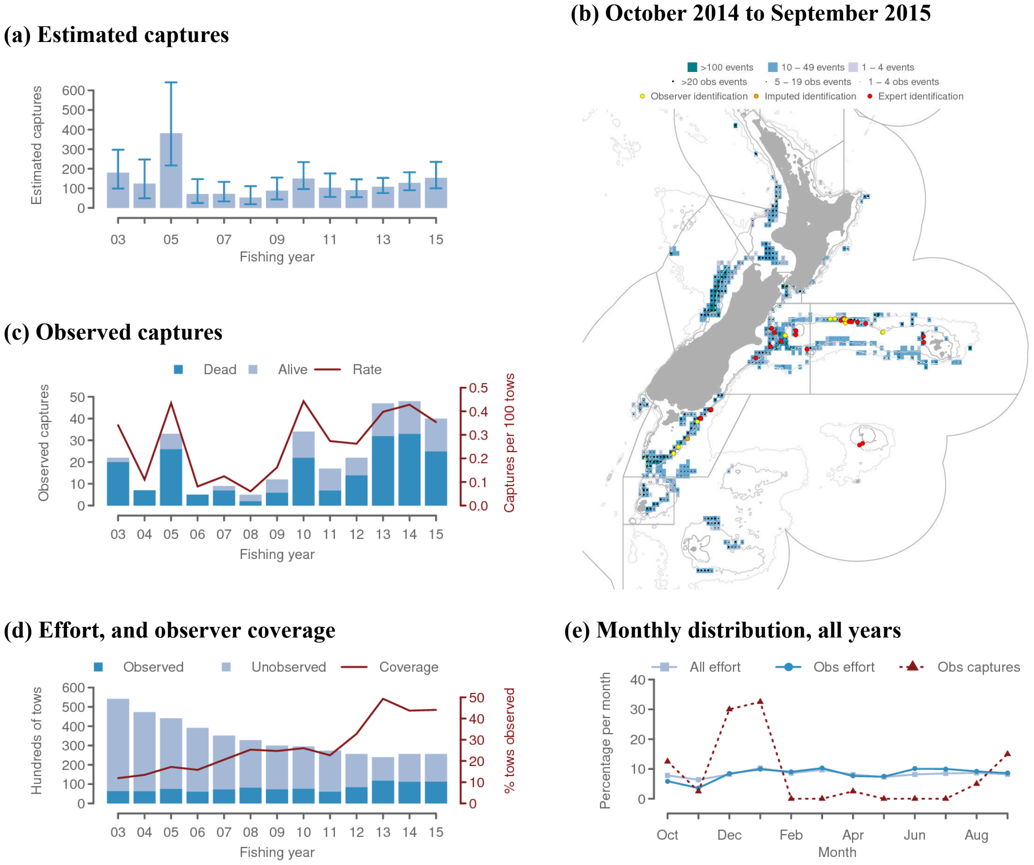


Figure B-11: Salvin's albatross captures in large-vessel trawl fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 97.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.3.3 Salvin's albatross captures in small-vessel bottom-longline fisheries

Table B-12: Annual fishing effort and number of hooks observed in small-vessel 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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	19 830 969	0.0	0	0.000	62	16–165	0.031	0.008–0.083
2003–04	19 879 853	1.1	0	0.000	57	13–180	0.029	0.007–0.091
2004–05	22 904 862	1.3	0	0.000	96	23–286	0.042	0.010–0.125
2005–06	22 257 310	0.7	0	0.000	86	16–289	0.039	0.007–0.130
2006–07	25 370 452	1.9	22	0.446	111	45–273	0.044	0.018–0.108
2007–08	27 377 199	1.7	0	0.000	102	26–291	0.037	0.009–0.106
2008–09	24 572 815	3.5	0	0.000	97	29–246	0.039	0.012–0.100
2009–10	26 835 631	3.7	0	0.000	100	29–257	0.037	0.011–0.096
2010–11	28 008 099	0.8	0	0.000	127	36–336	0.045	0.013–0.120
2011–12	26 313 256	0.3	0	0.000	132	36–364	0.050	0.014–0.138
2012–13	24 268 384	2.2	1	0.019	121	33–365	0.050	0.014–0.150
2013–14	24 417 104	5.0	0	0.000	103	30–267	0.042	0.012–0.109
2014–15	25 279 789	1.5	0	0.000	98	26–270	0.039	0.010–0.107

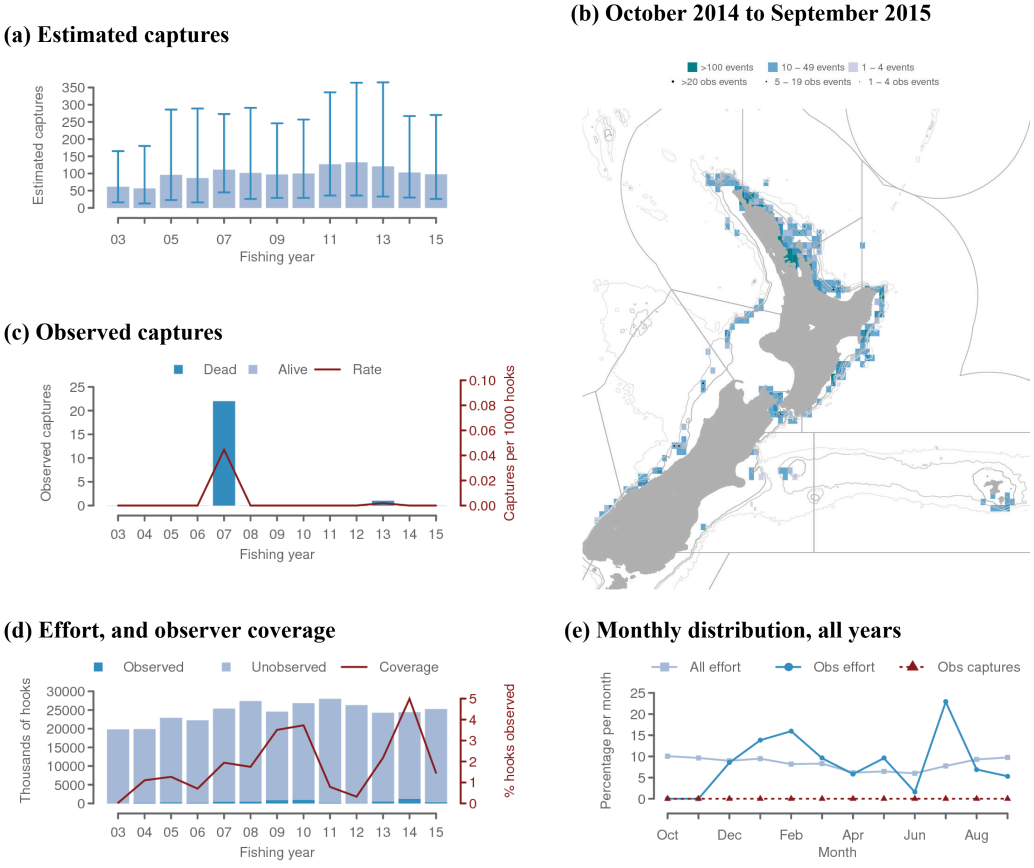


Figure B-12: Salvin's albatross captures in small-vessel bottom-longline fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 97.9% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, 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 small-vessel surface-longline fisheries

Table B-13: Annual fishing effort and number of hooks observed in small-vessel 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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	8 572 516	0.0	0	.	347	171–657	0.40	0.20–0.77
2003–04	5 730 239	2.4	0	0.00	298	144–584	0.52	0.25–1.02
2004–05	3 041 381	4.7	2	0.14	109	47–225	0.36	0.15–0.74
2005–06	3 027 229	3.2	5	0.51	132	58–266	0.44	0.19–0.88
2006–07	2 332 813	8.1	1	0.05	71	26–158	0.30	0.11–0.68
2007–08	1 677 854	8.1	3	0.22	68	27–156	0.41	0.16–0.93
2008–09	2 306 403	6.5	2	0.13	97	40–204	0.42	0.17–0.88
2009–10	2 516 706	7.7	24	1.23	130	72–236	0.52	0.29–0.94
2010–11	2 684 809	6.4	4	0.23	111	49–218	0.41	0.18–0.81
2011–12	2 548 837	6.8	4	0.23	147	63–308	0.58	0.25–1.21
2012–13	2 389 412	3.0	8	1.10	128	60–259	0.54	0.25–1.08
2013–14	1 896 434	6.8	8	0.62	112	49–231	0.59	0.26–1.22
2014–15	1 784 936	6.0	3	0.28	93	37–202	0.52	0.21–1.13

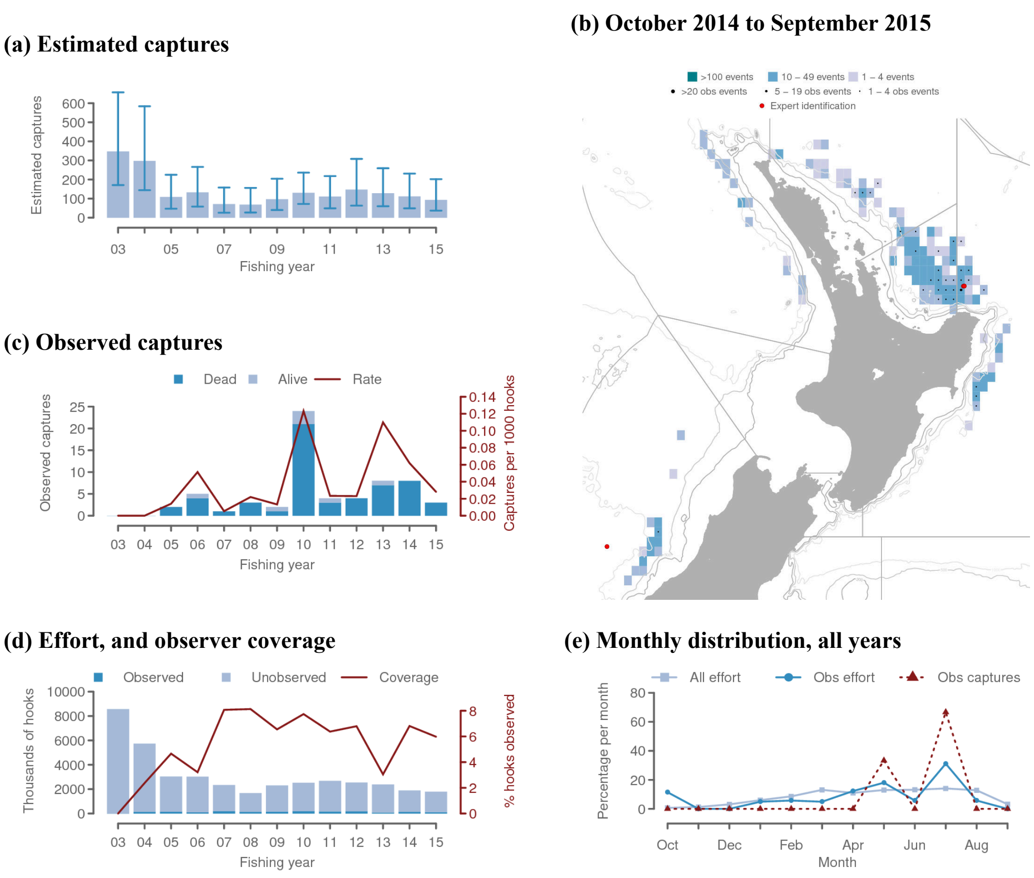


Figure B-13: Buller's albatrosses captures in small-vessel surface-longline fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 95.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.4.2 Buller’s albatrosses captures in large-vessel trawl fisheries

Table B-14: Annual fishing effort and number of tows observed in large-vessel 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, c.i.).

		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	80	34–144	0.148	0.063–0.266
2003–04	47 339	13.4	9	0.141	87	46–140	0.184	0.097–0.296
2004–05	44 156	17.2	21	0.277	124	78–186	0.281	0.177–0.421
2005–06	39 121	15.8	8	0.129	70	36–117	0.179	0.092–0.299
2006–07	35 188	20.6	5	0.069	47	20–82	0.134	0.057–0.233
2007–08	32 766	25.3	18	0.217	79	49–121	0.241	0.150–0.369
2008–09	29 978	24.7	17	0.230	58	37–87	0.193	0.123–0.290
2009–10	29 506	26.0	11	0.143	49	28–77	0.166	0.095–0.261
2010–11	27 393	22.7	20	0.322	66	44–97	0.241	0.161–0.354
2011–12	25 593	32.8	32	0.381	94	65–133	0.367	0.254–0.520
2012–13	23 972	49.3	59	0.499	85	71–105	0.355	0.296–0.438
2013–14	25 660	43.7	37	0.330	64	50–82	0.249	0.195–0.320
2014–15	25 621	44.1	34	0.301	68	51–91	0.265	0.199–0.355

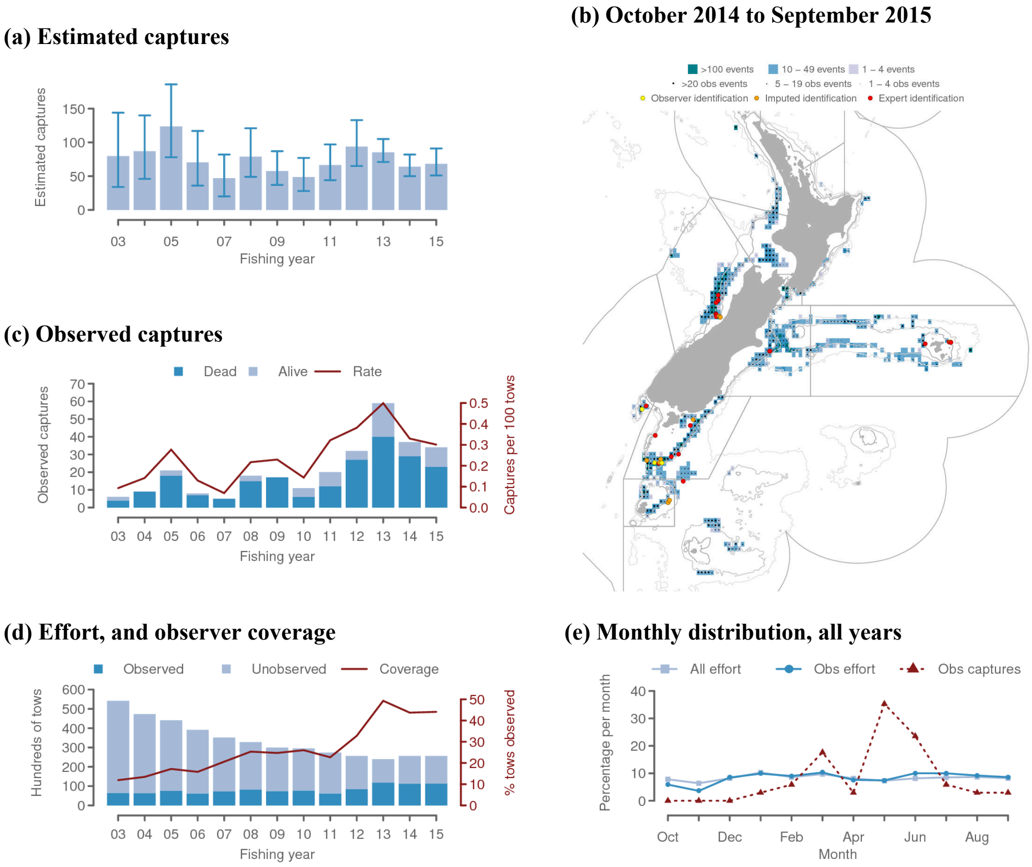


Figure B-14: Buller’s albatrosses captures in large-vessel trawl fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 97.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.5 Other albatross captures

B.5.1 Other albatross captures in small-vessel surface-longline fisheries

Table B-15: Annual fishing effort and number of hooks observed in small-vessel 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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	8 572 516	0.0	0	.	412	244–666	0.48	0.28–0.78
2003–04	5 730 239	2.4	1	0.07	268	158–445	0.47	0.28–0.78
2004–05	3 041 381	4.7	3	0.21	145	82–247	0.48	0.27–0.81
2005–06	3 027 229	3.2	5	0.51	170	93–283	0.56	0.31–0.93
2006–07	2 332 813	8.1	56	2.97	188	124–287	0.81	0.53–1.23
2007–08	1 677 854	8.1	4	0.29	88	46–152	0.52	0.27–0.91
2008–09	2 306 403	6.5	5	0.33	103	57–177	0.45	0.25–0.77
2009–10	2 516 706	7.7	20	1.03	153	95–243	0.61	0.38–0.97
2010–11	2 684 809	6.4	4	0.23	132	75–219	0.49	0.28–0.82
2011–12	2 548 837	6.8	17	0.98	122	76–192	0.48	0.30–0.75
2012–13	2 389 412	3.0	4	0.55	123	70–207	0.51	0.29–0.87
2013–14	1 896 434	6.8	3	0.23	98	54–170	0.52	0.28–0.90
2014–15	1 784 936	6.0	6	0.56	111	58–200	0.62	0.32–1.12

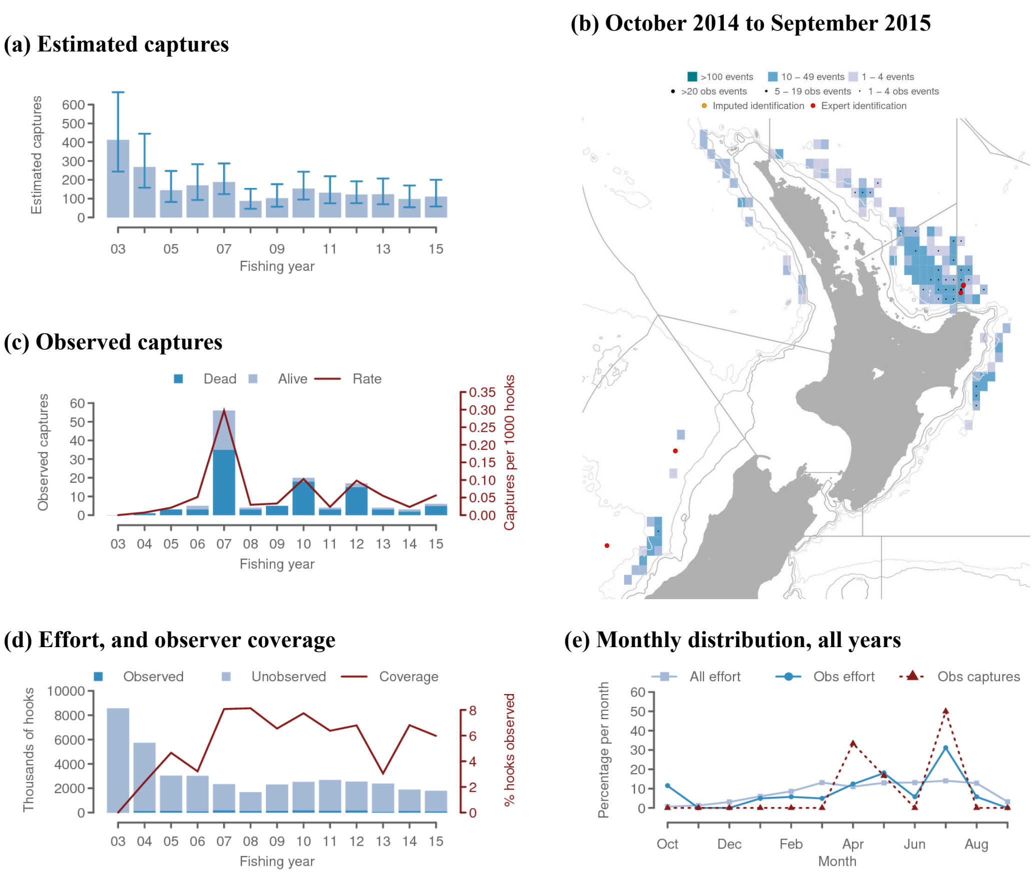


Figure B-15: Captures of other albatrosses in small-vessel surface-longline fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 95.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.5.2 Other albatross captures in small-vessel bottom-longline fisheries

Table B-16: Annual fishing effort and number of hooks observed in small-vessel 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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	19 830 969	0.0	0	0.000	94	38–188	0.047	0.019–0.095
2003–04	19 879 853	1.1	0	0.000	91	35–189	0.046	0.018–0.095
2004–05	22 904 862	1.3	0	0.000	106	42–213	0.046	0.018–0.093
2005–06	22 257 310	0.7	0	0.000	98	37–202	0.044	0.017–0.091
2006–07	25 370 452	1.9	14	0.284	126	59–245	0.050	0.023–0.097
2007–08	27 377 199	1.7	4	0.084	126	53–256	0.046	0.019–0.094
2008–09	24 572 815	3.5	0	0.000	101	40–209	0.041	0.016–0.085
2009–10	26 835 631	3.7	0	0.000	110	45–227	0.041	0.017–0.085
2010–11	28 008 099	0.8	0	0.000	131	53–265	0.047	0.019–0.095
2011–12	26 313 256	0.3	0	0.000	113	45–229	0.043	0.017–0.087
2012–13	24 268 384	2.2	0	0.000	96	37–199	0.040	0.015–0.082
2013–14	24 417 104	5.0	1	0.008	95	39–188	0.039	0.016–0.077
2014–15	25 279 789	1.5	0	0.000	96	40–193	0.038	0.016–0.076

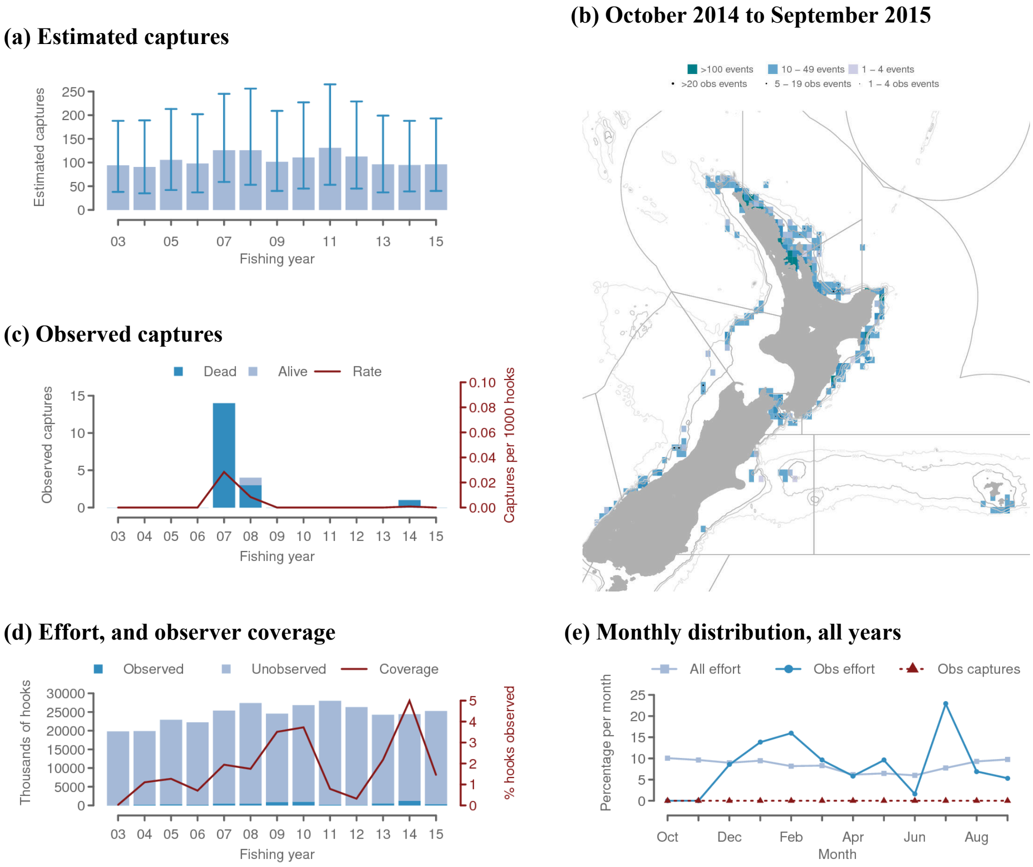


Figure B-16: Captures of other albatrosses in small-vessel bottom-longline fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 97.9% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.6 White-chinned petrel captures

B.6.1 White-chinned petrel captures in large-vessel trawl fisheries

Table B-17: Annual fishing effort and number of tows observed in large-vessel 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, c.i.).

