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Tini a Tangaroa

Assessment of the risk of commercial fisheries to New Zealand seabirds, 2006–07 to 2016–17

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EXECUTIVE SUMMARY

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Seabirds are incidentally caught in commercial fisheries in New Zealand waters, with a range of species featuring in bycatch records across different fisheries. The potential impact of these incidental captures on seabird populations breeding within New Zealand's Exclusive Economic Zone has been regularly assessed through a systematic risk assessment framework, which allowed the identification of species and fisheries associated with the highest risk and the monitoring of changes in risk status over time. The risk assessments are based on the Spatially Explicit Fisheries Risk Assessment (SEFRA) framework, which allows risk to be calculated for all species and fisheries of interest, even when bycatch and population data are incomplete or uncertain. The present analysis provides an updated assessment of the risk of commercial fisheries in New Zealand for 71 seabird taxa breeding in the New Zealand region, including data to the 2016–17 fishing year.

The SEFRA risk assessment framework is based on an estimation of the rate at which seabirds encounter fishing effort, based on spatial overlap between seabird and fishing effort distributions, and the probability of incidental capture or death per encounter. The estimation is based on data from government observers, who record incidental captures onboard commercial fishing vessels. These bycatch records are extrapolated to the unobserved fishing effort, based on the spatial overlap, while taking into account cryptic mortality (deaths that are not observable). The resulting total fishery-related deaths (D) are then compared to a Population Sustainability Threshold (PST), which is the maximum number of fisheries deaths that the population can sustain while still achieving a defined population objective. The calculation of this Population Sustainability Threshold (PST) for each species is based on demographic information, such as population size and productivity. The ratio of total fishery-related deaths to the PST is referred to as the "risk ratio", which can be specific to a particular fishery or cumulative across fisheries to yield total fisheries risk at the species level.

The default population outcome (ϕ) applied in the current update of the multi-species seabird risk assessment was $\phi = 0.5$, to ensure that populations for which the risk score is less than 1 will recover to or stabilise at a level at or above 75% of the non-impacted status. Species-specific risk assessments may define other population outcomes, reflecting different policy goals for particular species.

The current update of the previous seabird risk assessment included two additional years of data, from 2015–16 and 2016–17. In addition, discrepancies identified during the preparation of fishing effort and observer data for the 2016–17 fishing year were corrected, including data discrepancies in earlier fishing years. The update was carried out in three stages, distinguishing differences through the addition of more recent data from differences caused by the data correction. No changes were made to the demographic parameters that inform the risk assessment nor to the modelling approach used to estimate the number of captures.

When updating the previous risk assessment with the corrected data, there was only one change in risk category at the species level: for spotted shag, it increased from "low risk" to "medium risk", suggesting that the corrections only had a minor impact on the results. Compared with the previous assessment for the period from 2012–13 to 2014–15, estimating risk for the 2014–15 and 2016–17 fishing years following the corrections, led to a change in risk category for four species: the risk ranking decreased from "high risk" to "medium risk" for Chatham Island and New Zealand white-capped albatrosses, and from "medium risk" to "low risk" for spotted shag. In contrast, there was an increase in the risk category for white-chinned petrel, with a change from "negligible risk" to "low risk".

Black petrel remained at "very high risk" from commercial fisheries; it was the only species at the highest risk ranking. There were five taxa in the second-highest category, with Salvin's albatross, Westland petrel, flesh-footed shearwater, southern Buller's albatross and Gibson's albatross assessed to be at "high

risk" from fisheries. While the species-level risk score for black petrel was relatively unchanged from previous risk assessments, the current assessment estimated that the greatest fisheries risk to black petrel is from inshore trawl fisheries; previously, bottom-longline fisheries were estimated to pose the greatest risk to this species.

The findings from the risk assessments support New Zealand government's framework for reducing the impact of fishing on New Zealand seabird populations, outlined in the draft "National Plan of Action - Seabirds 2020" to reduce the incidental catch of seabirds in New Zealand fisheries.

1. INTRODUCTION

New Zealand supports over 90 breeding seabird taxa, with a higher number of single-country endemic seabird species than any other country (Croxall et al. 2012). A number of these taxa are critically endangered, with several species in decline (Robertson et al. 2017). Almost all seabird species are legally protected in New Zealand, but feature frequently in incidental capture records in different fisheries within New Zealand waters (e.g., Abraham & Richard 2019). Quantifying the number of incidental captures and assessing their impact on seabird populations in the form of systematic risk assessments contribute to the management and conservation of seabird species.