		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	123	61–225	0.23	0.11–0.42
2003–04	47 339	13.4	20	0.31	107	61–179	0.23	0.13–0.38
2004–05	44 156	17.2	54	0.71	226	153–331	0.51	0.35–0.75
2005–06	39 121	15.8	70	1.13	377	243–573	0.96	0.62–1.46
2006–07	35 188	20.6	32	0.44	140	83–224	0.40	0.24–0.64
2007–08	32 766	25.3	58	0.70	228	150–346	0.70	0.46–1.06
2008–09	29 978	24.7	104	1.40	288	207–404	0.96	0.69–1.35
2009–10	29 506	26.0	73	0.95	276	183–409	0.94	0.62–1.39
2010–11	27 393	22.7	113	1.82	378	261–549	1.38	0.95–2.00
2011–12	25 593	32.8	61	0.73	182	125–266	0.71	0.49–1.04
2012–13	23 972	49.3	308	2.61	407	361–477	1.70	1.51–1.99
2013–14	25 660	43.7	145	1.29	210	180–256	0.82	0.70–1.00
2014–15	25 621	44.1	282	2.50	383	338–448	1.49	1.32–1.75

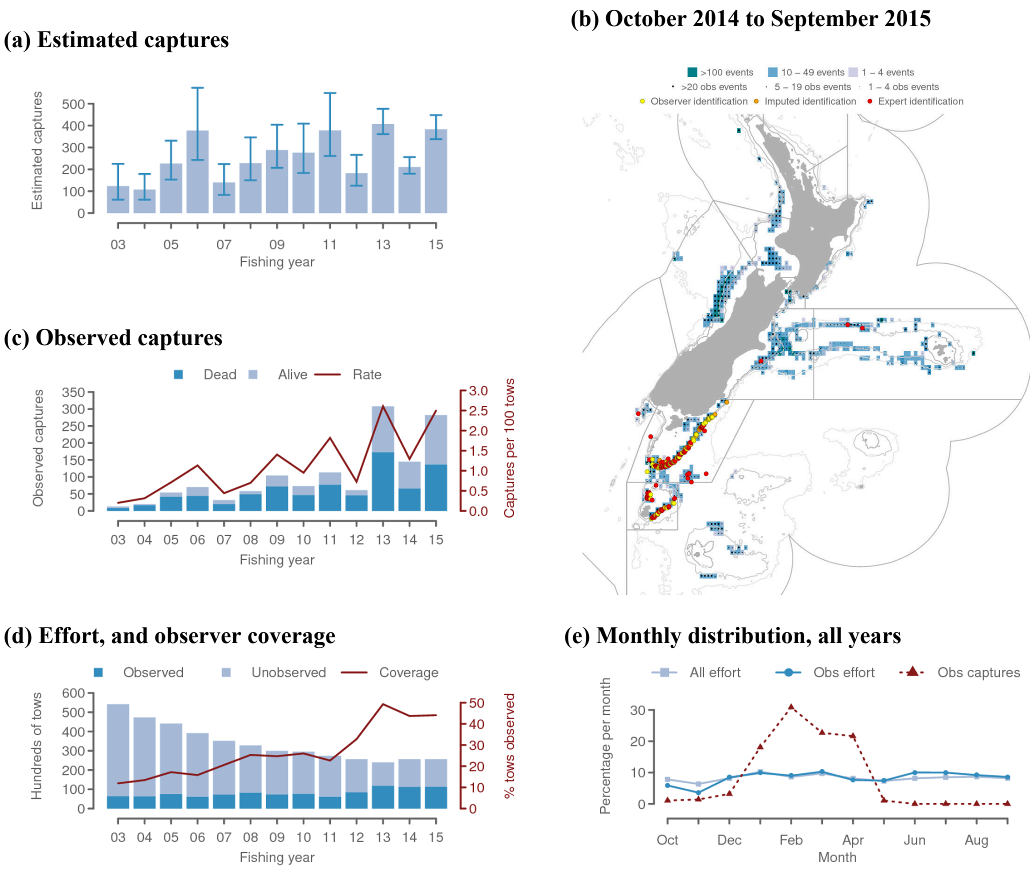


Figure B-17: White-chinned petrel captures in large-vessel trawl fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 97.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.6.2 White-chinned petrel captures in small-vessel bottom-longline fisheries

Table B-18: Annual fishing effort and number of hooks observed in small-vessel 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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	19 830 969	0.0	0	0.000	150	43–388	0.076	0.022–0.196
2003–04	19 879 853	1.1	0	0.000	113	25–345	0.057	0.013–0.174
2004–05	22 904 862	1.3	0	0.000	232	60–682	0.101	0.026–0.298
2005–06	22 257 310	0.7	0	0.000	224	48–737	0.101	0.022–0.331
2006–07	25 370 452	1.9	1	0.020	317	70–1 053	0.125	0.028–0.415
2007–08	27 377 199	1.7	3	0.063	291	71–942	0.106	0.026–0.344
2008–09	24 572 815	3.5	0	0.000	278	74–853	0.113	0.030–0.347
2009–10	26 835 631	3.7	0	0.000	253	69–722	0.094	0.026–0.269
2010–11	28 008 099	0.8	0	0.000	313	86–984	0.112	0.031–0.351
2011–12	26 313 256	0.3	0	0.000	292	72–1 012	0.111	0.027–0.385
2012–13	24 268 384	2.2	0	0.000	244	64–762	0.101	0.026–0.314
2013–14	24 417 104	5.0	0	0.000	161	47–423	0.066	0.019–0.173
2014–15	25 279 789	1.5	0	0.000	175	43–523	0.069	0.017–0.207

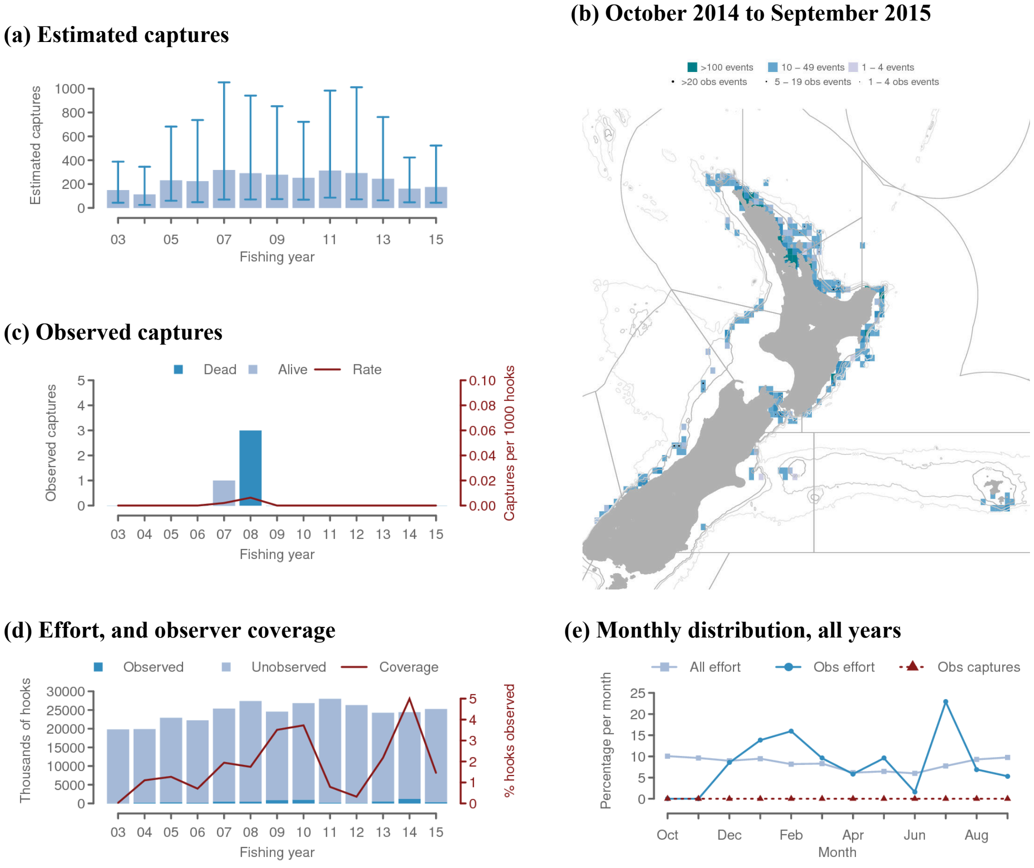


Figure B-18: White-chinned petrel captures in small-vessel bottom-longline fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 97.9% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.6.3 White-chinned petrel captures in large-vessel bottom-longline fisheries

Table B-19: Annual fishing effort and number of hooks observed in large-vessel 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, c.i.).

		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	306	189–547	0.171	0.105–0.305
2003–04	23 347 151	20.7	15	0.031	106	35–291	0.045	0.015–0.125
2004–05	18 932 296	13.7	11	0.042	472	130–1 322	0.249	0.069–0.698
2005–06	14 888 123	24.5	13	0.036	126	36–384	0.085	0.024–0.258
2006–07	12 759 288	14.3	12	0.066	420	105–1 248	0.329	0.082–0.978
2007–08	14 123 096	21.9	7	0.023	203	46–653	0.144	0.033–0.462
2008–09	12 870 071	24.8	1	0.003	154	14–539	0.120	0.011–0.419
2009–10	13 607 740	12.6	1	0.006	127	15–442	0.093	0.011–0.325
2010–11	12 914 717	11.8	15	0.099	180	51–513	0.139	0.039–0.397
2011–12	11 560 277	17.5	1	0.005	57	4–229	0.049	0.003–0.198
2012–13	8 240 515	3.3	0	0.000	97	10–363	0.118	0.012–0.441
2013–14	16 482 357	11.6	35	0.183	352	120–890	0.214	0.073–0.540
2014–15	14 021 683	2.5	11	0.308	249	70–711	0.178	0.050–0.507

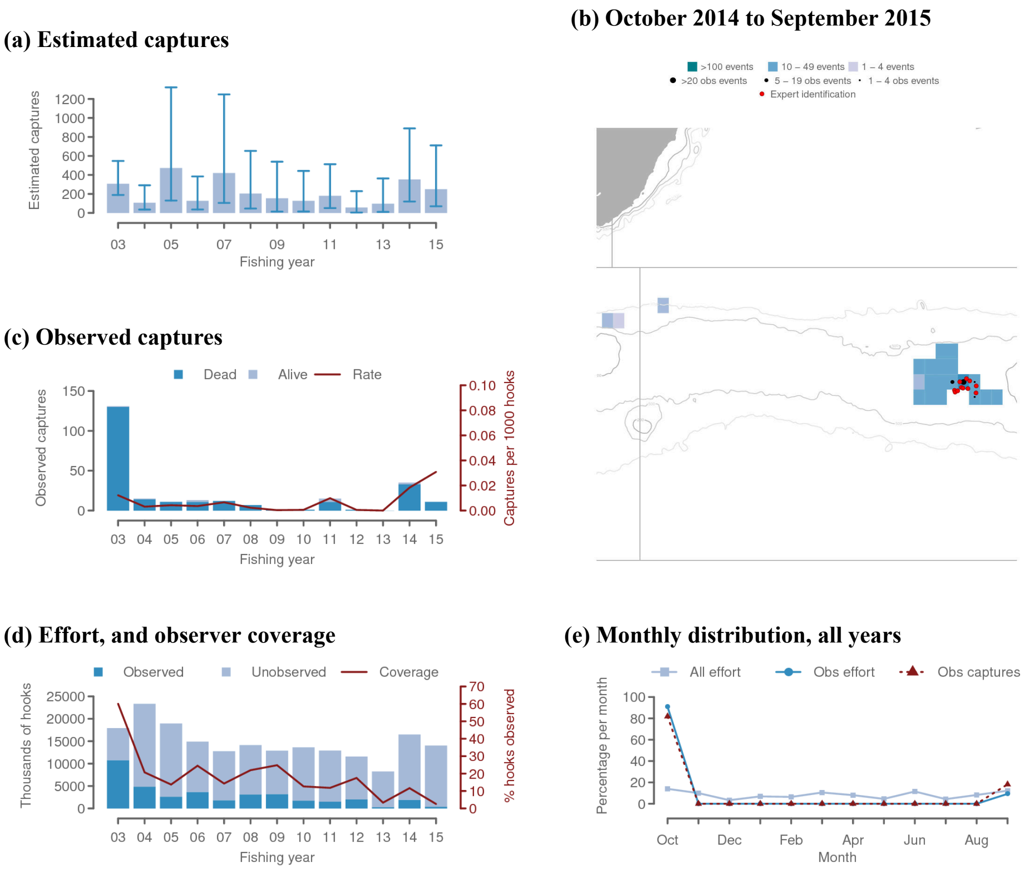


Figure B-19: White-chinned petrel captures in large-vessel bottom-longline fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 75.1% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.6.4 White-chinned petrel captures in small-vessel surface-longline fisheries

Table B-20: Annual fishing effort and number of hooks observed in small-vessel surface-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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	8 572 516	0.0	0	.	181	41–587	0.211	0.048–0.685
2003–04	5 730 239	2.4	0	0.000	154	23–822	0.269	0.040–1.434
2004–05	3 041 381	4.7	1	0.071	46	10–142	0.151	0.033–0.467
2005–06	3 027 229	3.2	0	0.000	73	10–398	0.241	0.033–1.315
2006–07	2 332 813	8.1	2	0.106	31	8–85	0.133	0.034–0.364
2007–08	1 677 854	8.1	0	0.000	21	5–54	0.125	0.030–0.322
2008–09	2 306 403	6.5	1	0.066	24	7–58	0.104	0.030–0.251
2009–10	2 516 706	7.7	1	0.051	31	9–74	0.123	0.036–0.294
2010–11	2 684 809	6.4	4	0.234	33	12–75	0.123	0.045–0.279
2011–12	2 548 837	6.8	4	0.231	34	13–77	0.133	0.051–0.302
2012–13	2 389 412	3.0	0	0.000	40	11–110	0.167	0.046–0.460
2013–14	1 896 434	6.8	0	0.000	27	7–75	0.142	0.037–0.395
2014–15	1 784 936	6.0	2	0.187	36	9–111	0.202	0.050–0.622

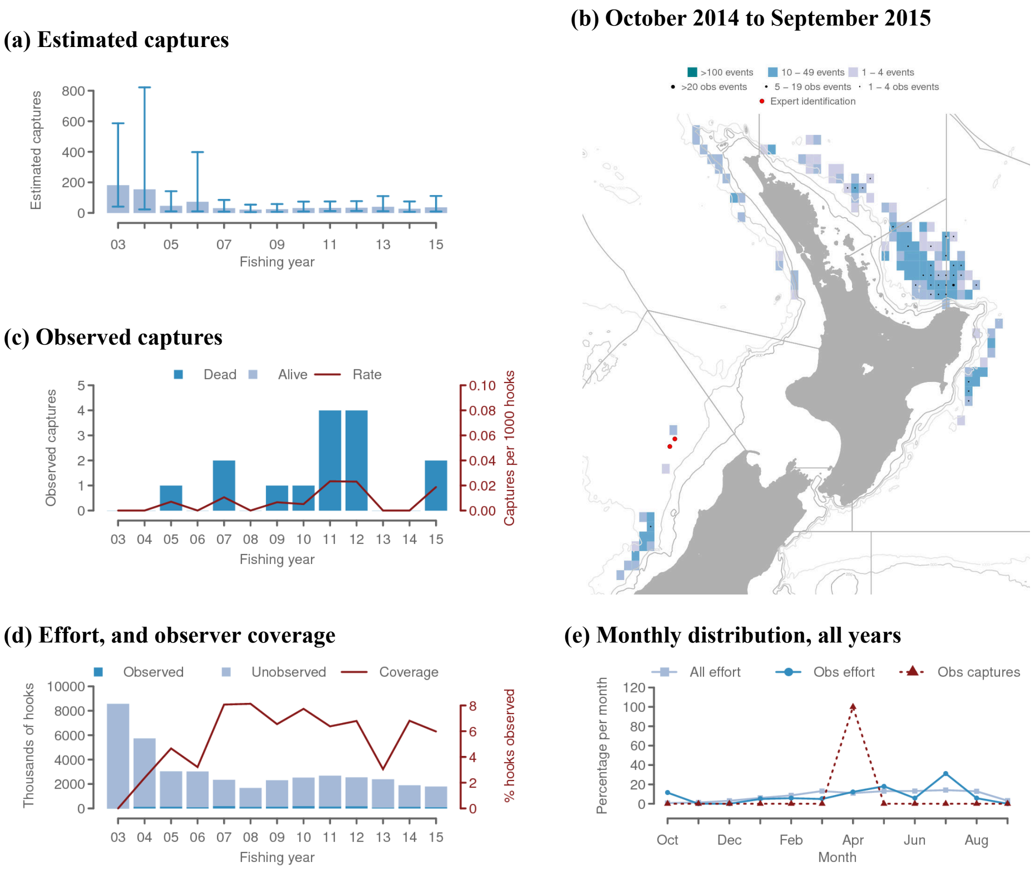


Figure B-20: White-chinned petrel captures in small-vessel surface-longline fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 95.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, 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 trawl fisheries

Table B-21: Annual fishing effort and number of tows observed in large-vessel 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, c.i.).

		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	120	1.86	872	608–1 242	1.61	1.12–2.29
2003–04	47 339	13.4	52	0.82	407	262–608	0.86	0.55–1.28
2004–05	44 156	17.2	74	0.98	402	270–580	0.91	0.61–1.31
2005–06	39 121	15.8	171	2.77	845	602–1 182	2.16	1.54–3.02
2006–07	35 188	20.6	69	0.95	364	241–534	1.03	0.68–1.52
2007–08	32 766	25.3	79	0.95	311	217–441	0.95	0.66–1.35
2008–09	29 978	24.7	140	1.89	478	351–653	1.59	1.17–2.18
2009–10	29 506	26.0	49	0.64	219	147–322	0.74	0.50–1.09
2010–11	27 393	22.7	95	1.53	379	271–525	1.38	0.99–1.92
2011–12	25 593	32.8	32	0.38	136	84–211	0.53	0.33–0.82
2012–13	23 972	49.3	130	1.10	198	167–241	0.83	0.70–1.01
2013–14	25 660	43.7	124	1.11	222	181–278	0.87	0.71–1.08
2014–15	25 621	44.1	134	1.19	249	198–313	0.97	0.77–1.22

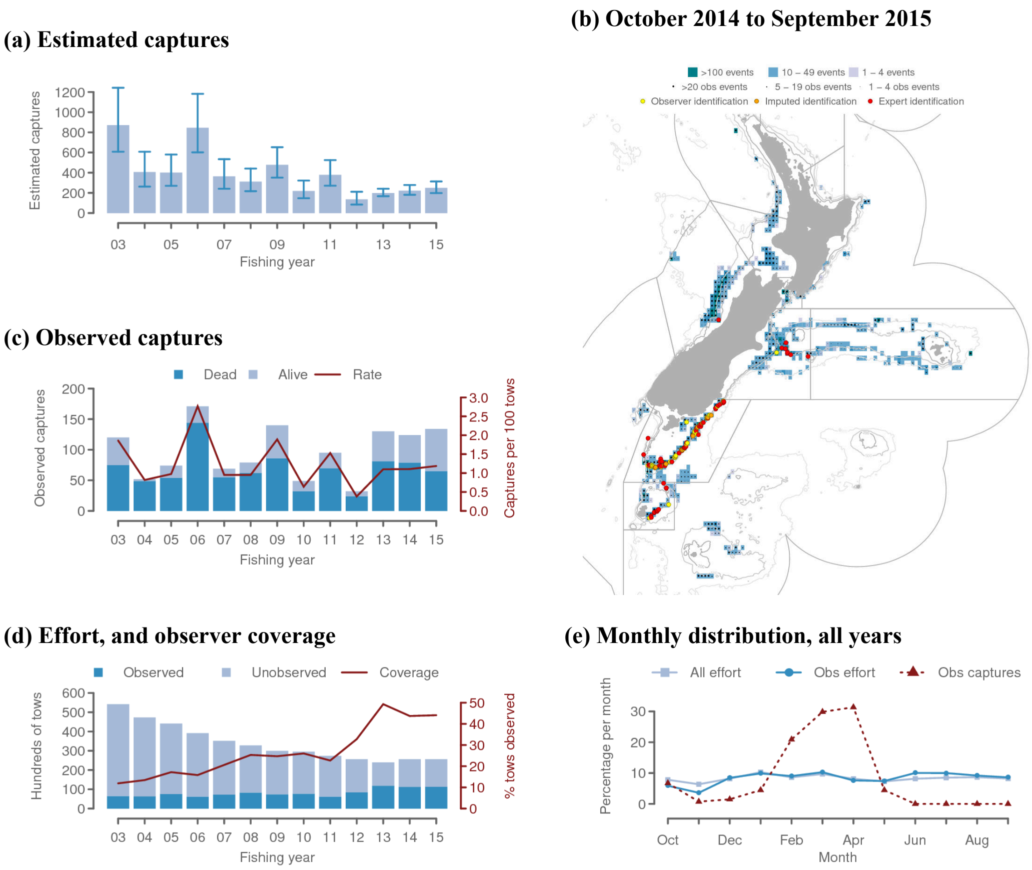


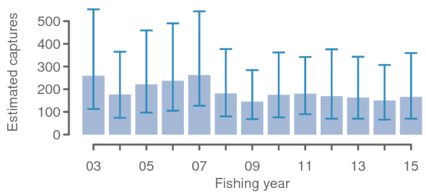
Figure B-21: Sooty shearwater captures in large-vessel trawl fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 97.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.7.2 Sooty shearwater captures in small-vessel trawl fisheries

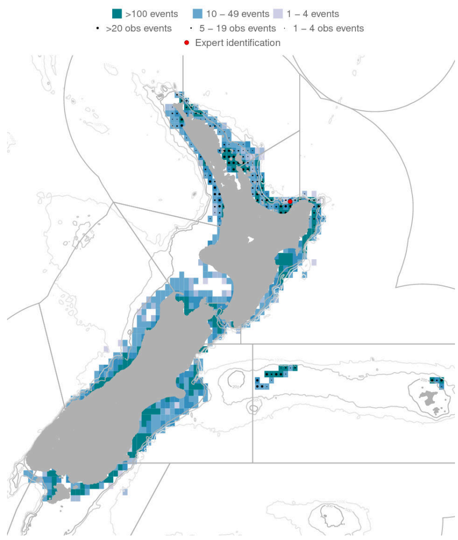
Table B-22: Annual fishing effort and number of tows observed in small-vessel trawl fisheries, number of observed captures of sooty shearwater and observed capture rate (captures per hundred tows), estimated captures and capture rate of sooty shearwater (mean and 95% credible interval, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	75 956	0.5	0	0.00	259	113–552	0.34	0.15–0.73
2003–04	73 498	0.3	0	0.00	176	74–365	0.24	0.10–0.50
2004–05	76 275	0.2	0	0.00	221	97–459	0.29	0.13–0.60
2005–06	70 823	0.6	0	0.00	237	105–490	0.33	0.15–0.69
2006–07	68 109	1.0	14	2.04	262	127–543	0.38	0.19–0.80
2007–08	56 761	1.3	2	0.27	181	80–377	0.32	0.14–0.66
2008–09	57 572	4.5	11	0.42	145	68–284	0.25	0.12–0.49
2009–10	63 383	2.9	0	0.00	175	76–362	0.28	0.12–0.57
2010–11	58 693	2.3	19	1.39	180	90–342	0.31	0.15–0.58
2011–12	58 828	1.6	0	0.00	169	70–376	0.29	0.12–0.64
2012–13	59 870	1.0	0	0.00	163	70–343	0.27	0.12–0.57
2013–14	59 454	3.3	0	0.00	150	66–307	0.25	0.11–0.52
2014–15	53 075	4.3	1	0.04	166	70–359	0.31	0.13–0.68

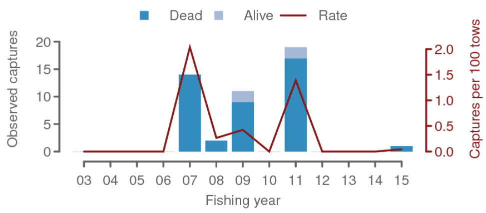
(a) Estimated captures



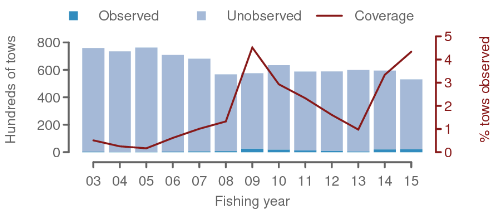
(b) October 2014 to September 2015



(c) Observed captures



(d) Effort, and observer coverage



(e) Monthly distribution, all years

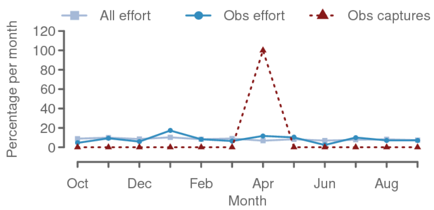


Figure B-22: Sooty shearwater captures in small-vessel trawl fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.8 Black petrel captures