The regular assessment of the risk of commercial fisheries to seabirds in New Zealand waters is based on the Spatially Explicit Fisheries Risk Assessment (SEFRA) framework (Sharp 2017), with the most recent risk assessment including data to the 2014–15 fishing year (Richard et al. 2017a). This framework allows risk to be calculated for all species and fisheries of interest, even when bycatch and species demographic data are incomplete or uncertain.

The current analysis provides an update of the previous risk assessment by including two additional years of data (2015–16 and 2016–17), with observer records and fishing effort data spanning the period from 2006–07 to 2015–16. The calculation of risk was based on annual average fishing effort for the period from 2014–15 to 2016–17. In addition, the current update incorporated data corrections following the detection of discrepancies during the preparation of observer and capture data (Abraham & Berkenbusch 2019).

Findings from the current risk assessment support the draft "National Plan of Action - Seabirds 2020" (NPOA; Ministry for Primary Industries 2019). The risk assessment provides a systematic framework for estimating risk to seabird populations from commercial fisheries in New Zealand waters, and for informing risk management.

2. METHODS

The present assessment applied the same methods used previously to estimate the total fishery-related deaths (D; previously referred to as the number of annual potential fatalities, APF) of seabirds in fisheries, the Population Sustainability Threshold (PST) and the risk ratio (D/PST) (see details in Richard et al. 2017a). The methods for the overall assessment approach are based on the Spatially Explicit Fisheries Risk Assessment (SEFRA) framework (described in Sharp 2017).

Within this framework, total fishery-related deaths are a function of the rate at which seabirds encounter fishing effort, estimated based on the spatial overlap between seabird and fishing effort distributions, and the probability of death per encounter, estimated from fisheries observer data.

The total fishery-related deaths include all fatalities from fisheries with sufficient observations, i.e., trawl, bottom-longline, surface-longline and set-net fisheries within New Zealand's Exclusive Economic Zone (EEZ). In addition, the estimates of total fishery-related deaths include cryptic mortalities, i.e., birds that were killed by the fishing activity but not brought on-board the fishing vessel, and not included in captures reported by fisheries observers. The inverse of the probability that the incident would have been recorded by observers is the cryptic multiplier, which allows the total number of incidents to be estimated from the observed captures (see details in Appendix A).

The Population Sustainability Threshold is adapted from the Potential Biological Removal index (PBR; Wade 1998), which was developed under the United States Marine Mammal Protection Act to assess the maximum level of human-induced mortality that a population can incur, while being able to stay above half its carrying capacity in the long term (Wade 1998). Under the SEFRA framework, the PST can be adjusted to reflect different population outcomes, based on policy decisions.

In accordance with the NPOA, the risk of fisheries to seabirds was categorised according to the median and the upper limit of the 95% credible interval of the risk ratio:

- Very high risk: median risk ratio above 1 or an upper 95% credible limit above 2,
- High risk: median above 0.3 or an upper 95% credible limit above 1,
- Medium risk: median above 0.1 or an upper 95% credible limit above 0.3,
- Low risk: upper 95% credible limit above 0.1,
- Negligible risk: upper 95% credible limit less than 0.1.

The current study included the same 71 seabird taxa (Table 1) as the previous analysis. No changes were made to their population size information, other demographic parameters or spatial distributions (see population data summarised in Appendix B, and detailed in Richard et al. 2017b). Fishing effort and observer data were updated to include two additional years of data the 2015–16 and 2016–17 fishing years, extending the assessment period from 2006–07 to 2016–17. The calculation of risk was based on annual average fishing effort for the three-year period from 2014–15 to 2016–17 (compared with the previous assessment period from 2012–13 to 2014–15; Richard et al. 2017a).

Over the entire assessment period, there were 5683 total observed seabird captures, including 3927 fatal captures and 1756 captures that were live releases (Table 2; and see detail in Appendix C, Table C-8). Within the current risk assessment approach, the estimation of fishery mortality was constrained to not exceed the total annual mortality of the adult population. This constraint was necessary to prevent large uncertainties in total fishery-related deaths potentially leading to mortality rates that are inconsistent with estimates of current adult survival. The constraint was based on the assumption that all bird captures were of adults. This assumption was supported by necropsy data, which documented that most of the captured birds recovered for necropsy and identification were adults (Appendix C, Table C-9). Of the total 2031 seabird captures between 2010–11 and 2016–17 that were recovered for necropsy, 1983 captures (97.6%) were of adults.

In addition to extending the assessment period, the current update included a number of corrections following the identification of discrepancies in some of the previous data during the preparation of data from the 2016–17 fishing year (a detailed description of this data preparation, the discrepancies, subsequent corrections and improvements is provided by Abraham & Berkenbusch 2019).

The main corrections and changes were as follows:

1. Early during the development of electronic reporting by observers (through the handheld Nomad devices), the data were not included in the Centralised Observer Database (COD), and the observer effort was generated from fisher effort. During data preparation for the 2016–17, the observer data from these devices were included directly in COD.
2. Linking of observer effort and fisher effort was revised. This revision highlighted that some vessel keys recorded in COD were incorrect, leading to the inclusion of a process in the data preparation that identified observer trips that may have incorrect vessel keys.
3. Some records of seabird captures had been created following review of photographs. Some of these records had no capture method associated with them. Following review of the photographs, some of these records were determined to be deck captures (which are not included in the seabird bycatch estimation).
4. Imputation of the location of set-net data in West Coast North Island harbours was carried out, based on tracking of small vessels undertaken by Trident Systems.

Table 1: List of the 71 seabird taxa included in the current risk assessment. Seabird groupings were used for the estimation of vulnerability, of cryptic mortalities in trawl fisheries, and for the correction of total population size.

Common name	Scientific name	Groups		
		Vulnerability	Cryptic mortality	Population correction
Gibson's albatross	*Diomedea antipodensis gibsoni*	Wandering albatrosses	Large albatrosses	Antipodean albatross
Antipodean albatross	*Diomedea antipodensis antipodensis*	Wandering albatrosses	Large albatrosses	Antipodean albatross
Southern royal albatross	*Diomedea epomophora*	Royal albatrosses	Large albatrosses	Antipodean albatross
Northern royal albatross	*Diomedea sanfordi*	Royal albatrosses	Large albatrosses	Antipodean albatross
Campbell black-browed albatross	*Thalassarche impavida*	Campbell black-browed albatross	Mollymawks & giant petrel	Grey-headed albatross
New Zealand white-capped albatross	*Thalassarche cauta steadi*	White-capped albatross	Mollymawks & giant petrel	Grey-headed albatross
Salvin's albatross	*Thalassarche salvini*	Salvin's albatross	Mollymawks & giant petrel	Grey-headed albatross
Chatham Island albatross	*Thalassarche eremita*	Chatham albatross	Mollymawks & giant petrel	Grey-headed albatross
Grey-headed albatross	*Thalassarche chrysostoma*	Grey-headed albatross	Mollymawks & giant petrel	Grey-headed albatross
Southern Buller's albatross	*Thalassarche bulleri bulleri*	Buller's albatrosses	Mollymawks & giant petrel	Grey-headed albatross
Northern Buller's albatross	*Thalassarche bulleri platei*	Buller's albatrosses	Mollymawks & giant petrel	Grey-headed albatross
Light-mantled sooty albatross	*Phoebetria palpebrata*	Light-mantled sooty albatross	Mollymawks & giant petrel	Antipodean albatross
Northern giant petrel	*Macronectes halli*	Giant petrel	Mollymawks & giant petrel	Giant petrel
Grey petrel	*Procellaria cinerea*	Grey petrel	Medium-sized seabirds	Black petrel
Black petrel	*Procellaria parkinsoni*	Black petrel	Medium-sized seabirds	Black petrel
Westland petrel	*Procellaria westlandica*	Westland petrel	Medium-sized seabirds	Black petrel
White-chinned petrel	*Procellaria aequinoctialis*	White-chinned petrel	Medium-sized seabirds	Black petrel
Flesh-footed shearwater	*Puffinus carneipes*	Flesh-footed shearwater	Medium-sized seabirds	Flesh-footed shearwater
Wedge-tailed shearwater	*Puffinus pacificus*	Shearwaters	Small-sized seabirds	Flesh-footed shearwater
Buller's shearwater	*Puffinus bulleri*	Shearwaters	Small-sized seabirds	Flesh-footed shearwater
Sooty shearwater	*Puffinus griseus*	Sooty shearwater	Medium-sized seabirds	Flesh-footed shearwater
Fluttering shearwater	*Puffinus gavia*	Shearwaters	Small-sized seabirds	Flesh-footed shearwater
Hutton's shearwater	*Puffinus huttoni*	Shearwaters	Small-sized seabirds	Flesh-footed shearwater
Little shearwater	*Puffinus assimilis*	Shearwaters	Small-sized seabirds	Fairy prion