B.8.1 Black petrel captures in small-vessel bottom-longline fisheries

Table B-23: Annual fishing effort and number of hooks observed in small-vessel 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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	19 830 969	0.0	0	0.000	518	264–1 021	0.261	0.133–0.515
2003–04	19 879 853	1.1	2	0.091	497	247–1 012	0.250	0.124–0.509
2004–05	22 904 862	1.3	1	0.034	438	216–882	0.191	0.094–0.385
2005–06	22 257 310	0.7	2	0.127	404	191–844	0.182	0.086–0.379
2006–07	25 370 452	1.9	4	0.081	480	221–1 046	0.189	0.087–0.412
2007–08	27 377 199	1.7	3	0.063	381	182–790	0.139	0.066–0.289
2008–09	24 572 815	3.5	8	0.093	350	173–719	0.142	0.070–0.293
2009–10	26 835 631	3.7	34	0.340	401	206–801	0.149	0.077–0.298
2010–11	28 008 099	0.8	2	0.091	378	186–742	0.135	0.066–0.265
2011–12	26 313 256	0.3	0	0.000	317	159–643	0.120	0.060–0.244
2012–13	24 268 384	2.2	2	0.038	260	133–498	0.107	0.055–0.205
2013–14	24 417 104	5.0	7	0.057	255	130–493	0.104	0.053–0.202
2014–15	25 279 789	1.5	2	0.054	240	121–467	0.095	0.048–0.185

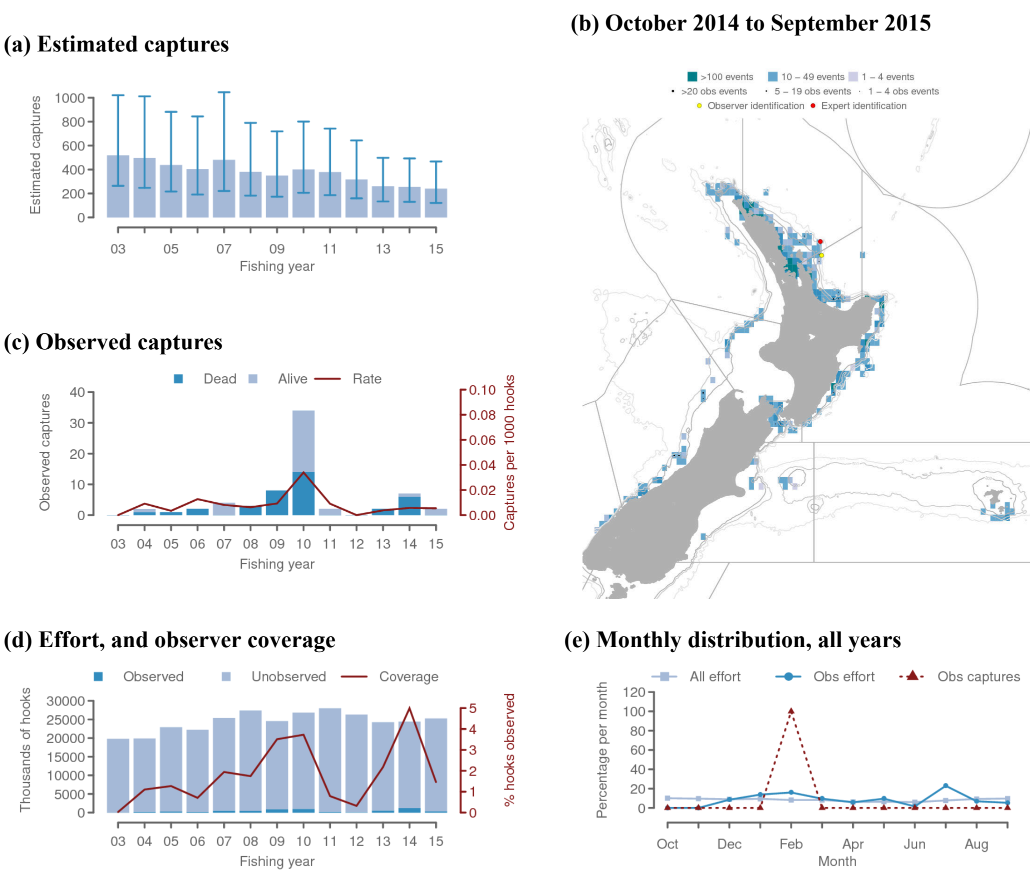


Figure B-23: Black petrel captures in small-vessel bottom-longline fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 97.9% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.8.2 Black petrel captures in small-vessel surface-longline fisheries

Table B-24: Annual fishing effort and number of hooks observed in small-vessel 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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	8 572 516	0.0	0	.	248	95–586	0.289	0.111–0.684
2003–04	5 730 239	2.4	1	0.074	152	57–348	0.265	0.099–0.607
2004–05	3 041 381	4.7	0	0.000	126	35–369	0.414	0.115–1.213
2005–06	3 027 229	3.2	0	0.000	91	30–214	0.301	0.099–0.707
2006–07	2 332 813	8.1	0	0.000	73	24–176	0.313	0.103–0.754
2007–08	1 677 854	8.1	1	0.073	62	19–153	0.370	0.113–0.912
2008–09	2 306 403	6.5	2	0.132	76	26–178	0.330	0.113–0.772
2009–10	2 516 706	7.7	16	0.821	90	44–185	0.358	0.175–0.735
2010–11	2 684 809	6.4	1	0.058	100	33–246	0.372	0.123–0.916
2011–12	2 548 837	6.8	1	0.058	77	24–186	0.302	0.094–0.730
2012–13	2 389 412	3.0	0	0.000	76	24–189	0.318	0.100–0.791
2013–14	1 896 434	6.8	0	0.000	62	17–160	0.327	0.090–0.844
2014–15	1 784 936	6.0	0	0.000	49	10–146	0.275	0.056–0.818

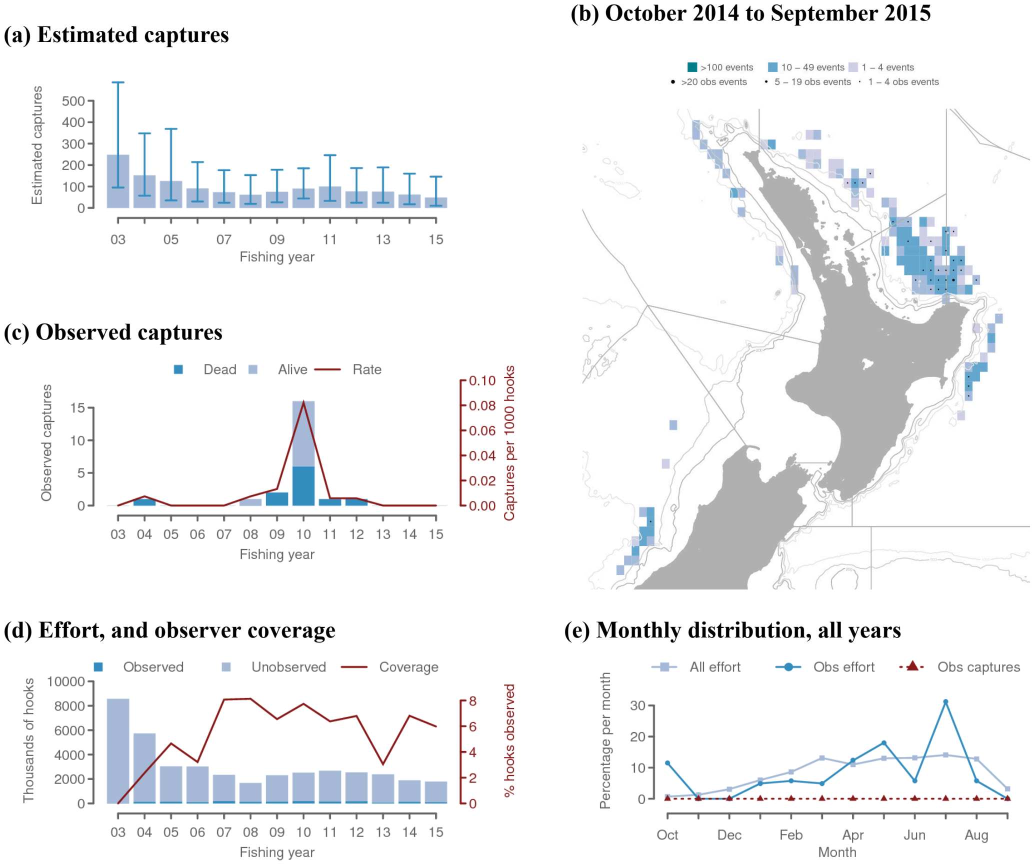


Figure B-24: Black petrel captures in small-vessel surface-longline fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 95.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.9 Grey petrel captures

B.9.1 Grey petrel captures in small-vessel bottom-longline fisheries

Table B-25: Annual fishing effort and number of hooks observed in small-vessel 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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	19 830 969	0.0	0	0.000	211	73–491	0.106	0.037–0.248
2003–04	19 879 853	1.1	0	0.000	182	63–421	0.092	0.032–0.212
2004–05	22 904 862	1.3	0	0.000	182	64–419	0.079	0.028–0.183
2005–06	22 257 310	0.7	0	0.000	184	60–436	0.083	0.027–0.196
2006–07	25 370 452	1.9	0	0.000	188	61–463	0.074	0.024–0.182
2007–08	27 377 199	1.7	0	0.000	182	58–455	0.066	0.021–0.166
2008–09	24 572 815	3.5	2	0.023	161	54–384	0.066	0.022–0.156
2009–10	26 835 631	3.7	0	0.000	209	68–519	0.078	0.025–0.193
2010–11	28 008 099	0.8	0	0.000	191	66–457	0.068	0.024–0.163
2011–12	26 313 256	0.3	0	0.000	169	59–396	0.064	0.022–0.150
2012–13	24 268 384	2.2	0	0.000	153	51–366	0.063	0.021–0.151
2013–14	24 417 104	5.0	1	0.008	169	57–407	0.069	0.023–0.167
2014–15	25 279 789	1.5	3	0.081	172	58–424	0.068	0.023–0.168

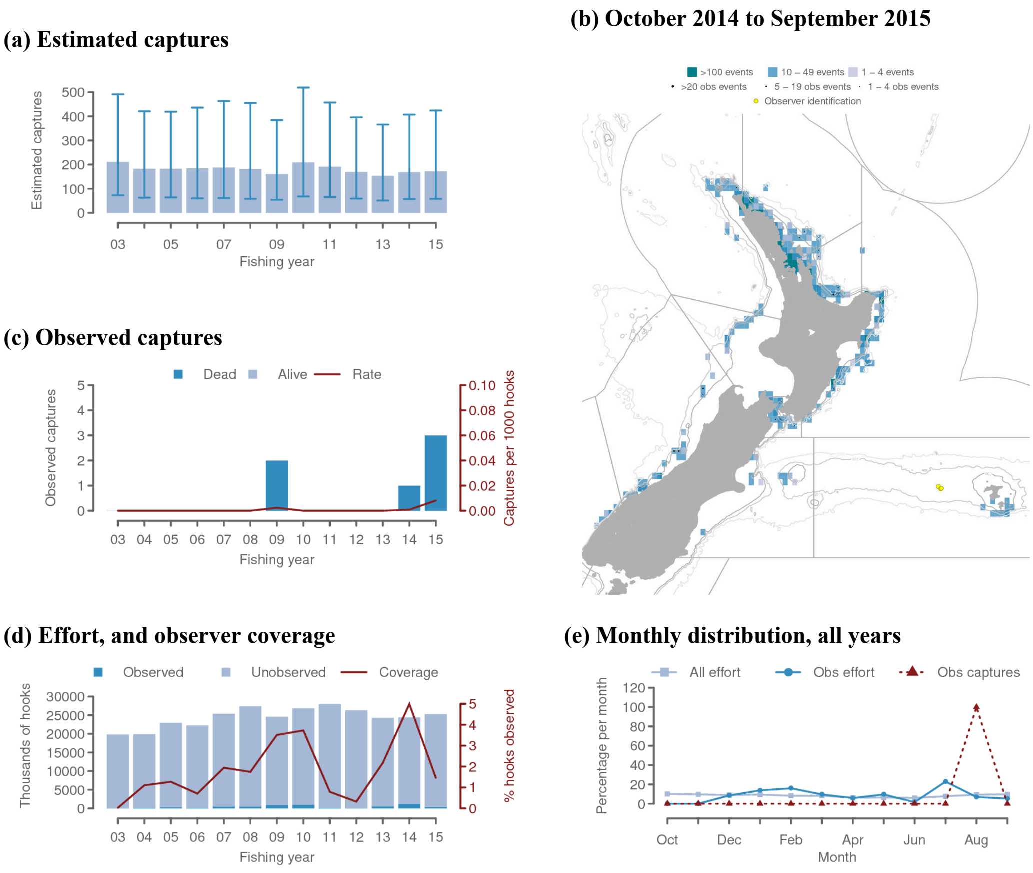


Figure B-25: Grey petrel captures in small-vessel bottom-longline fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 97.9% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) 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 bottom-longline fisheries

Table B-26: Annual fishing effort and number of hooks observed in small-vessel 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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	19 830 969	0.0	0	0.000	676	367–1 260	0.341	0.185–0.635
2003–04	19 879 853	1.1	3	0.137	589	311–1 097	0.296	0.156–0.552
2004–05	22 904 862	1.3	9	0.310	558	298–1 058	0.244	0.130–0.462
2005–06	22 257 310	0.7	0	0.000	444	228–875	0.199	0.102–0.393
2006–07	25 370 452	1.9	0	0.000	459	243–877	0.181	0.096–0.346
2007–08	27 377 199	1.7	0	0.000	395	210–737	0.144	0.077–0.269
2008–09	24 572 815	3.5	15	0.174	409	222–744	0.166	0.090–0.303
2009–10	26 835 631	3.7	13	0.130	390	211–711	0.145	0.079–0.265
2010–11	28 008 099	0.8	0	0.000	438	233–791	0.156	0.083–0.282
2011–12	26 313 256	0.3	0	0.000	378	206–674	0.144	0.078–0.256
2012–13	24 268 384	2.2	2	0.038	392	205–731	0.162	0.084–0.301
2013–14	24 417 104	5.0	31	0.254	388	216–712	0.159	0.088–0.292
2014–15	25 279 789	1.5	8	0.217	365	191–701	0.144	0.076–0.277

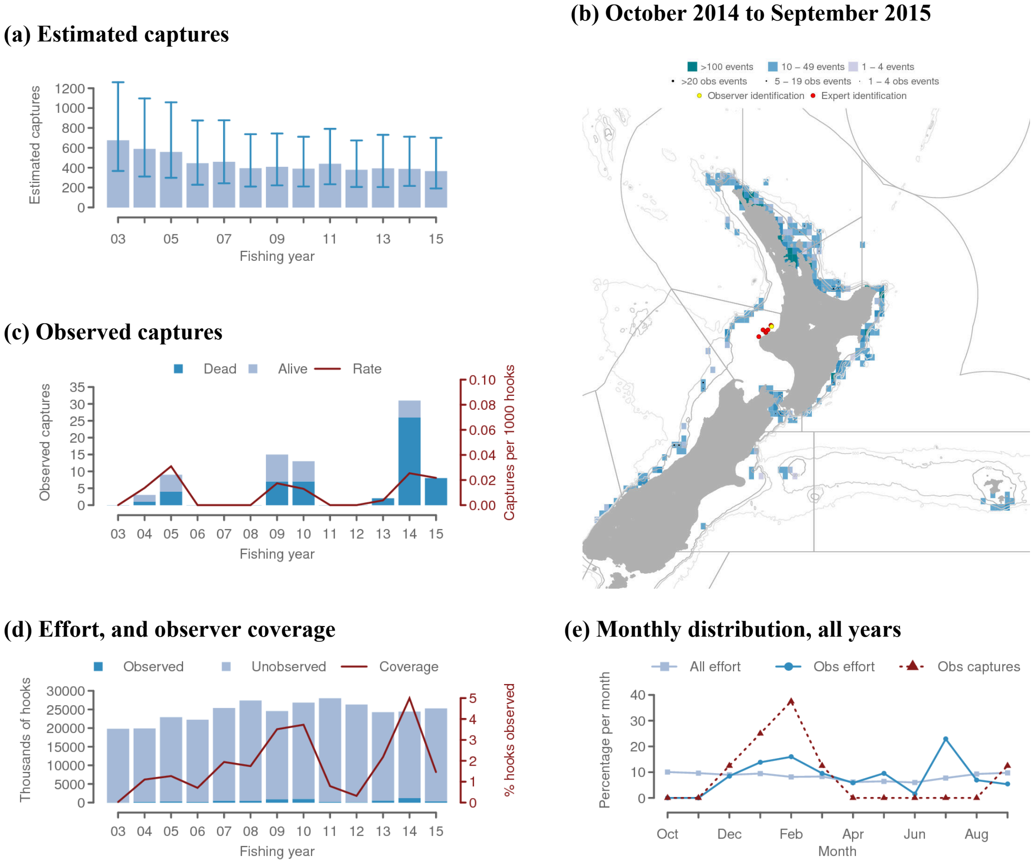


Figure B-26: Flesh-footed shearwater captures in small-vessel bottom-longline fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 97.9% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.10.2 Flesh-footed shearwater captures in small-vessel surface-longline fisheries

Table B-27: Annual fishing effort and number of hooks observed in small-vessel 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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	8 572 516	0.0	0	.	628	294–1 277	0.733	0.343–1.490
2003–04	5 730 239	2.4	0	0.000	393	176–805	0.686	0.307–1.405
2004–05	3 041 381	4.7	1	0.071	233	87–528	0.766	0.286–1.736
2005–06	3 027 229	3.2	4	0.411	235	94–509	0.776	0.311–1.681
2006–07	2 332 813	8.1	3	0.159	192	75–418	0.823	0.322–1.792
2007–08	1 677 854	8.1	2	0.147	166	60–388	0.989	0.358–2.312
2008–09	2 306 403	6.5	0	0.000	207	82–441	0.898	0.356–1.912
2009–10	2 516 706	7.7	0	0.000	210	83–455	0.834	0.330–1.808
2010–11	2 684 809	6.4	2	0.117	270	104–619	1.006	0.387–2.306
2011–12	2 548 837	6.8	0	0.000	216	74–514	0.847	0.290–2.017
2012–13	2 389 412	3.0	0	0.000	192	68–459	0.804	0.285–1.921
2013–14	1 896 434	6.8	0	0.000	165	52–388	0.870	0.274–2.046
2014–15	1 784 936	6.0	1	0.094	100	26–270	0.560	0.146–1.513

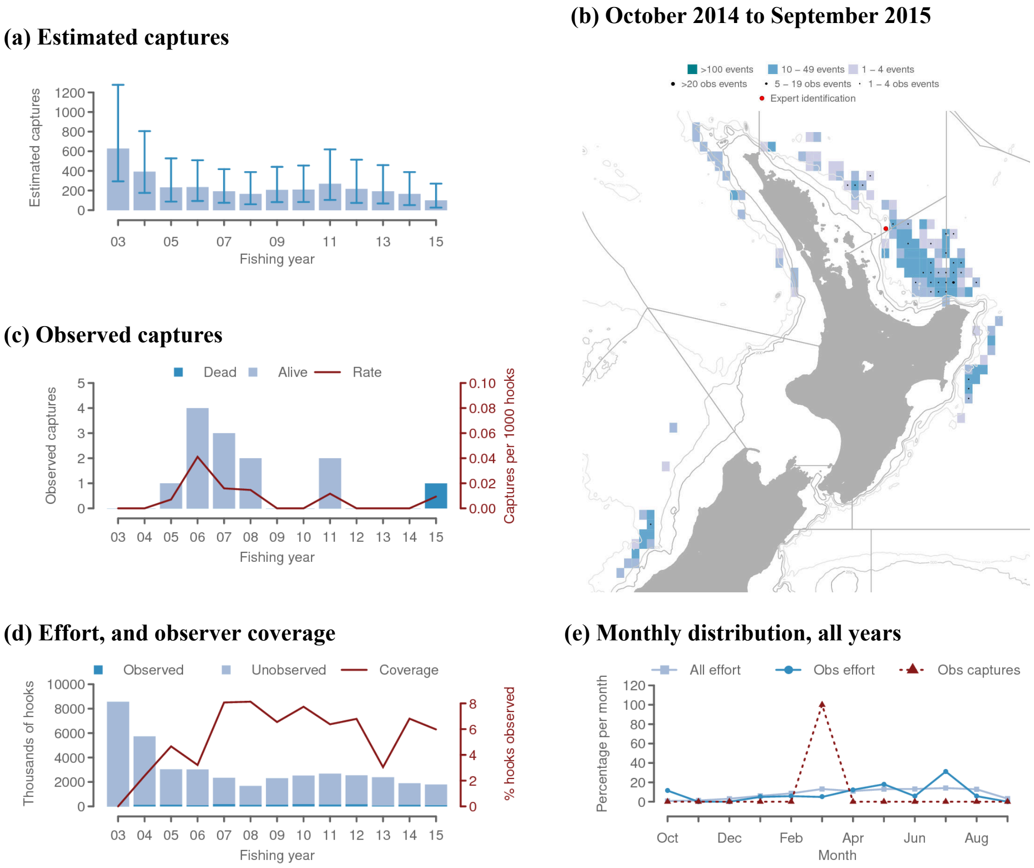


Figure B-27: Flesh-footed shearwater captures in small-vessel surface-longline fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 95.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.10.3 Flesh-footed shearwater captures in small-vessel trawl fisheries

Table B-28: Annual fishing effort and number of tows observed in small-vessel 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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	75 956	0.5	0	0.00	145	77–256	0.19	0.10–0.34
2003–04	73 498	0.3	0	0.00	135	73–241	0.18	0.10–0.33
2004–05	76 275	0.2	0	0.00	137	74–230	0.18	0.10–0.30
2005–06	70 823	0.6	8	1.83	128	72–204	0.18	0.10–0.29
2006–07	68 109	1.0	6	0.87	127	70–212	0.19	0.10–0.31
2007–08	56 761	1.3	4	0.53	112	63–187	0.20	0.11–0.33
2008–09	57 572	4.5	3	0.12	113	62–189	0.20	0.11–0.33
2009–10	63 383	2.9	2	0.11	134	73–235	0.21	0.12–0.37
2010–11	58 693	2.3	15	1.10	137	78–227	0.23	0.13–0.39
2011–12	58 828	1.6	1	0.11	106	57–180	0.18	0.10–0.31
2012–13	59 870	1.0	0	0.00	117	62–210	0.20	0.10–0.35
2013–14	59 454	3.3	9	0.45	114	62–202	0.19	0.10–0.34
2014–15	53 075	4.3	8	0.35	104	59–177	0.20	0.11–0.33