Snares Cape petrel	*Daption capense australe*	Cape petrel	Small-sized seabirds	Fairy prion
Fairy prion	*Pachyptila turtur*	Prions	Small-sized seabirds	Fairy prion
Antarctic prion	*Pachyptila desolata*	Prions	Small-sized seabirds	Fairy prion
Broad-billed prion	*Pachyptila vittata*	Prions	Small-sized seabirds	Fairy prion
Pycroft's petrel	*Pterodroma pycrofti*	Small *Pterodroma* petrels	Small-sized seabirds	Fairy prion
Cook's petrel	*Pterodroma cookii*	Small *Pterodroma* petrels	Small-sized seabirds	Fairy prion
Chatham petrel	*Pterodroma axillaris*	Small *Pterodroma* petrels	Small-sized seabirds	Fairy prion
Mottled petrel	*Pterodroma inexpectata*	Small *Pterodroma* petrels	Small-sized seabirds	Fairy prion
White-naped petrel	*Pterodroma cervicalis*	Large *Pterodroma* petrels	Medium-sized seabirds	Flesh-footed shearwater
Kermadec petrel	*Pterodroma neglecta*	Large *Pterodroma* petrels	Medium-sized seabirds	Flesh-footed shearwater
Grey-faced petrel	*Pterodroma macroptera gouldi*	Large *Pterodroma* petrels	Medium-sized seabirds	Flesh-footed shearwater
Chatham Island taiko	*Pterodroma magentae*	Large *Pterodroma* petrels	Medium-sized seabirds	Flesh-footed shearwater
White-headed petrel	*Pterodroma lessonii*	Large *Pterodroma* petrels	Medium-sized seabirds	Flesh-footed shearwater
Soft-plumaged petrel	*Pterodroma mollis*	Small *Pterodroma* petrels	Small-sized seabirds	Fairy prion
Common diving petrel	*Pelecanoides urinatrix*	Diving petrels	Small-sized seabirds	Common diving-petrel
South Georgian diving petrel	*Pelecanoides georgicus*	Diving petrels	Small-sized seabirds	Common diving-petrel
New Zealand white-faced storm petrel	*Pelagodroma marina maoriana*	Storm petrels	Small-sized seabirds	Storm petrel
White-bellied storm petrel	*Fregetta grallaria grallaria*	Storm petrels	Small-sized seabirds	Storm petrel
Black-bellied storm petrel	*Fregetta tropica*	Storm petrels	Small-sized seabirds	Storm petrel
Kermadec storm petrel	*Pelagodroma albiclunis*	Storm petrels	Small-sized seabirds	Storm petrel
New Zealand storm petrel	*Pealeornis maoriana*	Storm petrels	Small-sized seabirds	Storm petrel
Yellow-eyed penguin	*Megadyptes antipodes*	Yellow-eyed penguin	Diving seabirds	Yellow-eyed penguin
Northern little penguin	*Eudyptula minor f. iredalei*	Little penguins	Diving seabirds	Erect-crested penguin
White-flippered little penguin	*Eudyptula minor f. albosignata*	Little penguins	Diving seabirds	Erect-crested penguin
Southern little penguin	*Eudyptula minor f. minor*	Little penguins	Diving seabirds	Erect-crested penguin
Chatham Island little penguin	*Eudyptula minor f. chathamensis*	Little penguins	Diving seabirds	Erect-crested penguin
Eastern rockhopper penguin	*Eudyptes chrysocome filholi*	Crested penguins	Diving seabirds	Erect-crested penguin
Fiordland crested penguin	*Eudyptes pachyrhynchus*	Crested penguins	Diving seabirds	Erect-crested penguin
Snares crested penguin	*Eudyptes robustus*	Crested penguins	Diving seabirds	Erect-crested penguin
Erect-crested penguin	*Eudyptes sclateri*	Crested penguins	Diving seabirds	Erect-crested penguin
Australasian gannet	*Morus serrator*	Boobies and gannets	Diving seabirds	Shag
Masked booby	*Sula dactylatra*	Boobies and gannets	Diving seabirds	Shag
Pied shag	*Phalacrocorax varius varius*	Solitary shags	Diving seabirds	Shag
Little black shag	*Phalacrocorax sulcirostris*	Solitary shags	Diving seabirds	Shag
New Zealand king shag	*Leucocarbo carunculatus*	Solitary shags	Diving seabirds	Shag
Otago shag	*Leucocarbo chalconotus*	Group foraging shags	Diving seabirds	Shag
Foveaux shag	*Leucocarbo stewarti*	Group foraging shags	Diving seabirds	Shag
Chatham Island shag	*Leucocarbo onslowi*	Group foraging shags	Diving seabirds	Shag
Bounty Island shag	*Leucocarbo ranfurlyi*	Group foraging shags	Diving seabirds	Shag
Auckland Island shag	*Leucocarbo colensoi*	Group foraging shags	Diving seabirds	Shag
Campbell Island shag	*Leucocarbo campbelli*	Group foraging shags	Diving seabirds	Shag
Spotted shag	*Stictocarbo punctatus*	Group foraging shags	Diving seabirds	Shag
Pitt Island shag	*Stictocarbo featherstoni*	Solitary shags	Diving seabirds	Shag
Subantarctic skua	*Catharacta antarctica lonnbergi*	Gulls, terns & skua	Medium-sized seabirds	Shag
Southern black-backed gull	*Larus dominicanus dominicanus*	Gulls, terns & skua	Medium-sized seabirds	Caspian tern
Caspian tern	*Hydroprogne caspia*	Gulls, terns & skua	Medium-sized seabirds	Caspian tern
White tern	*Gygis alba candida*	Gulls, terns & skua	Medium-sized seabirds	Caspian tern