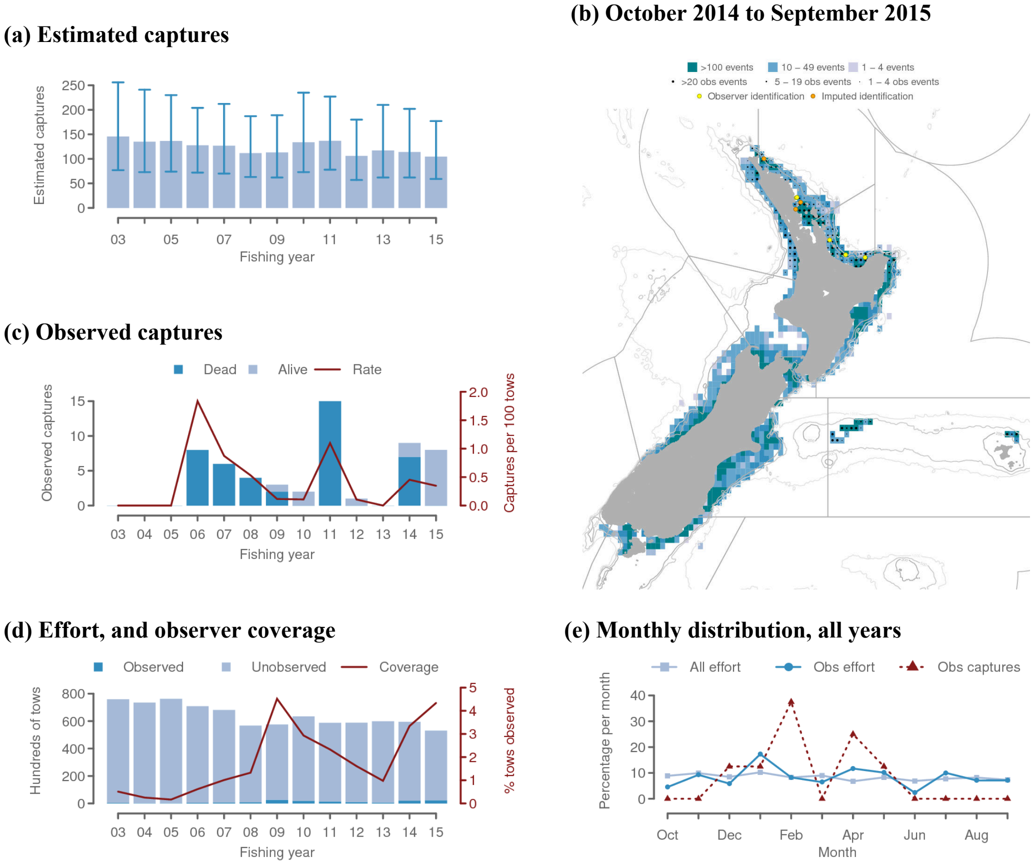


Figure B-28: Flesh-footed shearwater captures in small-vessel trawl fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.11 Other bird captures

B.11.1 Other bird captures in small-vessel bottom-longline fisheries

Table B-29: Annual fishing effort and number of hooks observed in small-vessel 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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	19 830 969	0.0	2	3.64	478	282–789	0.24	0.14–0.40
2003–04	19 879 853	1.1	5	0.23	428	256–711	0.22	0.13–0.36
2004–05	22 904 862	1.3	3	0.10	411	242–684	0.18	0.11–0.30
2005–06	22 257 310	0.7	10	0.64	351	205–579	0.16	0.09–0.26
2006–07	25 370 452	1.9	3	0.06	367	213–605	0.14	0.08–0.24
2007–08	27 377 199	1.7	6	0.13	342	199–573	0.12	0.07–0.21
2008–09	24 572 815	3.5	9	0.10	341	205–555	0.14	0.08–0.23
2009–10	26 835 631	3.7	1	0.01	348	200–587	0.13	0.07–0.22
2010–11	28 008 099	0.8	0	0.00	410	246–681	0.15	0.09–0.24
2011–12	26 313 256	0.3	1	0.12	375	216–618	0.14	0.08–0.23
2012–13	24 268 384	2.2	2	0.04	331	192–552	0.14	0.08–0.23
2013–14	24 417 104	5.0	16	0.13	320	196–509	0.13	0.08–0.21
2014–15	25 279 789	1.5	2	0.05	302	179–502	0.12	0.07–0.20

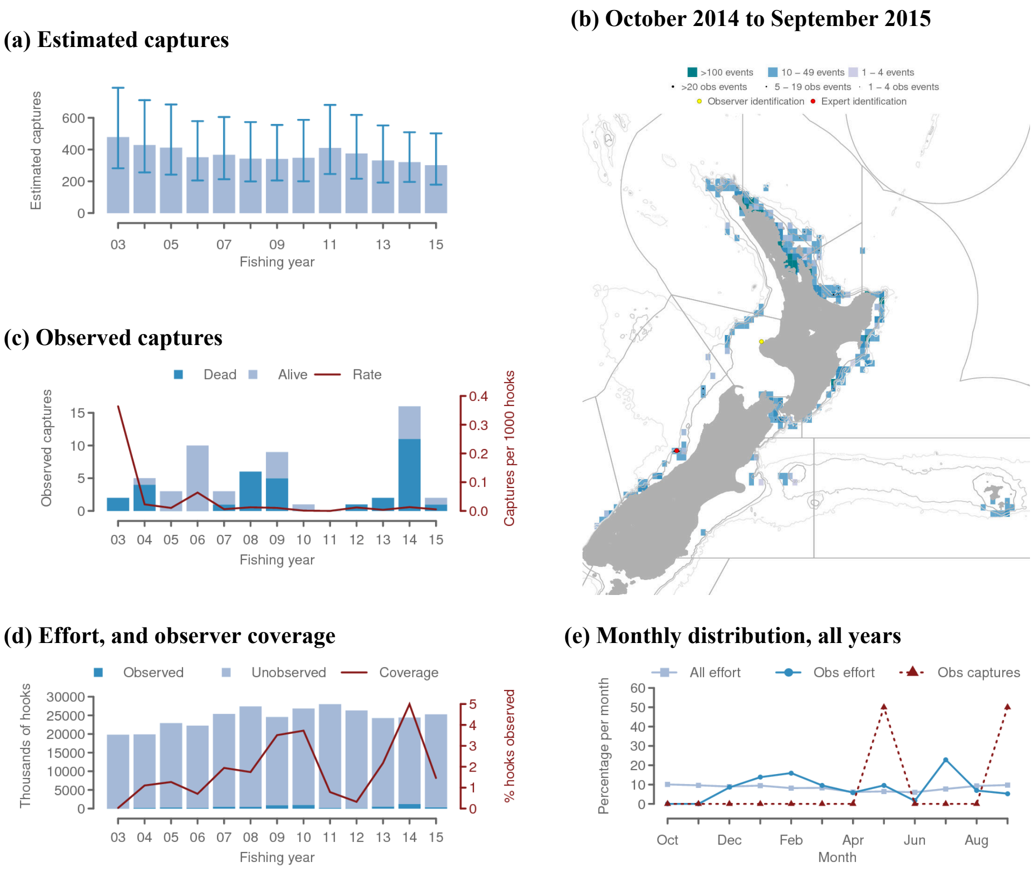


Figure B-29: Captures of other birds in small-vessel bottom-longline fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 97.9% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.11.2 Other bird captures in small-vessel trawl fisheries

Table B-30: Annual fishing effort and number of tows observed in small-vessel 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, c.i.).

		Observed			Est. captures		Est. capture rate	
Year	Effort	% obs.	Cap.	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	75 956	0.5	0	0.00	427	248–716	0.56	0.33–0.94
2003–04	73 498	0.3	0	0.00	416	241–704	0.57	0.33–0.96
2004–05	76 275	0.2	0	0.00	427	247–715	0.56	0.32–0.94
2005–06	70 823	0.6	1	0.23	380	218–639	0.54	0.31–0.90
2006–07	68 109	1.0	2	0.29	386	218–650	0.57	0.32–0.95
2007–08	56 761	1.3	0	0.00	311	176–527	0.55	0.31–0.93
2008–09	57 572	4.5	35	1.35	334	203–544	0.58	0.35–0.94
2009–10	63 383	2.9	0	0.00	329	188–555	0.52	0.30–0.88
2010–11	58 693	2.3	0	0.00	265	152–442	0.45	0.26–0.75
2011–12	58 828	1.6	0	0.00	292	166–494	0.50	0.28–0.84
2012–13	59 870	1.0	0	0.00	291	169–484	0.49	0.28–0.81
2013–14	59 454	3.3	2	0.10	280	162–465	0.47	0.27–0.78
2014–15	53 075	4.3	5	0.22	243	143–400	0.46	0.27–0.75

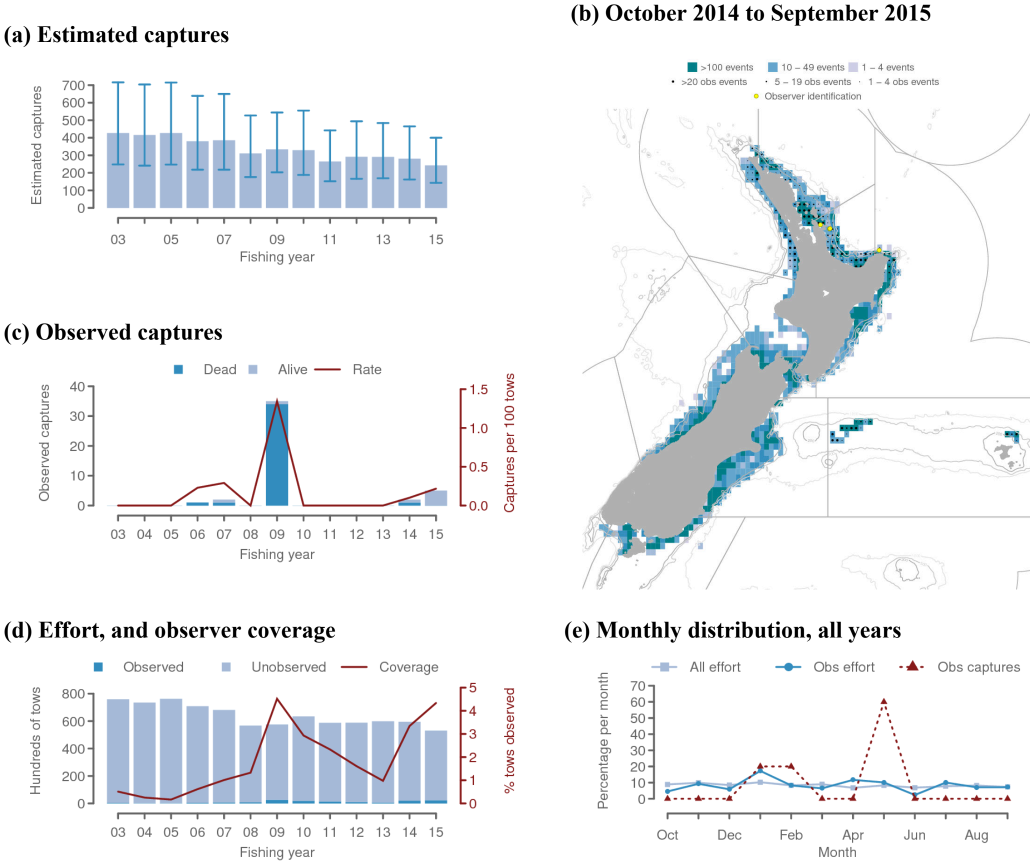


Figure B-30: Captures of other birds in small-vessel trawl fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 , (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

B.11.3 Other bird captures in large-vessel trawl fisheries

Table B-31: Annual fishing effort and number of tows observed in large-vessel 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, c.i.).

		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	18	0.279	143	91–212	0.264	0.168–0.391
2003–04	47 339	13.4	15	0.236	102	63–154	0.215	0.133–0.325
2004–05	44 156	17.2	22	0.290	119	79–176	0.269	0.179–0.399
2005–06	39 121	15.8	9	0.146	65	35–104	0.166	0.089–0.266
2006–07	35 188	20.6	8	0.110	51	27–81	0.145	0.077–0.230
2007–08	32 766	25.3	11	0.133	53	31–81	0.162	0.095–0.247
2008–09	29 978	24.7	13	0.176	56	34–84	0.187	0.113–0.280
2009–10	29 506	26.0	24	0.313	86	58–124	0.291	0.197–0.420
2010–11	27 393	22.7	36	0.579	119	83–167	0.434	0.303–0.610
2011–12	25 593	32.8	12	0.143	40	24–62	0.156	0.094–0.242
2012–13	23 972	49.3	19	0.161	38	28–53	0.159	0.117–0.221
2013–14	25 660	43.7	15	0.134	36	24–52	0.140	0.094–0.203
2014–15	25 621	44.1	27	0.239	61	45–82	0.238	0.176–0.320

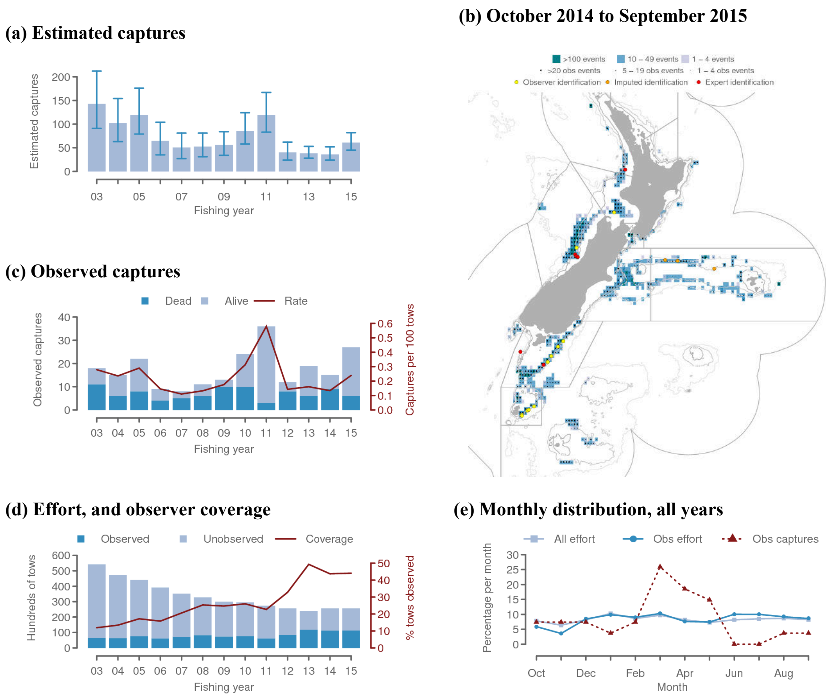


Figure B-31: Captures of other birds in large-vessel trawl fisheries. (a) Estimated captures, with 95% credible intervals, (b) Mapped effort and captures in 2014–15 (following confidentiality rules, 97.4% of total effort is shown), (c) Observed captures, (d) Effort and observed effort, and (e) Monthly distribution of fishing effort, observed effort, and observed captures.

APPENDIX C: SUMMARIES OF MODELS USED FOR THE SEABIRD ESTIMATION

C.1 White-capped albatross

Table C-32: Model strata with the highest number of estimated captures of white-capped albatross. 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 fishing method, fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2014–15 for bottom- and surface-longline fisheries, and between 2002–03 and 2014–15 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, c.i., of the total estimated number of captures. The cut-off length between small and large vessels was 28 m in trawl fisheries, 34 m in bottom-longline (BLL) fisheries, and 45 m in surface-longline (SLL) fisheries.

Method	Fishery	Vessel size	Area	Season	Observations				Estimated captures	
					Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
Trawl	Squid trawl	Large	Stewart-Snares Shelf	Summer	372	8 787	0.346	1 076	1 196	949–1 497
SLL	Southern bluefin SLL	Small	West Coast South Island	Autumn	40	101	0.048	839	606	215–1 368
Trawl	Squid trawl	Large	Auckland Islands	Summer	289	5 920	0.449	644	560	417–720
Trawl	Squid trawl	Large	Stewart-Snares Shelf	Autumn	105	2 487	0.294	357	402	281–558
Trawl	Squid trawl	Large	Auckland Islands	Autumn	71	2 145	0.313	227	286	195–402
Trawl	Inshore trawl	Small	Stewart-Snares Shelf	Summer	2	156	0.022	90	224	105–414
Trawl	Inshore trawl	Small	West Coast South Island	Summer	12	449	0.046	259	172	85–309
Trawl	Flatfish trawl	Small	Stewart-Snares Shelf	Summer	0	576	0.025	0	160	44–376
Trawl	Inshore trawl	Small	Stewart-Snares Shelf	Autumn	0	0	0.000		151	65–298
Trawl	Inshore trawl	Small	West Coast South Island	Autumn	2	13	0.002	1 299	151	72–276
SLL	Southern bluefin SLL	Small	East of North Island	Autumn	3	276	0.036	83	120	38–269
Trawl	Flatfish trawl	Small	Stewart-Snares Shelf	Autumn	3	32	0.002	1 434	108	28–259
SLL	Southern bluefin SLL	Large	Fiordland	Autumn	81	3 055	0.900	90	100	58–156
SLL	Southern bluefin SLL	Small	Fiordland	Autumn	0	0	0.000		95	19–268
SLL	Southern bluefin SLL	Small	West Coast South Island	Summer	0	0	0.000		89	20–244

Figure C-32: Trace of the three Monte Carlo Markov chains for the main parameters in the estimation of captures of white-capped albatross. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line.

Table C-33: Summary of the posterior distributions of the model parameters for white-capped albatross. Given the large number of parameters related to annual variation (with a coefficient for each year, method and vessel size), only the 95% credible interval, c.i., of the coefficient of variation (CV) is 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. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line. Significance of positive and negative effects is indicated by plus and minus symbols, respectively. Also shown are the number of chains (out of three) that failed the convergence test, the half-width test, and the effective percentage of samples lost due to autocorrelation (AC loss).

Parameter			Statistic	Significance			Diagnostics
	Median	Mean	95% c.i.		Convergence	Half-width	AC loss (%)
Intercept	0.01	0.01	0.00–0.02				43.2
Method - Large-vessel SLL	1.63	1.66	0.38–8.01				1.6
Method - Large-vessel BLL	0.28	0.29	0.04–2.58				1.3
Method - Small-vessel trawl	1.05	1.05	0.53–2.07			3	5.3
Method - Small-vessel SLL	13.15	13.50	3.07–69.46	+			4.9
Method - Small-vessel BLL	1.51	1.48	0.26–7.68			2	3.5
Region - North	0.07	0.07	0.02–0.38	-			8.3
Season - Autumn (Apr–Jun)	1.01	1.01	0.78–1.31			3	
Season - Winter (Jul–Sep)	0.29	0.29	0.18–0.47	-			
Season - Spring (Oct–Dec)	0.47	0.47	0.31–0.71	-			
CV(Year) - Trawl	0.37	0.38	0.22–0.63				
CV(Year) - SLL	0.60	0.60	0.10–1.09				
CV(Year) - BLL	0.84	0.99	0.04–2.84				
Area - Stewart–Snares Shelf	2.32	2.44	1.09–4.54	+			27.4
Area - Auckland Islands	2.10	2.23	0.96–4.12				23.1
Area - West Coast South Island	1.31	1.39	0.55–2.72				26.2
Area - Fiordland	1.20	1.29	0.49–2.61				19.2
Area - Western Chatham Rise	0.30	0.33	0.12–0.66	-			26.8
Area - East of North Island	1.04	1.23	0.19–3.39				
Area - Cook Strait	0.68	0.75	0.20–1.71				7.9
Area - West Coast North Island	0.93	1.09	0.17–3.09				
Area - Eastern Chatham Rise	0.11	0.12	0.03–0.30	-			14.0
Area - North East	0.61	0.74	0.10–2.15				
Area - South Subantarctic	0.16	0.22	0.01–0.73	-			2.8
Area - East Subantarctic	0.16	0.25	0.00–1.06				
Area - Kermadec Islands	0.56	0.80	0.01–2.94				4.0
CV(Area)	0.97	1.00	0.61–1.57				
Fishery - Squid trawl	2.30	2.40	1.08–4.33	+			21.7
Fishery - Southern bluefin SLL	1.86	2.15	0.51–5.50				
Fishery - Middle depths trawl	1.76	1.84	0.83–3.31				21.4
Fishery - Hoki trawl	0.62	0.66	0.28–1.21				23.2
Fishery - Inshore trawl	1.55	1.68	0.60–3.53				5.5
Fishery - Scampi trawl	0.98	1.07	0.38–2.20				1.0
Fishery - Mackerel trawl	0.66	0.72	0.25–1.52				12.8
Fishery - Hake trawl	0.51	0.56	0.20–1.15				7.1
Fishery - Ling trawl	1.03	1.12	0.39–2.40				
Fishery - Large-vessel ling (no IWL) BLL	1.35	1.66	0.21–4.91				
Fishery - Small-vessel ling BLL	1.69	2.03	0.43–5.53				
Fishery - Flatfish trawl	0.32	0.38	0.08–1.02				3.2
Fishery - Swordfish SLL	0.70	0.90	0.10–2.80				
Fishery - Bigeye SLL	0.35	0.47	0.03–1.60				
Fishery - Deepwater trawl	0.06	0.08	0.01–0.26	-			
Fishery - Large-vessel ling (IWL) BLL	0.26	0.41	0.00–1.71				
Fishery - Minor targets BLL	0.50	0.70	0.01–2.41				
Fishery - Bluenose BLL	0.50	0.72	0.01–2.66				10.0
Fishery - Snapper BLL	0.42	0.62	0.01–2.42				
Fishery - Hāpuku BLL	0.58	0.82	0.01–2.98				
Fishery - Albacore SLL	0.55	0.77	0.01–2.82				
Fishery - Minor surface longline	0.59	0.83	0.01–3.11				
Fishery - Southern blue whiting trawl	0.22	0.36	0.00–1.49				3.7
CV(Fishery)	0.96	0.99	0.61–1.53				
CV(Overdispersion) - Trawl	8.03	8.02	6.48–9.53				
CV(Overdispersion) - SLL	6.78	6.86	4.46–9.57				
CV(Overdispersion) - BLL	1.10	1.59	0.19–6.15				61.7
Deviance	1 258.98	1 259.97	1 197.83–1 324.05	+			

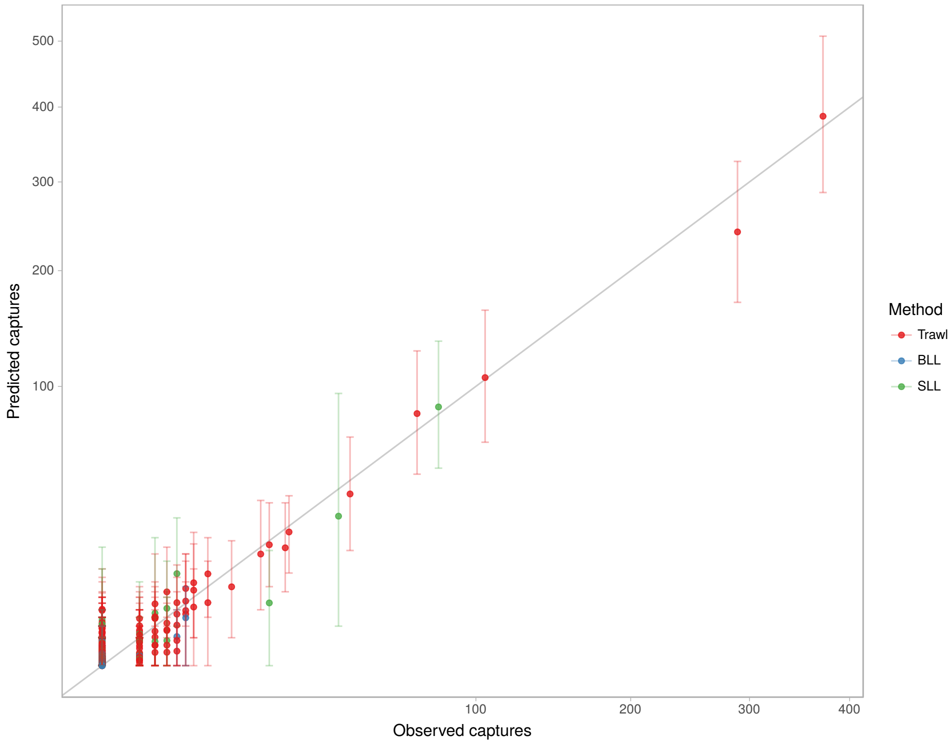


Figure C-33: Comparison between the observed and the predicted number of captures of white-capped albatross (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points are coloured according to the fishing method (BLL, bottom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

Table C-34: 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 four of these strata, representing 0.7% of all 577 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	5.05	0–17
Trawl	Ling trawl	Small	South	West Coast South Island	Autumn (Apr–Jun)	20	4	0.27	0–2
Trawl	Flatfish trawl	Small	South	Stewart–Snares Shelf	Autumn (Apr–Jun)	32	3	0.23	0–2
Trawl	Inshore trawl	Small	North	East of North Island	Spring (Oct–Dec)	19	1	0.01	0–0

C.2 Salvin's albatross

Table C-35: Model strata with the highest number of estimated captures of Salvin's albatross. 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 fishing method, fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2014–15 for bottom- and surface-longline fisheries, and between 2002–03 and 2014–15 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, c.i., of the total estimated number of captures. The cut-off length between small and large vessels was 28 m in trawl fisheries, 34 m in bottom-longline (BLL) fisheries, and 45 m in surface-longline (SLL) fisheries. IWL: Integrated weight line.

Method	Fishery	Vessel size	Area	Season	Observations				Estimated captures	
					Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
Trawl	Inshore trawl	Small	Western Chatham Rise	Spring	4	167	0.010	399	767	338–1 488
Trawl	Middle depths trawl	Small	Western Chatham Rise	Spring	0	35	0.006	0	361	132–821
Trawl	Inshore trawl	Small	Western Chatham Rise	Summer	14	453	0.022	650	295	135–564
BLL	Large-vessel ling (no IWL) BLL	Large	East Subantarctic	Spring	100	551	0.419	238	291	75–838
Trawl	Inshore trawl	Small	Western Chatham Rise	Winter	1	131	0.012	86	283	117–580
Trawl	Hoki trawl	Large	Eastern Chatham Rise	Spring	56	1 939	0.216	259	267	164–410
BLL	Large-vessel ling (no IWL) BLL	Large	Eastern Chatham Rise	Winter	1	964	0.148	6	266	92–651
BLL	Large-vessel ling (no IWL) BLL	Large	Eastern Chatham Rise	Spring	11	343	0.111	98	252	75–671
Trawl	Hoki trawl	Large	Western Chatham Rise	Spring	34	2 162	0.186	182	250	158–379
BLL	Small-vessel ling BLL	Small	Western Chatham Rise	Spring	1	43	0.015	65	232	75–569
BLL	Small-vessel ling BLL	Small	Eastern Chatham Rise	Spring	6	110	0.058	102	194	63–463
Trawl	Scampi trawl	Small	Eastern Chatham Rise	Spring	10	541	0.113	88	190	93–344
BLL	Small-vessel ling BLL	Small	Eastern Chatham Rise	Winter	22	159	0.051	433	171	61–385
Trawl	Inshore trawl	Small	East of North Island	Spring	0	19	0.001	0	166	40–442
BLL	Large-vessel ling (no IWL) BLL	Large	Western Chatham Rise	Spring	0	44	0.019	0	152	40–415

Figure C-34: Trace of the three Monte Carlo Markov chains for the main parameters in the estimation of captures of Salvin's albatross. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line.

Table C-36: Summary of the posterior distributions of the model parameters for Salvin's albatross. Given the large number of parameters related to annual variation (with a coefficient for each year, method and vessel size), only the 95% credible interval, c.i., of the coefficient of variation (CV) is 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. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line. Significance of positive and negative effects is indicated by plus and minus symbols, respectively. Also shown are the number of chains (out of three) that failed the convergence test, the half-width test, and the effective percentage of samples lost due to autocorrelation (AC loss).

Parameter	Statistic			Significance	Diagnostics		
	Median	Mean	95% c.i.		Convergence	Half-width	AC loss (%)
Intercept	0.01	0.01	0.00–0.03				61.4
Method - Large-vessel BLL	1.43	1.51	0.25–11.87			3	22.1
Method - Large-vessel SLL	20.69	20.86	2.20–230.21	+			
Method - Small-vessel trawl	1.76	1.77	0.74–4.14		1	1	2.7
Method - Small-vessel BLL	3.08	3.12	0.57–18.07				
Method - Small-vessel SLL	17.76	18.07	3.11–106.30	+			
Region - North	0.07	0.07	0.01–1.29				2.9
Season - Autumn (Apr–Jun)	0.21	0.21	0.10–0.39	-			
Season - Winter (Jul–Sep)	1.74	1.74	1.09–2.75	+			
Season - Spring (Oct–Dec)	3.24	3.25	2.22–4.78	+			
CV(Year) - Trawl	0.57	0.59	0.32–0.96				
CV(Year) - BLL	1.49	1.55	0.85–2.59				
CV(Year) - SLL	0.85	1.05	0.03–3.30				1.1
Area - Eastern Chatham Rise	1.62	1.83	0.33–4.43				38.7
Area - Western Chatham Rise	1.28	1.46	0.25–3.47				34.9
Area - East Subantarctic	4.41	4.97	1.04–12.31	+			28.5
Area - Stewart–Snares Shelf	0.17	0.19	0.03–0.49	-			38.2
Area - East of North Island	2.24	2.93	0.15–9.80				
Area - Cook Strait	0.31	0.39	0.06–1.16				27.7
Area - South Subantarctic	0.11	0.14	0.02–0.43	-			18.3
Area - North East	0.21	0.32	0.01–1.32				1.4
Area - Auckland Islands	0.02	0.03	0.00–0.12	-			16.4
Area - Fiordland	0.03	0.04	0.00–0.16	-			20.2
Area - West Coast South Island	0.01	0.01	0.00–0.04	-			7.6
Area - West Coast North Island	0.10	0.20	0.00–0.98	-			5.5
Area - Kermadec Islands	0.04	0.22	0.00–1.46			3	9.4
CV(Area)	1.63	1.66	1.14–2.39				14.6
Fishery - Large-vessel ling (no IWL) BLL	1.58	1.84	0.28–5.12				
Fishery - Hoki trawl	0.98	1.03	0.43–1.88				3.2
Fishery - Middle depths trawl	1.50	1.59	0.67–2.95				
Fishery - Scampi trawl	0.76	0.84	0.26–1.87				
Fishery - Small-vessel ling BLL	1.10	1.32	0.19–3.77				
Fishery - Squid trawl	1.48	1.60	0.62–3.28				
Fishery - Inshore trawl	1.09	1.21	0.37–2.77		1	1	
Fishery - Deepwater trawl	0.15	0.16	0.05–0.34	-			8.8
Fishery - Southern blue whiting trawl	0.33	0.39	0.09–1.02				7.4
Fishery - Ling trawl	1.61	1.79	0.63–3.90				
Fishery - Hake trawl	1.39	1.55	0.51–3.41				
Fishery - Bigeye SLL	1.51	1.79	0.39–4.74				
Fishery - Southern bluefin SLL	0.35	0.45	0.05–1.45				
Fishery - Minor targets BLL	1.38	1.71	0.26–5.08				
Fishery - Mackerel trawl	0.23	0.29	0.04–0.87	-			
Fishery - Large-vessel ling (IWL) BLL	0.16	0.25	0.01–0.99	-			
Fishery - Albacore SLL	1.11	1.36	0.16–3.93				
Fishery - Bluenose BLL	0.37	0.58	0.00–2.24				5.7
Fishery - Snapper BLL	0.47	0.68	0.01–2.61				
Fishery - Hāpuku BLL	0.42	0.65	0.01–2.58				2.1
Fishery - Swordfish SLL	0.57	0.81	0.01–2.85				5.1
Fishery - Minor surface longline	0.61	0.84	0.01–3.20				
Fishery - Flatfish trawl	0.11	0.19	0.00–0.83	-			6.8
CV(Fishery)	0.97	0.99	0.61–1.50				
CV(Overdispersion) - Trawl	9.35	9.23	7.94–9.92				
CV(Overdispersion) - BLL	9.53	9.38	8.09–9.94				
CV(Overdispersion) - SLL	1.72	2.48	0.23–8.16			1	73.6
Deviance	959.76	959.68	907.75–1 016.78	+			24.5

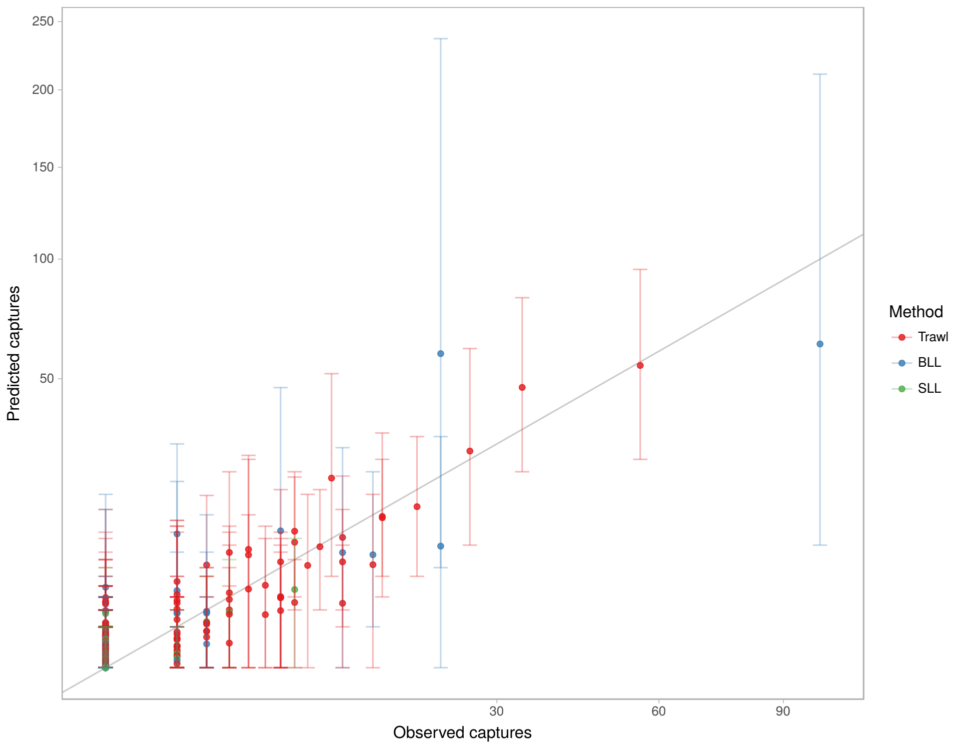


Figure C-35: Comparison between the observed and the predicted number of captures of Salvin's albatross (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points are coloured according to the fishing method (BLL, bottom longline;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

Table C-37: 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 three of these strata, representing 0.5% of all 577 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.
BLL	Large-vessel ling (no IWL) BLL	Large	South	Eastern Chatham Rise	Winter (Jul–Sep)	964	1	10.72	2–30
Trawl	Middle depths trawl	Large	South	Western Chatham Rise	Winter (Jul–Sep)	190	11	2.49	0–9
Trawl	Middle depths trawl	Small	South	West Coast South Island	Summer (Jan–Mar)	80	1	0.01	0–0

C.3 Buller's albatrosses

Table C-38: Model strata with the highest number of estimated captures of Buller's albatrosses. 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 fishing method, fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2014–15 for bottom- and surface-longline fisheries, and between 2002–03 and 2014–15 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, c.i., of the total estimated number of captures. The cut-off length between small and large vessels was 28 m in trawl fisheries, 34 m in bottom-longline (BLL) fisheries, and 45 m in surface-longline (SLL) fisheries.

Method	Fishery	Vessel size	Area	Season	Observations				Estimated captures	
					Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
SLL	Bigeye SLL	Small	East of North Island	Autumn	1	96	0.022	45	702	241–1 634
SLL	Southern bluefin SLL	Small	West Coast South Island	Autumn	31	101	0.048	650	525	211–1 138
SLL	Southern bluefin SLL	Large	Fiordland	Autumn	421	3 055	0.900	467	488	335–673
SLL	Southern bluefin SLL	Small	East of North Island	Autumn	14	276	0.036	391	468	214–882
SLL	Albacore SLL	Small	East of North Island	Autumn	0	23	0.015	0	251	55–747
SLL	Southern bluefin SLL	Small	Fiordland	Autumn	0	0	0.000		193	51–506
Trawl	Squid trawl	Large	Stewart-Snares Shelf	Autumn	62	2 487	0.294	211	157	101–230
SLL	Bigeye SLL	Small	North East	Autumn	2	54	0.012	165	150	47–356
SLL	Bigeye SLL	Small	East of North Island	Summer	6	151	0.025	238	131	47–293
Trawl	Hoki trawl	Large	West Coast South Island	Winter	37	11 591	0.316	117	100	66–142
SLL	Bigeye SLL	Small	North East	Winter	2	100	0.013	148	82	24–198
BLL	Bluenose BLL	Small	Eastern Chatham Rise	Autumn	2	26	0.016	125	79	15–211
Trawl	Hoki trawl	Large	Stewart-Snares Shelf	Autumn	18	1 677	0.265	68	72	40–114
Trawl	Flatfish trawl	Small	Stewart-Snares Shelf	Autumn	0	32	0.002	0	67	0–256
Trawl	Squid trawl	Large	Stewart-Snares Shelf	Summer	18	8 787	0.346	52	66	40–98

Figure C-36: Trace of the three Monte Carlo Markov chains for the main parameters in the estimation of captures of Buller's albatrosses. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line.

Table C-39: Summary of the posterior distributions of the model parameters for Buller's albatrosses. Given the large number of parameters related to annual variation (with a coefficient for each year, method and vessel size), only the 95% credible interval, c.i., of the coefficient of variation (CV) is shown. Base levels of the factor covariates are: Large SLL 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. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line. Significance of positive and negative effects is indicated by plus and minus symbols, respectively. Also shown are the number of chains (out of three) that failed the convergence test, the half-width test, and the effective percentage of samples lost due to autocorrelation (AC loss).

Parameter	Statistic			Significance	Diagnostics		
	Median	Mean	95% c.i.		Convergence	Half-width	AC loss (%)
Intercept	0.01	0.01	0.00–0.07				70.6
Method - Large-vessel trawl	0.08	0.08	0.02–0.35	-			47.3
Method - Large-vessel BLL	0.05	0.05	0.01–0.55	-			14.1
Method - Small-vessel SLL	3.46	3.48	1.49–8.46	+			
Method - Small-vessel trawl	0.07	0.07	0.01–0.36	-			31.7
Method - Small-vessel BLL	0.27	0.27	0.05–1.53				23.0
Region - North	0.14	0.15	0.02–1.40				26.9
Season - Autumn (Apr–Jun)	7.26	7.28	5.00–10.50	+			5.4
Season - Winter (Jul–Sep)	2.39	2.40	1.47–3.88	+			
Season - Spring (Oct–Dec)	0.38	0.37	0.16–0.79	-			
CV(Year) - SLL	0.20	0.23	0.01–0.61				
CV(Year) - Trawl	0.36	0.37	0.09–0.68				
CV(Year) - BLL	0.99	1.16	0.04–3.28				
Area - Fiordland	2.73	2.98	0.78–6.84				42.5
Area - Stewart–Snares Shelf	1.66	1.80	0.45–4.09				32.4
Area - West Coast South Island	1.28	1.38	0.33–3.17				39.3
Area - East of North Island	2.34	2.79	0.27–8.16				
Area - Eastern Chatham Rise	1.30	1.43	0.35–3.36				34.6
Area - Auckland Islands	0.54	0.60	0.13–1.43				28.5
Area - Western Chatham Rise	0.46	0.51	0.12–1.22				31.4
Area - North East	0.48	0.63	0.05–2.14				
Area - South Subantarctic	0.07	0.11	0.00–0.47	-			3.6
Area - East Subantarctic	0.07	0.20	0.00–1.12			1	19.0
Area - Cook Strait	0.02	0.06	0.00–0.32	-			2.7
Area - West Coast North Island	0.03	0.10	0.00–0.61	-		1	3.0
Area - Kermadec Islands	0.12	0.32	0.00–1.80				12.8
CV(Area)	1.35	1.41	0.83–2.29				19.6
Fishery - Southern bluefin SLL	0.61	0.70	0.17–1.70				43.2
Fishery - Squid trawl	1.66	1.76	0.72–3.39				
Fishery - Hoki trawl	0.97	1.02	0.42–1.91				
Fishery - Middle depths trawl	1.79	1.88	0.80–3.55				
Fishery - Bigeye SLL	1.53	1.72	0.45–4.10				23.9
Fishery - Scampi trawl	1.57	1.75	0.47–4.05				
Fishery - Albacore SLL	1.40	1.64	0.35–4.26				
Fishery - Small-vessel ling BLL	0.96	1.15	0.21–3.22				1.2
Fishery - Ling trawl	1.45	1.60	0.50–3.58				
Fishery - Hake trawl	0.44	0.48	0.12–1.09				
Fishery - Large-vessel ling (no IWL) BLL	1.42	1.72	0.27–4.95				
Fishery - Deepwater trawl	0.11	0.13	0.03–0.34	-			
Fishery - Mackerel trawl	0.42	0.48	0.11–1.18				
Fishery - Bluenose BLL	1.34	1.59	0.32–4.28				
Fishery - Swordfish SLL	0.31	0.44	0.02–1.61				
Fishery - Southern blue whiting trawl	0.70	0.91	0.07–3.05				
Fishery - Large-vessel ling (IWL) BLL	0.22	0.35	0.00–1.51				
Fishery - Minor targets BLL	0.56	0.76	0.01–2.72				
Fishery - Snapper BLL	0.41	0.59	0.01–2.24				
Fishery - Hāpuku BLL	0.54	0.74	0.01–2.53				4.7
Fishery - Minor surface longline	0.62	0.86	0.01–3.19				
Fishery - Flatfish trawl	0.31	0.44	0.00–1.61				
Fishery - Inshore trawl	0.23	0.35	0.00–1.35				
CV(Fishery)	0.92	0.95	0.57–1.49				5.6
CV(Overdispersion) - SLL	6.52	6.57	5.02–8.39				
CV(Overdispersion) - Trawl	7.88	7.83	5.62–9.73				10.6
CV(Overdispersion) - BLL	1.52	2.11	0.23–7.07				64.0
Deviance	1 018.13	1 019.36	962.49–1 082.52	+			8.2

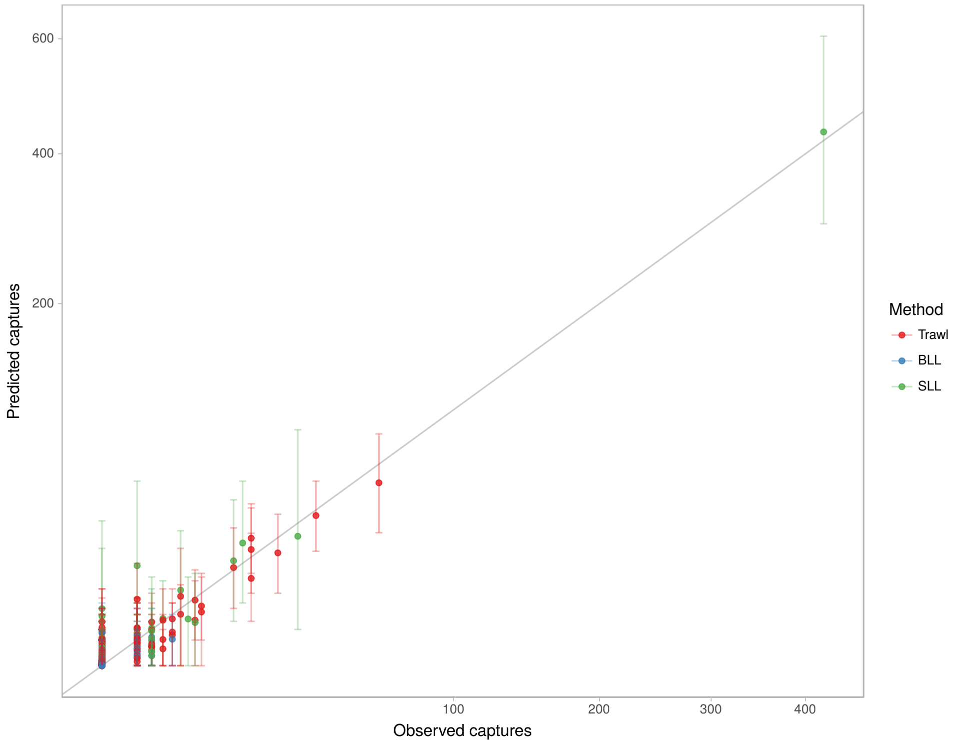


Figure C-37: Comparison between the observed and the predicted number of captures of Buller's albatrosses (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points are coloured according to the fishing method (BLL, bottom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

Table C-40: 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 three of these strata, representing 0.5% of all 577 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	South	Eastern Chatham Rise	Summer (Jan–Mar)	240	3	0.43	0–2
BLL	Large-vessel ling (no IWL) BLL	Large	South	Western Chatham Rise	Winter (Jul–Sep)	47	2	0.15	0–1
Trawl	Mackerel trawl	Large	South	Eastern Chatham Rise	Summer (Jan–Mar)	42	1	0.03	0–0

C.4 Other albatrosses

Table C-41: Model strata with the highest number of estimated captures of other albatrosses. 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 fishing method, fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2014–15 for bottom- and surface-longline fisheries, and between 2002–03 and 2014–15 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, c.i., of the total estimated number of captures. The cut-off length between small and large vessels was 28 m in trawl fisheries, 34 m in bottom-longline (BLL) fisheries, and 45 m in surface-longline (SLL) fisheries.

Method	Fishery	Vessel size	Area	Season	Observations				Estimated captures	
					Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
SLL	Southern bluefin SLL	Small	East of North Island	Autumn	12	276	0.036	335	529	262–978
SLL	Bigeye SLL	Small	North East	Spring	21	158	0.024	891	467	232–858
SLL	Bigeye SLL	Small	East of North Island	Autumn	0	96	0.022	0	291	110–627
SLL	Bigeye SLL	Small	North East	Winter	2	100	0.013	148	263	117–519
SLL	Bigeye SLL	Small	East of North Island	Summer	3	151	0.025	119	244	93–532
SLL	Albacore SLL	Small	East of North Island	Autumn	0	23	0.015	0	221	65–565
SLL	Bigeye SLL	Small	North East	Autumn	1	54	0.012	82	143	62–290
BLL	Bluenose BLL	Small	East of North Island	Spring	0	0	0.000		137	27–415
SLL	Bigeye SLL	Small	East of North Island	Spring	0	11	0.013	0	127	44–296
SLL	Southern bluefin SLL	Small	East of North Island	Winter	14	168	0.101	138	125	55–243
BLL	Snapper BLL	Small	North East	Spring	0	340	0.009	0	122	5–400
SLL	Southern bluefin SLL	Small	North East	Winter	6	265	0.093	64	108	46–216
SLL	Bigeye SLL	Small	North East	Summer	3	144	0.028	107	101	43–201
BLL	Small-vessel ling BLL	Small	East of North Island	Spring	0	0	0.000		95	23–257
BLL	Small-vessel ling BLL	Small	East of North Island	Winter	1	48	0.009	107	88	26–212

Figure C-38: Trace of the three Monte Carlo Markov chains for the main parameters in the estimation of captures of other albatrosses. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line.

Table C-42: Summary of the posterior distributions of the model parameters for other albatrosses. Given the large number of parameters related to annual variation (with a coefficient for each year, method and vessel size), only the 95% credible interval, c.i., of the coefficient of variation (CV) is shown. Base levels of the factor covariates are: Large 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. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line. Significance of positive and negative effects is indicated by plus and minus symbols, respectively. Also shown are the number of chains (out of three) that failed the convergence test, the half-width test, and the effective percentage of samples lost due to autocorrelation (AC loss).

Parameter	Statistic			Significance	Diagnostics		
	Median	Mean	95% c.i.		Convergence	Half-width	AC loss (%)
Intercept	0.04	0.04	0.01–0.14				12.6
Method - Large-vessel trawl	0.01	0.01	0.00–0.03	-			
Method - Large-vessel BLL	0.07	0.07	0.01–0.44	-			
Method - Small-vessel SLL	1.28	1.30	0.63–2.83				
Method - Small-vessel trawl	0.01	0.01	0.00–0.03	-			3.0
Method - Small-vessel BLL	0.10	0.10	0.03–0.39	-			2.7
Region - South	1.04	1.03	0.33–3.20			3	4.4
Season - Autumn (Apr–Jun)	1.63	1.63	0.92–2.92				5.4
Season - Winter (Jul–Sep)	1.80	1.80	0.96–3.31				7.3
Season - Spring (Oct–Dec)	3.58	3.59	2.02–6.45	+			
CV(Year) - SLL	0.22	0.27	0.01–0.80				2.6
CV(Year) - Trawl	0.17	0.21	0.01–0.58				2.6
CV(Year) - BLL	1.18	1.23	0.45–2.24				
Area - East of North Island	1.62	1.74	0.63–3.56				
Area - Kermadec Islands	1.02	1.13	0.32–2.67				
Area - North East	0.81	0.87	0.30–1.82				2.8
Area - Eastern Chatham Rise	1.97	2.06	1.02–3.57	+			
Area - Stewart–Snares Shelf	1.14	1.20	0.56–2.17				4.0
Area - West Coast South Island	0.75	0.79	0.32–1.51		1	1	4.2
Area - Fiordland	0.17	0.19	0.06–0.44	-			
Area - South Subantarctic	0.92	0.98	0.38–1.99				
Area - Auckland Islands	1.17	1.25	0.49–2.43				
Area - Western Chatham Rise	0.89	0.94	0.38–1.76				2.0
Area - West Coast North Island	0.22	0.26	0.05–0.71	-			
Area - Cook Strait	0.97	1.08	0.30–2.43				4.4
Area - East Subantarctic	0.45	0.51	0.07–1.37				
CV(Area)	0.71	0.73	0.46–1.13				
Fishery - Southern bluefin SLL	0.56	0.60	0.20–1.23				3.0
Fishery - Swordfish SLL	2.03	2.25	0.90–4.87				
Fishery - Bigeye SLL	0.52	0.57	0.17–1.22				
Fishery - Large-vessel ling (no IWL) BLL	0.94	1.04	0.21–2.48				3.4
Fishery - Albacore SLL	1.06	1.17	0.35–2.61				4.9
Fishery - Hoki trawl	0.89	0.92	0.41–1.63				
Fishery - Small-vessel ling BLL	1.46	1.63	0.58–3.66				2.2
Fishery - Squid trawl	1.69	1.83	0.85–3.54				
Fishery - Deepwater trawl	0.80	0.84	0.35–1.55				1.3
Fishery - Scampi trawl	1.03	1.14	0.39–2.49				
Fishery - Large-vessel ling (IWL) BLL	0.67	0.74	0.13–1.81				
Fishery - Middle depths trawl	0.80	0.85	0.31–1.69				
Fishery - Southern blue whiting trawl	1.30	1.44	0.49–3.06				3.9
Fishery - Bluenose BLL	1.15	1.28	0.36–2.97				
Fishery - Ling trawl	0.96	1.04	0.26–2.31				
Fishery - Hake trawl	0.79	0.86	0.20–1.96				
Fishery - Minor targets BLL	0.78	0.87	0.14–2.20				2.7
Fishery - Hāpuku BLL	0.89	1.00	0.16–2.55				
Fishery - Inshore trawl	0.61	0.68	0.09–1.66				
Fishery - Snapper BLL	0.25	0.33	0.01–1.03				2.6
Fishery - Minor surface longline	0.62	0.71	0.04–2.03				
Fishery - Flatfish trawl	0.67	0.76	0.06–2.01				
Fishery - Mackerel trawl	0.37	0.44	0.02–1.24				3.3
CV(Fishery)	0.66	0.68	0.27–1.17				
CV(Overdispersion) - SLL	6.16	6.24	4.78–8.00				
CV(Overdispersion) - Trawl	0.98	1.49	0.18–6.30			3	93.3
CV(Overdispersion) - BLL	9.39	9.23	7.60–9.93				
Deviance	891.55	891.71	847.21–938.10	+			44.2

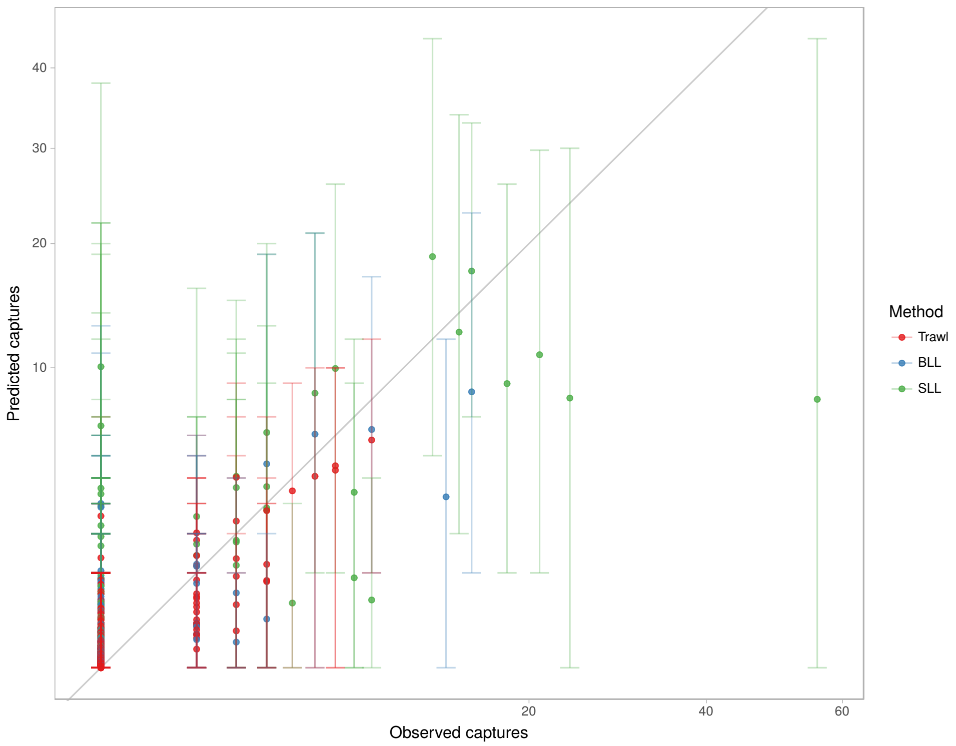


Figure C-39: Comparison between the observed and the predicted number of captures of other albatrosses (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points are coloured according to the fishing method (BLL, bottom longline;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

Table C-43: 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 seven of these strata, representing 1.2% of all 577 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	8.01	0–44
BLL	Small-vessel ling BLL	Small	South	Eastern Chatham Rise	Winter (Jul–Sep)	159	13	3.25	0–12
SLL	Southern bluefin SLL	Large	North	East of North Island	Autumn (Apr–Jun)	9	8	0.51	0–4
SLL	Bigeye SLL	Small	North	West Coast North Island	Spring (Oct–Dec)	23	4	0.46	0–3
BLL	Bluenose BLL	Small	North	North East	Autumn (Apr–Jun)	44	3	0.26	0–2
Trawl	Scampi trawl	Small	North	North East	Autumn (Apr–Jun)	337	2	0.15	0–1
BLL	Large-vessel ling (no IWL) BLL	Large	South	Auckland Islands	Autumn (Apr–Jun)	20	2	0.07	0–1

C.5 White-chinned petrel

Table C-44: Model strata with the highest number of estimated captures of white-chinned petrel. 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 fishing method, fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2014–15 for bottom- and surface-longline fisheries, and between 2002–03 and 2014–15 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, c.i., of the total estimated number of captures. The cut-off length between small and large vessels was 28 m in trawl fisheries, 34 m in bottom-longline (BLL) fisheries, and 45 m in surface-longline (SLL) fisheries. IWL: Integrated weight line.

Method	Fishery	Vessel size	Area	Season	Observations				Estimated captures	
					Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
Trawl	Squid trawl	Large	Stewart-Snares Shelf	Summer	431	8 787	0.346	1 246	1 040	790–1 355
BLL	Large-vessel ling (no IWL) BLL	Large	Stewart-Snares Shelf	Spring	145	910	0.465	311	987	409–2 054
Trawl	Squid trawl	Large	Auckland Islands	Summer	371	5 920	0.449	826	731	519–1 002
BLL	Large-vessel ling (no IWL) BLL	Large	Eastern Chatham Rise	Spring	324	343	0.111	2 908	605	264–1 243
BLL	Large-vessel ling (no IWL) BLL	Large	East Subantarctic	Summer	82	526	0.368	222	556	166–1 433
BLL	Large-vessel ling (no IWL) BLL	Large	Eastern Chatham Rise	Summer	40	285	0.170	234	465	142–1 153
BLL	Bluenose BLL	Small	Eastern Chatham Rise	Summer	0	32	0.018	0	425	22–2 002
BLL	Large-vessel ling (no IWL) BLL	Large	Western Chatham Rise	Spring	5	44	0.019	263	375	139–850
BLL	Small-vessel ling BLL	Small	Western Chatham Rise	Spring	3	43	0.015	195	341	97–875
BLL	Large-vessel ling (no IWL) BLL	Large	East Subantarctic	Spring	68	551	0.419	162	334	105–852
BLL	Large-vessel ling (no IWL) BLL	Large	Eastern Chatham Rise	Autumn	0	9	0.005	0	291	106–640
BLL	Large-vessel ling (no IWL) BLL	Large	South Subantarctic	Summer	13	12	0.007	1 742	276	70–759
BLL	Large-vessel ling (no IWL) BLL	Large	Western Chatham Rise	Summer	6	65	0.052	115	268	79–682
BLL	Small-vessel ling BLL	Small	Eastern Chatham Rise	Spring	24	110	0.058	411	263	82–676
BLL	Small-vessel ling BLL	Small	Eastern Chatham Rise	Summer	0	8	0.006	0	241	66–652

Figure C-40: Trace of the three Monte Carlo Markov chains for the main parameters in the estimation of captures of white-chinned petrel. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line.

Table C-45: Summary of the posterior distributions of the model parameters for white-chinned petrel. Given the large number of parameters related to annual variation (with a coefficient for each year, method and vessel size), only the 95% credible interval, c.i., of the coefficient of variation (CV) is 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. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line. Significance of positive and negative effects is indicated by plus and minus symbols, respectively. Also shown are the number of chains (out of three) that failed the convergence test, the half-width test, and the effective percentage of samples lost due to autocorrelation (AC loss).

Parameter	Statistic			Significance	Diagnostics		
	Median	Mean	95% c.i.		Convergence	Half-width	AC loss (%)
Intercept	0.01	0.01	0.00–0.05				78.4
Method - Large-vessel BLL	10.13	10.20	1.72–62.23	+			77.2
Method - Large-vessel SLL	18.58	19.47	2.33–201.64	+			22.1
Method - Small-vessel trawl	0.19	0.19	0.07–0.48	-			33.5
Method - Small-vessel BLL	18.11	18.77	3.14–140.68	+			36.0
Method - Small-vessel SLL	205.95	216.97	26.66–2 437.69	+			26.1
Region - North	0.01	0.01	0.00–0.08	-			10.1
Season - Autumn (Apr–Jun)	0.47	0.47	0.35–0.62	-			
Season - Winter (Jul–Sep)	0.01	0.01	0.01–0.03	-			4.1
Season - Spring (Oct–Dec)	0.73	0.73	0.51–1.02				10.5
CV(Year) - Trawl	0.67	0.70	0.47–1.05				
CV(Year) - BLL	0.94	0.96	0.55–1.46				
CV(Year) - SLL	0.32	0.38	0.01–1.10				
Area - Stewart–Snares Shelf	1.96	2.04	0.93–3.66				37.7
Area - Auckland Islands	2.50	2.62	1.19–4.72	+			36.6
Area - Eastern Chatham Rise	0.88	0.93	0.39–1.74				30.1
Area - East Subantarctic	0.96	1.08	0.34–2.45				6.0
Area - Fiordland	0.63	0.68	0.24–1.42				19.4
Area - Western Chatham Rise	0.76	0.80	0.33–1.51				32.0
Area - South Subantarctic	0.62	0.69	0.23–1.48				9.0
Area - East of North Island	0.91	1.08	0.18–2.95				
Area - West Coast South Island	0.04	0.05	0.00–0.17	-			10.4
Area - North East	0.72	0.86	0.14–2.36				
Area - Cook Strait	0.26	0.32	0.06–0.87	-			
Area - West Coast North Island	0.58	0.71	0.09–2.10				
Area - Kermadec Islands	0.98	1.20	0.15–3.41				
CV(Area)	0.89	0.92	0.59–1.40				
Fishery - Squid trawl	2.19	2.34	0.81–4.77				63.8
Fishery - Large-vessel ling (no IWL) BLL	2.40	2.82	0.57–7.54				51.2
Fishery - Middle depths trawl	1.13	1.22	0.40–2.49				62.3
Fishery - Hoki trawl	0.52	0.56	0.18–1.15				64.8
Fishery - Scampi trawl	2.71	2.94	0.95–6.34				49.4
Fishery - Small-vessel ling BLL	0.84	1.07	0.12–3.36				
Fishery - Southern bluefin SLL	0.14	0.21	0.01–0.84	-			
Fishery - Large-vessel ling (IWL) BLL	0.48	0.60	0.09–1.79				36.9
Fishery - Mackerel trawl	0.96	1.07	0.31–2.44				53.6
Fishery - Minor targets BLL	0.82	1.07	0.14–3.58				
Fishery - Ling trawl	0.50	0.58	0.14–1.44				44.3
Fishery - Bigeye SLL	0.72	0.92	0.10–3.03				
Fishery - Swordfish SLL	1.14	1.44	0.15–4.39				
Fishery - Hake trawl	0.19	0.23	0.04–0.67	-			33.2
Fishery - Bluenose BLL	0.68	0.97	0.05–3.60				10.4
Fishery - Albacore SLL	1.78	2.18	0.29–6.45				
Fishery - Inshore trawl	0.48	0.65	0.04–2.21				3.3
Fishery - Deepwater trawl	0.02	0.02	0.00–0.08	-			36.6
Fishery - Snapper BLL	0.15	0.33	0.00–1.66				9.0
Fishery - Hāpuku BLL	0.21	0.48	0.00–2.55				
Fishery - Minor surface longline	0.35	0.63	0.00–2.97				
Fishery - Flatfish trawl	0.11	0.22	0.00–1.06				
Fishery - Southern blue whiting trawl	0.18	0.35	0.00–1.64				
CV(Fishery)	1.15	1.18	0.79–1.70				14.1
CV(Overdispersion) - Trawl	9.71	9.64	8.97–9.94				
CV(Overdispersion) - BLL	9.74	9.67	9.00–9.94				
CV(Overdispersion) - SLL	8.13	7.96	4.96–9.85				
Deviance	1 265.01	1 265.01	1 209.75–1 324.33	+			

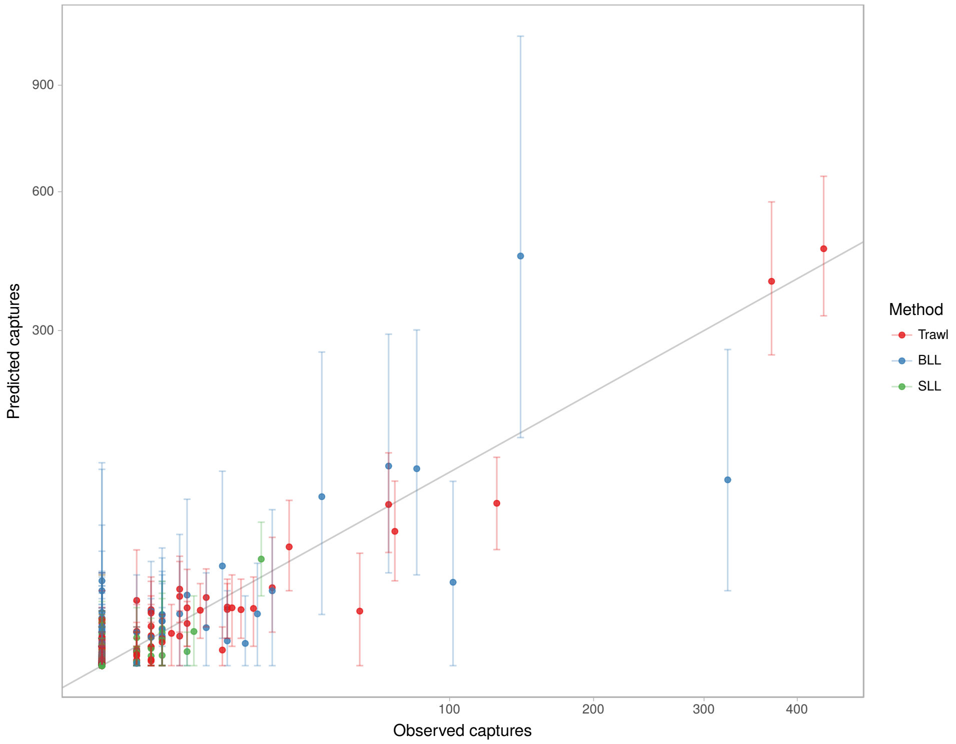


Figure C-41: Comparison between the observed and the predicted number of captures of white-chinned petrel (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points are coloured according to the fishing method (BLL, bottom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

Table C-46: 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 13 of these strata, representing 2.3% of all 577 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.
BLL	Large-vessel ling (no IWL) BLL	Large	South	Eastern Chatham Rise	Spring (Oct–Dec)	343	324	92.25	15–267
Trawl	Squid trawl	Large	South	Stewart–Snares Shelf	Autumn (Apr–Jun)	2 487	129	70.45	36–116
BLL	Large-vessel ling (no IWL) BLL	Large	South	Fiordland	Spring (Oct–Dec)	77	102	18.58	0–91
Trawl	Scampi trawl	Large	South	Auckland Islands	Summer (Jan–Mar)	111	55	7.94	0–34
BLL	Minor targets BLL	Small	South	Eastern Chatham Rise	Spring (Oct–Dec)	8	17	1.32	0–13
Trawl	Scampi trawl	Small	South	Auckland Islands	Summer (Jan–Mar)	38	12	0.65	0–4
SLL	Southern bluefin SLL	Large	South	South Subantarctic	Autumn (Apr–Jun)	55	6	0.53	0–3
SLL	Bigeye SLL	Small	North	West Coast North Island	Spring (Oct–Dec)	23	3	0.28	0–2
Trawl	Squid trawl	Large	South	South Subantarctic	Summer (Jan–Mar)	11	2	0.10	0–1
Trawl	Hoki trawl	Large	South	Fiordland	Spring (Oct–Dec)	33	2	0.05	0–1
BLL	Large-vessel ling (no IWL) BLL	Large	South	Stewart–Snares Shelf	Winter (Jul–Sep)	4	1	0.04	0–0
SLL	Southern bluefin SLL	Small	North	North East	Winter (Jul–Sep)	265	1	0.02	0–0
BLL	Bluenose BLL	Small	North	North East	Spring (Oct–Dec)	9	1	0.01	0–0

C.6 Black petrel

Table C-47: Model strata with the highest number of estimated captures of black petrel. 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 fishing method, fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2014–15 for bottom- and surface-longline fisheries, and between 2002–03 and 2014–15 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, c.i., of the total estimated number of captures. The cut-off length between small and large vessels was 28 m in trawl fisheries, 34 m in bottom-longline (BLL) fisheries, and 45 m in surface-longline (SLL) fisheries.

Method	Fishery	Vessel size	Area	Season	Observations				Estimated captures	
					Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
BLL	Snapper BLL	Small	North East	Summer	14	581	0.016	854	1 378	633–2 639
BLL	Bluenose BLL	Small	North East	Summer	9	36	0.006	1 529	1 236	302–3 708
BLL	Snapper BLL	Small	North East	Autumn	21	394	0.012	1 801	1 115	527–2 087
BLL	Bluenose BLL	Small	North East	Autumn	0	44	0.010	0	814	144–2 574
BLL	Snapper BLL	Small	North East	Spring	2	340	0.009	230	606	207–1 410
SLL	Bigeye SLL	Small	North East	Summer	7	144	0.028	249	556	184–1 370
SLL	Bigeye SLL	Small	North East	Autumn	0	54	0.012	0	427	116–1 152
BLL	Bluenose BLL	Small	North East	Spring	4	9	0.002	2 164	374	89–1 091
BLL	Bluenose BLL	Small	East of North Island	Summer	9	15	0.004	2 264	314	74–942
SLL	Bigeye SLL	Small	North East	Spring	11	158	0.024	466	268	92–633
SLL	Bigeye SLL	Small	East of North Island	Summer	14	151	0.025	555	259	94–577
BLL	Hāpuku BLL	Small	North East	Summer	0	1	0.001	0	239	34–869
BLL	Bluenose BLL	Small	East of North Island	Autumn	0	13	0.005	0	193	29–655
SLL	Bigeye SLL	Small	East of North Island	Autumn	0	96	0.022	0	173	44–471
BLL	Bluenose BLL	Small	East of North Island	Spring	0	0	0.000		164	24–539

Figure C-42: Trace of the three Monte Carlo Markov chains for the main parameters in the estimation of captures of black petrel. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line.

Table C-48: Summary of the posterior distributions of the model parameters for black petrel. Given the large number of parameters related to annual variation (with a coefficient for each year, method and vessel size), only the 95% credible interval, c.i., of the coefficient of variation (CV) is 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. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line. Significance of positive and negative effects is indicated by plus and minus symbols, respectively. Also shown are the number of chains (out of three) that failed the convergence test, the half-width test, and the effective percentage of samples lost due to autocorrelation (AC loss).

Parameter	Statistic			Significance	Diagnostics		
	Median	Mean	95% c.i.		Convergence	Half-width	AC loss (%)
Intercept	0.04	0.04	0.01–0.30				3.0
Method - Small-vessel SLL	1.37	1.46	0.24–12.76			3	6.0
Method - Small-vessel trawl	0.03	0.03	0.00–0.20	-			
Method - Large-vessel BLL	0.02	0.01	0.00–3.78				
Method - Large-vessel SLL	0.45	0.46	0.02–12.46			3	
Method - Large-vessel trawl	0.00	0.00	0.00–0.05	-			
Region - South	0.00	0.00	0.00–0.10	-			
Season - Autumn (Apr–Jun)	0.86	0.86	0.37–1.95			3	
Season - Winter (Jul–Sep)	0.03	0.03	0.00–0.22	-			
Season - Spring (Oct–Dec)	0.38	0.38	0.14–0.94	-			
CV(Year) - BLL	0.57	0.99	0.01–4.15				3.1
CV(Year) - SLL	0.48	0.78	0.01–3.26				
CV(Year) - Trawl	0.59	0.97	0.02–3.97				7.3
Area - North East	1.92	2.31	0.45–6.18				
Area - East of North Island	0.82	0.99	0.15–2.95				
Area - West Coast North Island	0.13	0.21	0.00–0.82	-			
Area - Kermadec Islands	0.63	0.82	0.03–2.88				
Area - East Subantarctic	0.67	0.96	0.00–3.90				
Area - Eastern Chatham Rise	0.64	0.92	0.00–3.79				
Area - Western Chatham Rise	0.66	0.95	0.00–3.80				
Area - South Subantarctic	0.67	0.97	0.00–4.07				
Area - Auckland Islands	0.69	1.01	0.00–4.01				4.6
Area - Stewart–Snares Shelf	0.69	0.95	0.00–3.83				
Area - Cook Strait	0.68	0.98	0.00–3.96				4.4
Area - Fiordland	0.64	0.91	0.00–3.64		1	1	
Area - West Coast South Island	0.67	0.95	0.00–3.64				
CV(Area)	1.03	1.12	0.38–2.33				
Fishery - Snapper BLL	0.52	0.60	0.10–1.62				2.9
Fishery - Bigeye SLL	0.97	1.13	0.12–3.15				4.9
Fishery - Bluenose BLL	2.19	2.59	0.59–6.70				
Fishery - Inshore trawl	1.23	1.52	0.22–4.59				3.9
Fishery - Hāpuku BLL	1.17	1.50	0.24–4.77				6.2
Fishery - Minor surface longline	1.14	1.43	0.16–4.58				
Fishery - Albacore SLL	1.12	1.44	0.15–4.68				4.2
Fishery - Swordfish SLL	0.66	0.87	0.05–2.92				
Fishery - Minor targets BLL	0.33	0.49	0.02–1.82				
Fishery - Scampi trawl	0.63	0.82	0.04–2.75				
Fishery - Large-vessel ling (no IWL) BLL	0.67	0.98	0.00–3.87				
Fishery - Large-vessel ling (IWL) BLL	0.65	0.94	0.00–3.72				25.8
Fishery - Small-vessel ling BLL	0.24	0.43	0.00–1.79				2.6
Fishery - Southern bluefin SLL	0.04	0.13	0.00–0.80	-			
Fishery - Flatfish trawl	0.57	0.82	0.00–3.14				
Fishery - Hoki trawl	0.63	0.88	0.00–3.47				4.6
Fishery - Middle depths trawl	0.56	0.78	0.00–3.07				
Fishery - Deepwater trawl	0.52	0.75	0.00–3.02				4.1
Fishery - Ling trawl	0.67	0.95	0.00–3.78				2.8
Fishery - Hake trawl	0.73	1.03	0.00–4.07				2.5
Fishery - Squid trawl	0.67	0.95	0.00–3.68				8.7
Fishery - Southern blue whiting trawl	0.68	0.99	0.00–4.06				1.1
Fishery - Mackerel trawl	0.64	0.92	0.00–3.56				10.6
CV(Fishery)	1.05	1.08	0.35–1.99				
CV(Overdispersion) - BLL	7.95	7.81	5.09–9.82				12.7
CV(Overdispersion) - SLL	8.73	8.52	6.19–9.90				
CV(Overdispersion) - Trawl	0.98	1.62	0.17–7.50			3	93.8
Deviance	216.63	217.36	192.64–246.09	+			4.0

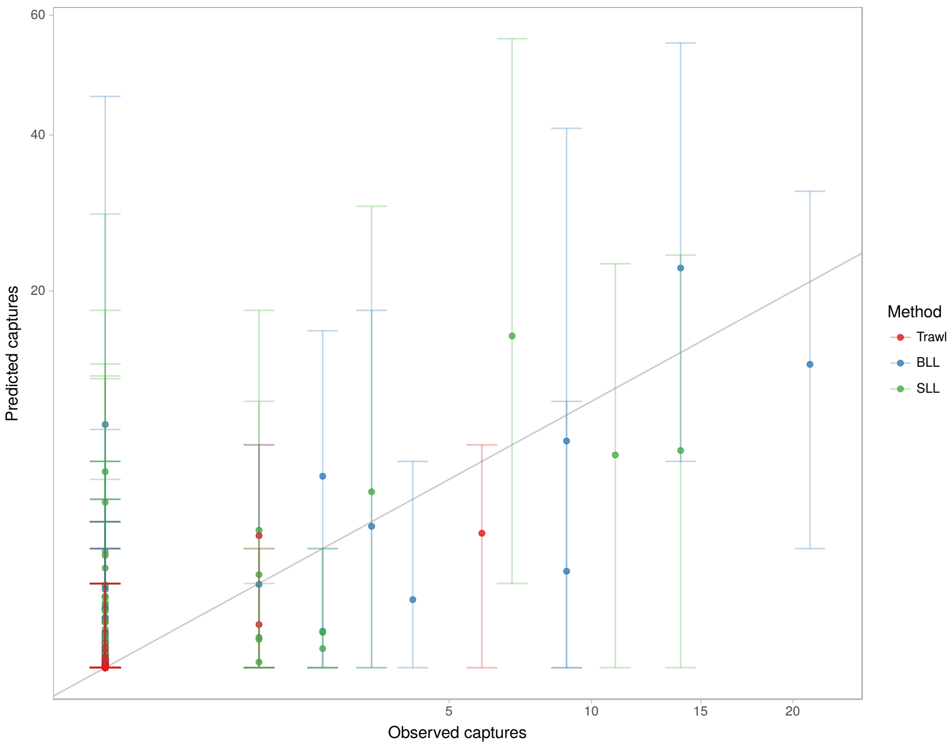


Figure C-43: Comparison between the observed and the predicted number of captures of black petrel (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points are coloured according to the fishing method (BLL, bottom longline; SLL, surface longline).

Table C-49: 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 577 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	0.05	0–0
SLL	Albacore SLL	Large	North	North East	Winter (Jul–Sep)	2	1	0.00	0–0

C.7 Grey petrel

Table C-50: Model strata with the highest number of estimated captures of grey petrel. 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 fishing method, fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2014–15 for bottom- and surface-longline fisheries, and between 2002–03 and 2014–15 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, c.i., of the total estimated number of captures. The cut-off length between small and large vessels was 28 m in trawl fisheries, 34 m in bottom-longline (BLL) fisheries, and 45 m in surface-longline (SLL) fisheries. IWL: Integrated weight line.

Method	Fishery	Vessel size	Area	Season	Observations				Estimated captures	
					Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
BLL	Snapper BLL	Small	North East	Winter	0	0	0.000		1 399	414–3 445
BLL	Snapper BLL	Small	North East	Autumn	11	394	0.012	943	582	204–1 360
BLL	Small-vessel ling BLL	Small	East of North Island	Winter	0	48	0.009	0	517	65–1 852
BLL	Large-vessel ling (no IWL) BLL	Large	South Subantarctic	Autumn	105	355	0.202	520	390	142–885
BLL	Large-vessel ling (no IWL) BLL	Large	Eastern Chatham Rise	Winter	9	964	0.148	60	332	99–869
SLL	Southern bluefin SLL	Small	East of North Island	Autumn	12	276	0.036	335	280	114–581
BLL	Large-vessel ling (no IWL) BLL	Large	Auckland Islands	Winter	99	165	0.359	276	272	46–918
BLL	Large-vessel ling (no IWL) BLL	Large	Western Chatham Rise	Winter	10	47	0.027	374	246	48–765
BLL	Large-vessel ling (no IWL) BLL	Large	South Subantarctic	Winter	103	55	0.185	556	166	24–541
BLL	Bluenose BLL	Small	East of North Island	Winter	0	6	0.002	0	160	2–831
SLL	Southern bluefin SLL	Small	East of North Island	Winter	7	168	0.101	69	155	57–365
BLL	Large-vessel ling (no IWL) BLL	Large	East Subantarctic	Autumn	0	8	0.013	0	120	22–372
BLL	Snapper BLL	Small	North East	Spring	0	340	0.009	0	117	22–345
BLL	Hāpuku BLL	Small	East of North Island	Winter	0	0	0.000		76	0–402
Trawl	Southern blue whiting trawl	Large	South Subantarctic	Winter	32	4 644	0.529	60	68	40–107

Figure C-44: Trace of the three Monte Carlo Markov chains for the main parameters in the estimation of captures of grey petrel. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line.

Table C-51: Summary of the posterior distributions of the model parameters for grey petrel. Given the large number of parameters related to annual variation (with a coefficient for each year, method and vessel size), only the 95% credible interval, c.i., of the coefficient of variation (CV) is shown. Base levels of the factor covariates are: Large BLL 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. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line. Significance of positive and negative effects is indicated by plus and minus symbols, respectively. Also shown are the number of chains (out of three) that failed the convergence test, the half-width test, and the effective percentage of samples lost due to autocorrelation (AC loss).

Parameter	Statistic			Significance	Diagnostics		
	Median	Mean	95% c.i.		Convergence	Half-width	AC loss (%)
Intercept	0.00	0.00	0.00–0.01				81.9
Method - Large-vessel SLL	0.52	0.52	0.04–6.48			3	31.9
Method - Large-vessel trawl	0.02	0.02	0.00–0.13	-			53.4
Method - Small-vessel BLL	0.36	0.35	0.04–3.31				31.7
Method - Small-vessel SLL	0.43	0.43	0.03–5.51			2	33.0
Method - Small-vessel trawl	0.00	0.00	0.00–0.02	-			7.1
Region - North	2.00	2.10	0.15–39.29			3	28.4
Season - Autumn (Apr–Jun)	54.25	58.18	11.40–447.84	+			67.6
Season - Winter (Jul–Sep)	138.86	147.10	28.66–1 105.00	+			65.5
Season - Spring (Oct–Dec)	8.54	9.03	1.43–80.33	+			64.7
CV(Year) - BLL	2.05	2.11	1.19–3.35				
CV(Year) - SLL	0.29	0.37	0.01–1.23				
CV(Year) - Trawl	0.61	0.62	0.08–1.25		1	1	21.0
Area - South Subantarctic	1.85	2.18	0.35–5.84				38.9
Area - Auckland Islands	1.89	2.34	0.32–6.88				17.5
Area - East of North Island	1.73	2.33	0.11–8.09				3.2
Area - Eastern Chatham Rise	0.38	0.48	0.06–1.43				20.6
Area - North East	0.36	0.54	0.02–2.03				
Area - Western Chatham Rise	0.85	1.08	0.14–3.30				16.3
Area - East Subantarctic	1.75	2.07	0.32–5.68				33.5
Area - Kermadec Islands	0.72	1.16	0.03–4.85				
Area - Stewart–Snares Shelf	0.07	0.13	0.00–0.57	-			7.9
Area - Fiordland	0.02	0.05	0.00–0.28	-			3.3
Area - Cook Strait	0.01	0.06	0.00–0.45	-		3	4.7
Area - West Coast South Island	0.00	0.01	0.00–0.09	-		3	
Area - West Coast North Island	0.01	0.05	0.00–0.32	-		3	
CV(Area)	1.65	1.69	1.07–2.57				
Fishery - Large-vessel ling (no IWL) BLL	0.96	1.13	0.18–3.09				35.0
Fishery - Large-vessel ling (IWL) BLL	1.12	1.34	0.22–3.80				10.9
Fishery - Southern bluefin SLL	0.73	0.88	0.11–2.58				
Fishery - Southern blue whiting trawl	2.33	2.59	0.78–6.01				
Fishery - Snapper BLL	1.81	2.17	0.44–5.93				
Fishery - Small-vessel ling BLL	0.73	0.92	0.12–2.86				
Fishery - Albacore SLL	0.63	0.80	0.06–2.57				
Fishery - Hoki trawl	1.03	1.17	0.23–3.02				3.9
Fishery - Swordfish SLL	1.69	2.04	0.38–5.65				
Fishery - Minor targets BLL	0.59	0.81	0.05–2.88				5.0
Fishery - Deepwater trawl	0.29	0.35	0.04–1.02				
Fishery - Bluenose BLL	0.29	0.45	0.01–1.77				3.6
Fishery - Bigeye SLL	0.18	0.27	0.01–1.03				
Fishery - Ling trawl	1.23	1.52	0.20–4.43				4.7
Fishery - Squid trawl	0.40	0.52	0.03–1.65				
Fishery - Hāpuku BLL	0.45	0.67	0.00–2.56				
Fishery - Minor surface longline	0.65	0.93	0.01–3.47				2.7
Fishery - Flatfish trawl	0.69	0.96	0.01–3.56				16.2
Fishery - Inshore trawl	0.58	0.81	0.01–2.85				
Fishery - Middle depths trawl	0.31	0.45	0.00–1.68				
Fishery - Hake trawl	0.62	0.86	0.01–3.15				
Fishery - Scampi trawl	0.43	0.60	0.00–2.16				5.6
Fishery - Mackerel trawl	0.48	0.67	0.00–2.54				9.9
CV(Fishery)	0.98	1.00	0.46–1.66				
CV(Overdispersion) - BLL	9.39	9.21	7.54–9.93				
CV(Overdispersion) - SLL	6.54	6.53	3.39–9.55				
CV(Overdispersion) - Trawl	4.71	4.74	0.25–9.82			3	98.1
Deviance	461.35	461.12	412.66–510.08	+			93.9

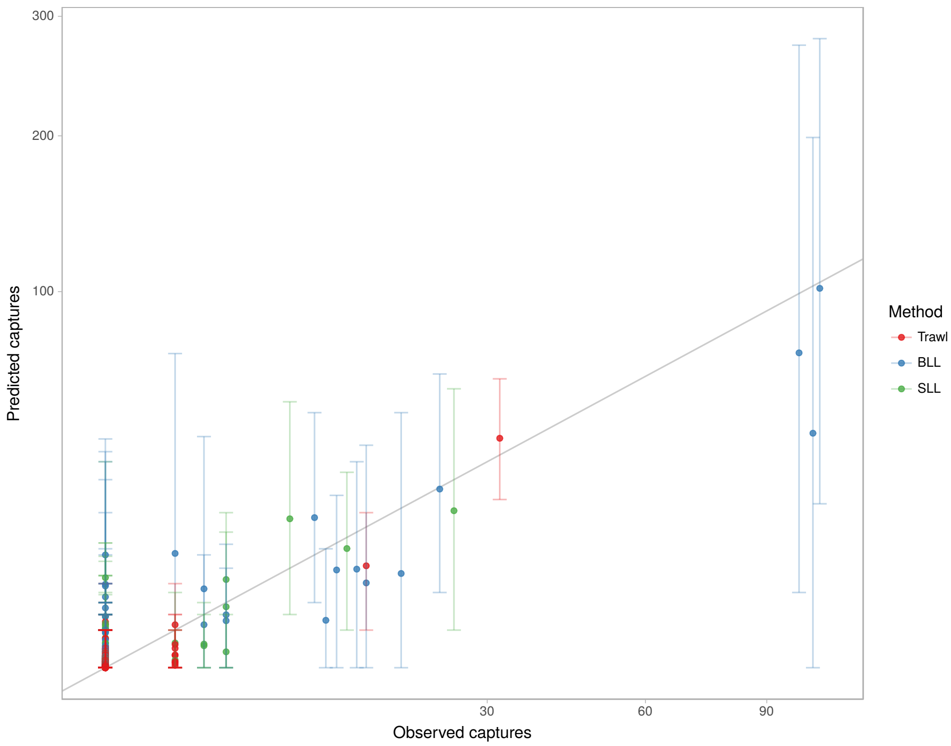


Figure C-45: Comparison between the observed and the predicted number of captures of grey petrel (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points are coloured according to the fishing method (BLL, bottom longline; SLL, surface longline).

Table C-52: 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 577 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	3	0.18	0–2
Trawl	Hoki trawl	Large	South	Stewart–Snares Shelf	Spring (Oct–Dec)	1 496	1	0.02	0–0
Trawl	Hoki trawl	Large	South	Fiordland	Winter (Jul–Sep)	140	1	0.01	0–0
Trawl	Squid trawl	Large	South	Western Chatham Rise	Winter (Jul–Sep)	5	1	0.00	0–0

C.8 Sooty shearwater

Table C-53: Model strata with the highest number of estimated captures of sooty shearwater. 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 fishing method, fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2014–15 for bottom- and surface-longline fisheries, and between 2002–03 and 2014–15 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, c.i., of the total estimated number of captures. The cut-off length between small and large vessels was 28 m in trawl fisheries, 34 m in bottom-longline (BLL) fisheries, and 45 m in surface-longline (SLL) fisheries. IWL: Integrated weight line.

Method	Fishery	Vessel size	Area	Season	Observations				Estimated captures	
					Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
Trawl	Squid trawl	Large	Stewart-Snares Shelf	Summer	325	8 787	0.346	940	1 022	789–1 313
Trawl	Squid trawl	Large	Stewart-Snares Shelf	Autumn	273	2 487	0.294	929	662	454–933
Trawl	Hoki trawl	Large	Western Chatham Rise	Autumn	97	1 953	0.144	675	524	351–752
Trawl	Middle depths trawl	Small	Western Chatham Rise	Autumn	0	0	0.000		402	135–964
Trawl	Middle depths trawl	Small	Western Chatham Rise	Summer	10	182	0.029	350	299	107–714
Trawl	Middle depths trawl	Small	Western Chatham Rise	Spring	0	35	0.006	0	293	96–733
Trawl	Hoki trawl	Large	Western Chatham Rise	Spring	52	2 162	0.186	279	261	169–384
Trawl	Squid trawl	Large	Western Chatham Rise	Autumn	18	218	0.083	216	244	128–424
Trawl	Hoki trawl	Large	Western Chatham Rise	Summer	39	1 547	0.131	296	232	150–338
Trawl	Squid trawl	Large	Auckland Islands	Summer	97	5 920	0.449	216	231	157–322
Trawl	Squid trawl	Large	Auckland Islands	Autumn	57	2 145	0.313	182	227	145–341
Trawl	Hoki trawl	Large	Stewart-Snares Shelf	Autumn	25	1 677	0.265	94	223	135–343
Trawl	Squid trawl	Small	Western Chatham Rise	Autumn	0	0	0.000		220	62–562
BLL	Large-vessel ling (no IWL) BLL	Large	Western Chatham Rise	Autumn	0	61	0.035	0	188	72–396
Trawl	Squid trawl	Small	Western Chatham Rise	Summer	0	2	0.001	0	187	58–470

Figure C-46: Trace of the three Monte Carlo Markov chains for the main parameters in the estimation of captures of sooty shearwater. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line.

Table C-54: Summary of the posterior distributions of the model parameters for sooty shearwater. Given the large number of parameters related to annual variation (with a coefficient for each year, method and vessel size), only the 95% credible interval, c.i., of the coefficient of variation (CV) is 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. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line. Significance of positive and negative effects is indicated by plus and minus symbols, respectively. Also shown are the number of chains (out of three) that failed the convergence test, the half-width test, and the effective percentage of samples lost due to autocorrelation (AC loss).

Parameter	Statistic			Significance	Diagnostics		
	Median	Mean	95% c.i.		Convergence	Half-width	AC loss (%)
Intercept	0.01	0.01	0.00–0.02				69.6
Method - Large-vessel BLL	4.20	4.62	0.67–64.73				25.7
Method - Large-vessel SLL	15.05	16.09	1.35–330.28	+			6.1
Method - Small-vessel trawl	1.53	1.54	0.62–3.99				10.1
Method - Small-vessel BLL	0.28	0.25	0.01–3.70				4.6
Method - Small-vessel SLL	1.06	0.96	0.03–17.26			3	4.2
Region - North	0.19	0.20	0.03–2.25				17.4
Season - Autumn (Apr–Jun)	1.95	1.95	1.49–2.53	+			
Season - Winter (Jul–Sep)	0.01	0.01	0.00–0.04	-			2.6
Season - Spring (Oct–Dec)	1.14	1.14	0.79–1.63				
CV(Year) - Trawl	0.38	0.39	0.21–0.65				6.9
CV(Year) - BLL	0.28	0.35	0.01–1.10				
CV(Year) - SLL	0.36	0.51	0.01–1.86				
Area - Stewart–Snares Shelf	2.82	3.00	0.98–6.07				51.0
Area - Western Chatham Rise	2.97	3.19	1.03–6.53	+			37.2
Area - Auckland Islands	1.17	1.26	0.40–2.64				45.1
Area - Fiordland	0.77	0.86	0.23–1.98				36.8
Area - Eastern Chatham Rise	0.28	0.31	0.09–0.70	-			38.4
Area - East of North Island	1.00	1.30	0.09–4.26				3.5
Area - North East	0.41	0.59	0.03–2.18				13.8
Area - West Coast South Island	0.08	0.10	0.01–0.29	-			18.3
Area - East Subantarctic	0.07	0.10	0.01–0.33	-			25.0
Area - Cook Strait	0.13	0.17	0.02–0.57	-			12.0
Area - South Subantarctic	0.04	0.06	0.00–0.24	-			12.7
Area - West Coast North Island	0.15	0.27	0.01–1.20				
Area - Kermadec Islands	1.28	1.73	0.10–6.09				7.9
CV(Area)	1.25	1.28	0.88–1.84				15.4
Fishery - Squid trawl	2.58	2.77	0.93–5.66				44.3
Fishery - Hoki trawl	1.13	1.22	0.40–2.51				46.7
Fishery - Middle depths trawl	1.64	1.76	0.58–3.60				43.8
Fishery - Large-vessel ling (no IWL) BLL	0.80	1.04	0.05–3.57				7.7
Fishery - Scampi trawl	1.01	1.15	0.29–2.90				20.7
Fishery - Ling trawl	1.10	1.25	0.35–3.06				31.8
Fishery - Hake trawl	1.07	1.22	0.33–2.91				24.8
Fishery - Large-vessel ling (IWL) BLL	0.59	0.83	0.04–3.03				3.7
Fishery - Mackerel trawl	0.33	0.38	0.09–0.96	-			29.4
Fishery - Albacore SLL	1.61	2.09	0.14–6.66				
Fishery - Southern bluefin SLL	0.01	0.02	0.00–0.10	-		1	
Fishery - Deepwater trawl	0.06	0.07	0.01–0.20	-			9.7
Fishery - Inshore trawl	0.10	0.14	0.01–0.51	-			16.8
Fishery - Bluenose BLL	0.93	1.36	0.06–5.10				
Fishery - Hāpuku BLL	1.79	2.37	0.15–8.32				
Fishery - Swordfish SLL	1.29	1.84	0.10–6.75				
Fishery - Minor targets BLL	0.13	0.36	0.00–1.91			1	5.4
Fishery - Snapper BLL	0.32	0.70	0.00–3.52				6.2
Fishery - Small-vessel ling BLL	0.19	0.49	0.00–2.83				2.6
Fishery - Bigeye SLL	0.12	0.32	0.00–1.86				3.7
Fishery - Minor surface longline	0.46	0.90	0.00–4.26				
Fishery - Flatfish trawl	0.01	0.03	0.00–0.16	-			4.6
Fishery - Southern blue whiting trawl	0.31	0.66	0.00–3.46				
CV(Fishery)	1.33	1.36	0.92–1.95				5.9
CV(Overdispersion) - Trawl	9.89	9.86	9.62–9.95				2.9
CV(Overdispersion) - BLL	8.18	7.99	4.99–9.84				
CV(Overdispersion) - SLL	1.75	2.80	0.24–9.19			2	78.9
Deviance	1 173.33	1 173.56	1 119.41–1 228.21	+			6.1

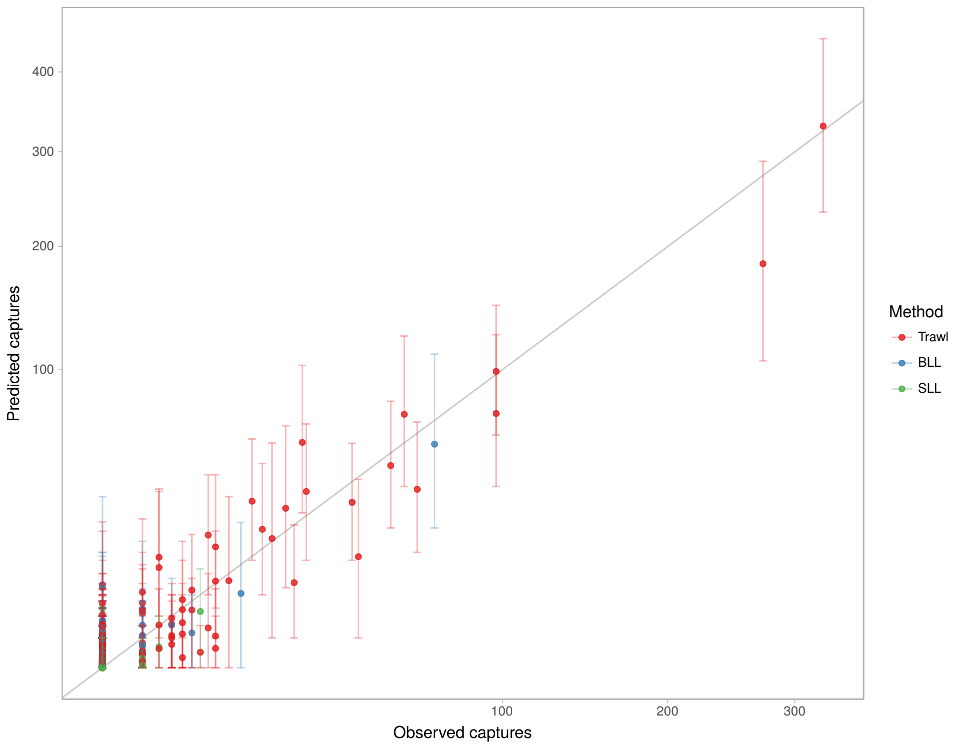


Figure C-47: Comparison between the observed and the predicted number of captures of sooty shearwater (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points are coloured according to the fishing method (BLL, bottom longline; SLL, surface longline).

Table C-55: 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 nine of these strata, representing 1.6% of all 577 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	Hoki trawl	Large	South	Stewart–Snares Shelf	Autumn (Apr–Jun)	1 677	25	57.20	27–103
Trawl	Middle depths trawl	Large	South	Western Chatham Rise	Autumn (Apr–Jun)	280	41	13.90	1–40
Trawl	Hake trawl	Large	South	Stewart–Snares Shelf	Spring (Oct–Dec)	657	2	13.74	3–36
Trawl	Ling trawl	Large	South	Western Chatham Rise	Spring (Oct–Dec)	48	8	1.13	0–7
Trawl	Scampi trawl	Small	South	Auckland Islands	Summer (Jan–Mar)	38	8	0.42	0–3
Trawl	Hoki trawl	Large	South	Fiordland	Spring (Oct–Dec)	33	6	0.27	0–2
Trawl	Hake trawl	Large	South	Eastern Chatham Rise	Summer (Jan–Mar)	69	4	0.11	0–1
Trawl	Hoki trawl	Large	South	Cook Strait	Winter (Jul–Sep)	983	1	0.01	0–0
SLL	Southern bluefin SLL	Large	South	South Subantarctic	Autumn (Apr–Jun)	55	1	0.01	0–0

C.9 Flesh-footed shearwater

Table C-56: Model strata with the highest number of estimated captures of flesh-footed shearwater. 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 fishing method, fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2014–15 for bottom- and surface-longline fisheries, and between 2002–03 and 2014–15 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, c.i., of the total estimated number of captures. The cut-off length between small and large vessels was 28 m in trawl fisheries, 34 m in bottom-longline (BLL) fisheries, and 45 m in surface-longline (SLL) fisheries.

Method	Fishery	Vessel size	Area	Season	Observations				Estimated captures	
					Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
BLL	Snapper BLL	Small	North East	Summer	38	581	0.016	2 319	2 953	1 498–5 576
BLL	Snapper BLL	Small	North East	Autumn	32	394	0.012	2 744	1 713	879–3 150
BLL	Snapper BLL	Small	North East	Spring	5	340	0.009	575	1 693	693–3 630
SLL	Bigeye SLL	Small	North East	Summer	17	144	0.028	607	1 602	614–3 679
SLL	Bigeye SLL	Small	North East	Spring	14	158	0.024	594	1 082	355–2 776
SLL	Bigeye SLL	Small	East of North Island	Summer	87	151	0.025	3 451	1 013	468–1 953
SLL	Bigeye SLL	Small	North East	Autumn	9	54	0.012	744	869	284–2 197
SLL	Bigeye SLL	Small	East of North Island	Autumn	0	96	0.022	0	473	157–1 084
BLL	Minor targets BLL	Small	North East	Summer	4	26	0.020	203	377	57–1 437
BLL	Minor targets BLL	Small	West Coast North Island	Summer	7	111	0.021	325	325	80–947
BLL	Hāpuku BLL	Small	North East	Summer	0	1	0.001	0	313	18–1 480
Trawl	Inshore trawl	Small	North East	Summer	7	833	0.026	265	251	113–470
SLL	Bigeye SLL	Small	West Coast North Island	Summer	0	60	0.023	0	229	43–666
BLL	Minor targets BLL	Small	North East	Autumn	1	16	0.014	73	206	30–810
BLL	Minor targets BLL	Small	North East	Spring	0	24	0.022	0	163	20–682

Figure C-48: Trace of the three Monte Carlo Markov chains for the main parameters in the estimation of captures of flesh-footed shearwater. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line.

Table C-57: Summary of the posterior distributions of the model parameters for flesh-footed shearwater. Given the large number of parameters related to annual variation (with a coefficient for each year, method and vessel size), only the 95% credible interval, c.i., of the coefficient of variation (CV) is 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. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line. Significance of positive and negative effects is indicated by plus and minus symbols, respectively. Also shown are the number of chains (out of three) that failed the convergence test, the half-width test, and the effective percentage of samples lost due to autocorrelation (AC loss).

Parameter	Statistic			Significance	Diagnostics		
	Median	Mean	95% c.i.		Convergence	Half-width	AC loss (%)
Intercept	0.08	0.08	0.01–0.69				46.1
Method - Small-vessel BLL	0.84	0.88	0.09–10.19			3	28.3
Method - Small-vessel trawl	0.23	0.24	0.03–2.52				19.9
Method - Large-vessel SLL	0.01	0.01	0.00–1.70				
Method - Large-vessel BLL	0.02	0.01	0.00–3.55				
Method - Large-vessel trawl	0.01	0.01	0.00–0.27	-			3.4
Region - South	0.01	0.01	0.00–0.08	-	1	1	2.6
Season - Autumn (Apr–Jun)	0.61	0.61	0.31–1.21				
Season - Winter (Jul–Sep)	0.02	0.01	0.00–0.10	-			
Season - Spring (Oct–Dec)	0.50	0.50	0.23–1.10				
CV(Year) - SLL	0.72	1.17	0.02–4.35				
CV(Year) - BLL	0.66	1.06	0.02–4.09				
CV(Year) - Trawl	0.69	1.12	0.02–4.28				3.7
Area - North East	1.63	1.92	0.49–5.31				9.7
Area - East of North Island	0.96	1.09	0.22–2.83				16.9
Area - West Coast North Island	0.45	0.52	0.07–1.36				14.0
Area - Western Chatham Rise	1.14	1.52	0.19–5.15				
Area - East Subantarctic	0.83	1.00	0.00–3.38				5.4
Area - Eastern Chatham Rise	0.73	0.82	0.00–2.62				13.2
Area - South Subantarctic	0.80	0.95	0.00–3.20				
Area - Auckland Islands	0.74	0.86	0.00–2.87				
Area - Stewart–Snares Shelf	0.75	0.88	0.00–3.01				
Area - Cook Strait	0.81	0.98	0.00–3.29				
Area - Fiordland	0.82	0.97	0.00–3.23				
Area - West Coast South Island	0.77	0.89	0.00–2.95				3.3
Area - Kermadec Islands	0.59	0.69	0.00–2.22				
CV(Area)	0.77	0.89	0.16–2.36				6.5
Fishery - Bigeye SLL	2.17	2.67	0.39–7.74				18.2
Fishery - Snapper BLL	0.74	0.98	0.07–3.42				
Fishery - Scampi trawl	1.65	2.01	0.24–5.88				
Fishery - Inshore trawl	0.26	0.32	0.03–1.01				1.1
Fishery - Minor targets BLL	1.89	2.36	0.26–7.49				
Fishery - Albacore SLL	1.10	1.54	0.14–5.88				
Fishery - Minor surface longline	0.65	1.06	0.06–4.35				
Fishery - Hoki trawl	2.02	2.62	0.29–8.88				5.7
Fishery - Hāpuku BLL	0.83	1.20	0.06–4.46				
Fishery - Swordfish SLL	0.35	0.57	0.02–2.39				4.2
Fishery - Middle depths trawl	0.34	0.56	0.02–2.29				
Fishery - Ling trawl	0.97	1.41	0.05–5.61				
Fishery - Large-vessel ling (no IWL) BLL	0.37	0.84	0.00–4.57		1	2	5.6
Fishery - Large-vessel ling (IWL) BLL	0.34	0.85	0.00–4.62				2.3
Fishery - Bluenose BLL	0.03	0.13	0.00–0.86	-		3	4.3
Fishery - Small-vessel ling BLL	0.06	0.23	0.00–1.49			1	
Fishery - Southern bluefin SLL	0.01	0.05	0.00–0.34	-		2	11.1
Fishery - Flatfish trawl	0.07	0.21	0.00–1.21			1	12.6
Fishery - Deepwater trawl	0.09	0.28	0.00–1.73			1	5.5
Fishery - Hake trawl	0.45	1.00	0.00–5.27				1.2
Fishery - Squid trawl	0.32	0.76	0.00–4.01				
Fishery - Southern blue whiting trawl	0.49	1.04	0.00–5.28				
Fishery - Mackerel trawl	0.10	0.34	0.00–2.08			1	
CV(Fishery)	1.43	1.47	0.82–2.37				
CV(Overdispersion) - SLL	8.92	8.78	6.88–9.90				
CV(Overdispersion) - BLL	8.67	8.53	6.27–9.89				
CV(Overdispersion) - Trawl	9.14	8.94	6.82–9.91				
Deviance	316.16	316.67	285.23–350.89	+			

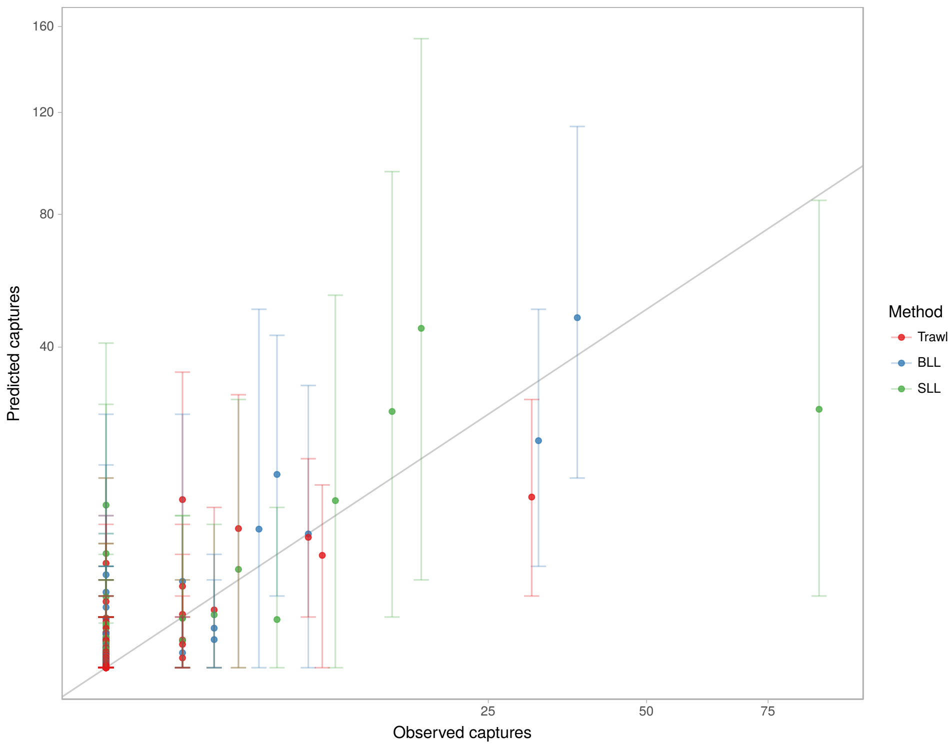


Figure C-49: Comparison between the observed and the predicted number of captures of flesh-footed shearwater (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points are coloured according to the fishing method (BLL, bottom longline; SLL, surface longline).

Table C-58: 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 were two of these strata, representing 0.3% of all 577 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	Summer (Jan–Mar)	151	87	26.00	2–85
Trawl	Scampi trawl	Small	North	North East	Spring (Oct–Dec)	447	31	11.33	2–28

C.10 Other birds

Table C-59: Model strata with the highest number of estimated captures of other birds. 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 fishing method, fishery, vessel size, area, and season. The number of observed captures between the fishing years 1998–99 and 2014–15 for bottom- and surface-longline fisheries, and between 2002–03 and 2014–15 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, c.i., of the total estimated number of captures. The cut-off length between small and large vessels was 28 m in trawl fisheries, 34 m in bottom-longline (BLL) fisheries, and 45 m in surface-longline (SLL) fisheries.

Method	Fishery	Vessel size	Area	Season	Observations				Estimated captures	
					Captures	Events	Coverage	Ratio est.	Mean	95% c.i.
BLL	Snapper BLL	Small	North East	Summer	22	581	0.016	1 343	1 132	598–1 976
BLL	Snapper BLL	Small	North East	Spring	8	340	0.009	921	1 102	547–2 030
BLL	Snapper BLL	Small	North East	Autumn	8	394	0.012	686	987	512–1 796
BLL	Snapper BLL	Small	North East	Winter	0	0	0.000		955	460–1 786
Trawl	Flatfish trawl	Small	Western Chatham Rise	Summer	32	248	0.012	2 705	301	157–524
Trawl	Flatfish trawl	Small	Stewart-Snares Shelf	Summer	0	576	0.025	0	271	122–521
Trawl	Flatfish trawl	Small	West Coast South Island	Autumn	0	14	0.001	0	250	103–528
Trawl	Flatfish trawl	Small	Western Chatham Rise	Autumn	0	39	0.002	0	247	113–469
Trawl	Flatfish trawl	Small	West Coast South Island	Winter	0	23	0.002	0	227	94–469
Trawl	Flatfish trawl	Small	Stewart-Snares Shelf	Spring	0	7	0.000	0	222	94–448
Trawl	Flatfish trawl	Small	Western Chatham Rise	Spring	0	54	0.003	0	222	103–425
Trawl	Flatfish trawl	Small	Western Chatham Rise	Winter	0	28	0.002	0	211	92–418
Trawl	Flatfish trawl	Small	West Coast North Island	Autumn	0	1	0.000	0	191	71–411
Trawl	Flatfish trawl	Small	West Coast South Island	Spring	0	105	0.011	0	187	74–396
Trawl	Flatfish trawl	Small	Stewart-Snares Shelf	Winter	0	0	0.000		186	72–390

Figure C-50: Trace of the three Monte Carlo Markov chains for the main parameters in the estimation of captures of other birds. Model strata included different different areas, seasons, years, target fisheries and areas for trawling, surface-longline (SLL), and bottom-longline (BLL) fisheries. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line.

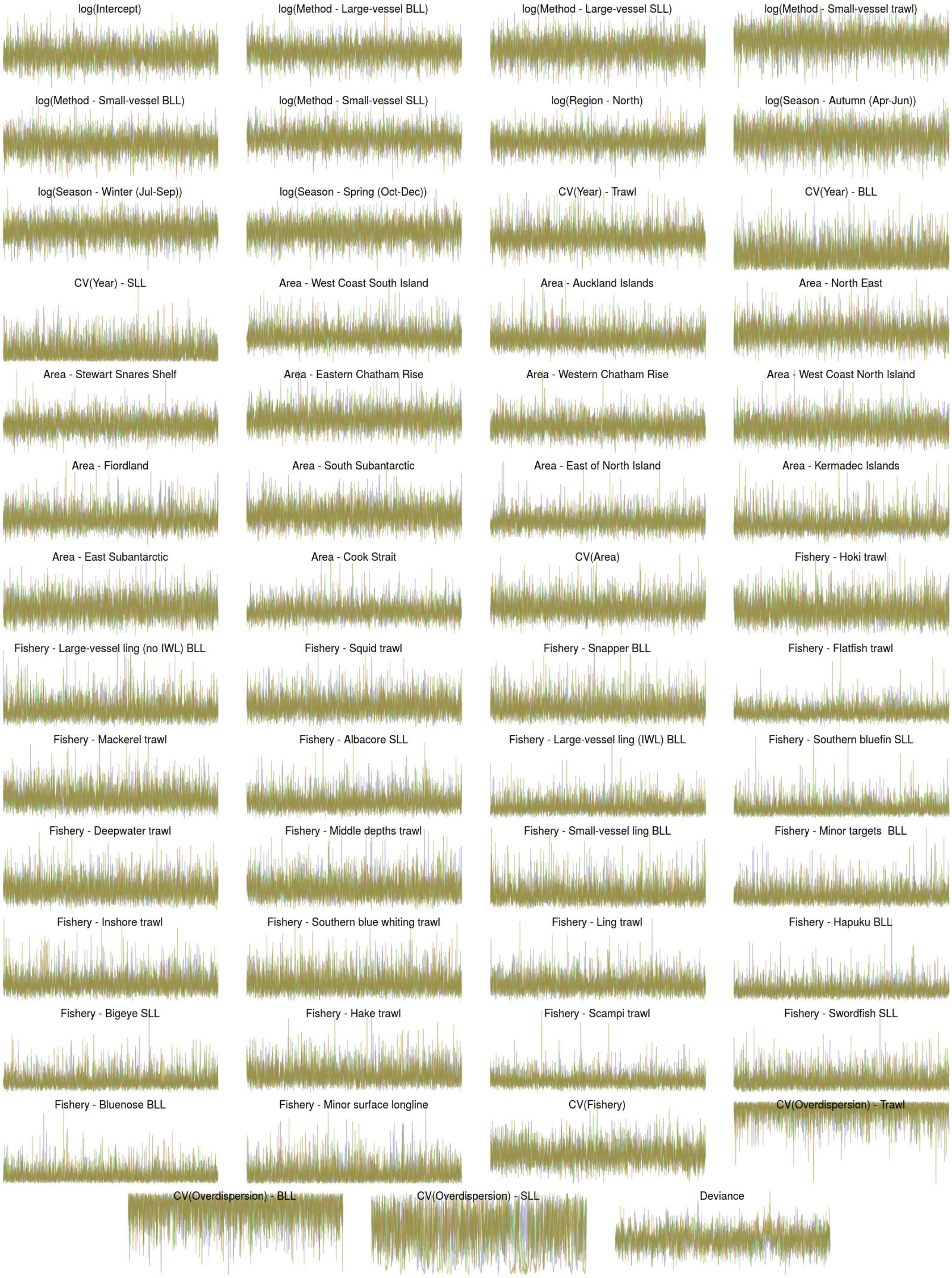


Table C-60: Summary of the posterior distributions of the model parameters for other birds. Given the large number of parameters related to annual variation (with a coefficient for each year, method and vessel size), only the 95% credible interval, c.i., of the coefficient of variation (CV) is shown. 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. Cut-off lengths between small and large vessels were 28 m for trawl, 34 m for BLL, and 45 m for SLL. IWL, integrated weight line. Significance of positive and negative effects is indicated by plus and minus symbols, respectively. Also shown are the number of chains (out of three) that failed the convergence test, the half-width test, and the effective percentage of samples lost due to autocorrelation (AC loss).

Parameter	Statistic			Significance	Diagnostics		
	Median	Mean	95% c.i.		Convergence	Half-width	AC loss (%)
Intercept	0.00	0.00	0.00–0.01				
Method - Large-vessel BLL	3.65	3.66	0.93–15.33				
Method - Large-vessel SLL	4.54	4.53	1.14–19.08	+			9.2
Method - Small-vessel trawl	0.96	0.95	0.40–2.17			3	3.8
Method - Small-vessel BLL	6.95	6.97	2.00–24.35	+			9.5
Method - Small-vessel SLL	5.60	5.64	1.28–27.78	+			6.4
Region - North	0.88	0.89	0.41–2.08			3	
Season - Autumn (Apr–Jun)	0.91	0.91	0.62–1.31			3	
Season - Winter (Jul–Sep)	0.95	0.95	0.62–1.45			3	
Season - Spring (Oct–Dec)	0.87	0.87	0.58–1.29				
CV(Year) - Trawl	0.38	0.39	0.18–0.67				
CV(Year) - BLL	0.26	0.32	0.01–0.89				
CV(Year) - SLL	0.26	0.36	0.01–1.19				
Area - West Coast South Island	1.19	1.22	0.76–1.91				
Area - Auckland Islands	1.65	1.72	1.07–2.72	+			
Area - North East	0.99	1.01	0.49–1.66				
Area - Stewart–Snares Shelf	0.68	0.69	0.42–1.00				
Area - Eastern Chatham Rise	0.86	0.87	0.51–1.30				
Area - Western Chatham Rise	0.84	0.85	0.50–1.30				
Area - West Coast North Island	0.69	0.71	0.29–1.22				
Area - Fiordland	1.20	1.24	0.71–2.00				3.2
Area - South Subantarctic	0.72	0.73	0.35–1.18				
Area - East of North Island	0.93	0.96	0.45–1.69				
Area - Kermadec Islands	1.23	1.31	0.64–2.50				4.1
Area - East Subantarctic	0.64	0.66	0.26–1.14				3.1
Area - Cook Strait	0.98	1.01	0.53–1.67		1	1	3.2
CV(Area)	0.39	0.40	0.18–0.71				
Fishery - Hoki trawl	0.73	0.75	0.29–1.38				
Fishery - Large-vessel ling (no IWL) BLL	1.28	1.44	0.34–3.48				
Fishery - Squid trawl	0.65	0.69	0.26–1.36				
Fishery - Snapper BLL	1.20	1.33	0.38–3.00				2.9
Fishery - Flatfish trawl	4.03	4.31	1.91–8.30	+			9.4
Fishery - Mackerel trawl	0.78	0.84	0.29–1.74				8.9
Fishery - Albacore SLL	2.69	2.93	0.98–6.33				3.1
Fishery - Large-vessel ling (IWL) BLL	0.66	0.75	0.16–1.89				
Fishery - Southern bluefin SLL	0.20	0.24	0.05–0.63	-			
Fishery - Deepwater trawl	0.27	0.29	0.10–0.60	-			
Fishery - Middle depths trawl	0.41	0.44	0.15–0.93	-			
Fishery - Small-vessel ling BLL	0.56	0.65	0.14–1.68				
Fishery - Minor targets BLL	0.94	1.07	0.29–2.53				
Fishery - Inshore trawl	0.44	0.48	0.16–1.07				
Fishery - Southern blue whiting trawl	0.59	0.66	0.17–1.60				
Fishery - Ling trawl	1.22	1.32	0.44–2.79				
Fishery - Hāpuku BLL	1.20	1.39	0.36–3.44				1.2
Fishery - Bigeye SLL	0.41	0.49	0.09–1.37		1	1	
Fishery - Hake trawl	0.43	0.49	0.14–1.13				
Fishery - Scampi trawl	0.38	0.42	0.13–0.93	-			
Fishery - Swordfish SLL	0.59	0.71	0.09–2.06				
Fishery - Bluenose BLL	0.32	0.43	0.04–1.36				
Fishery - Minor surface longline	0.52	0.69	0.02–2.31				
CV(Fishery)	0.84	0.85	0.56–1.23				8.1
CV(Overdispersion) - Trawl	9.86	9.82	9.47–9.95				
CV(Overdispersion) - BLL	9.41	9.26	7.85–9.93				3.9
CV(Overdispersion) - SLL	5.52	5.30	0.59–9.54				82.1
Deviance	1 251.66	1 252.19	1 187.53–1 320.41	+			69.1

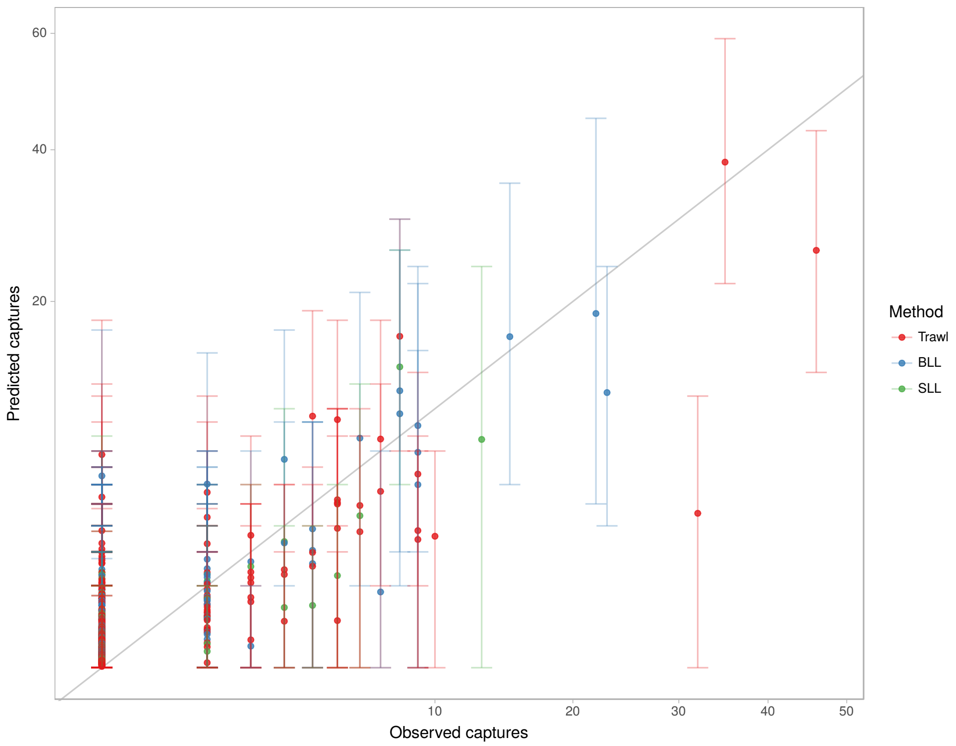


Figure C-51: Comparison between the observed and the predicted number of captures of other birds (represented by their mean and 95% credible interval), for each combination of region, fishery, vessel size, area, and season. The points are coloured according to the fishing method (BLL, bottom longline; SLL, surface longline).

Table C-61: 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 twelve of these strata, representing 2.1% of all 577 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	Auckland Islands	Summer (Jan–Mar)	5 920	46	25.97	13–43
Trawl	Flatfish trawl	Small	South	Stewart–Snares Shelf	Summer (Jan–Mar)	576	0	6.77	1–18
Trawl	Flatfish trawl	Small	South	Western Chatham Rise	Summer (Jan–Mar)	248	32	3.55	0–11
Trawl	Hoki trawl	Large	South	Cook Strait	Winter (Jul–Sep)	983	9	2.80	0–8
Trawl	Deepwater trawl	Large	South	Eastern Chatham Rise	Autumn (Apr–Jun)	2 911	10	2.58	0–7
Trawl	Mackerel trawl	Large	North	West Coast North Island	Summer (Jan–Mar)	1 485	9	2.45	0–7
SLL	Southern bluefin SLL	Small	South	West Coast South Island	Autumn (Apr–Jun)	101	4	0.58	0–3
Trawl	Hoki trawl	Large	South	Fiordland	Autumn (Apr–Jun)	127	5	0.33	0–2
Trawl	Ling trawl	Large	South	Fiordland	Winter (Jul–Sep)	54	3	0.32	0–2
Trawl	Hoki trawl	Large	South	Fiordland	Spring (Oct–Dec)	33	2	0.12	0–1
BLL	Small-vessel ling BLL	Small	South	Cook Strait	Summer (Jan–Mar)	4	2	0.07	0–1
Trawl	Ling trawl	Large	South	South Subantarctic	Summer (Jan–Mar)	1	1	0.00	0–0