Table 2: Seabird captures recorded by government observers between the fishing years 2006–07 and 2016–17 in New Zealand commercial trawl, longline and set-net fisheries. Data include the total number of captures, the number of mortalities, and the number of captures that were released alive.

Species group	Total	Dead	Alive
White-chinned petrel	1 704	1 144	560
Sooty shearwater	1 147	782	365
White-capped albatross	963	703	260
Buller's albatrosses	681	474	207
Salvin's albatross	400	285	115
Flesh-footed shearwater	148	100	48
Black petrel	138	67	71
Grey petrel	97	88	9
Wandering albatrosses	72	49	23
Westland petrel	57	43	14
Campbell black-browed albatross	46	37	9
Group foraging shags	38	38	0
Royal albatrosses	29	15	14
Diving petrels	24	7	17
Chatham albatross	23	22	1
Prions	21	7	14
Shearwaters	18	12	6
Large *Pterodroma* petrels	13	11	2
Giant petrel	13	6	7
Yellow-eyed penguin	12	12	0
Cape petrel	9	5	4
Gulls, terns & skua	8	4	4
Little penguins	8	8	0
Storm petrels	7	3	4
Crested penguins	4	3	1
Solitary shags	1	1	0
Grey-headed albatross	1	1	0
Boobies and gannets	1	0	1
Total	5 683	3 927	1 756

3. RESULTS

3.1 Model fit

Model diagnostics included examination of the model fit, including a comparison of estimated and observed data (Figure 1). There was a close relationship between the two data sets, indicating that the model reflected the observed data well (Figure 1). Of the 4380 strata of fishing group, species group, capture status (live or dead), and time period (before or after 2010–11) in the estimation, only 2.2% of the observed number of captures were outside the 95% credible interval (c.i.) of the estimated number of captures (see Appendix D for the estimation of live releases across different fishery groups).

There were 10 strata with over 40 captures for which the observed number of captures was outside the predicted 95% credible interval. All but two of the 10 strata were in trawl fisheries, including six strata in the squid target fishery (Table 3); the remaining strata were trawl fisheries targeting scampi and large-vessel trawl fisheries with processor plants. Two of the strata were in bottom-longline fisheries, in the large-vessel fleet without integrated weight lines, and the fleet targeting ling and ribaldo. Of the 10 strata, the observed number of captures was lower than predicted in three of the strata, and higher in the remaining seven strata.

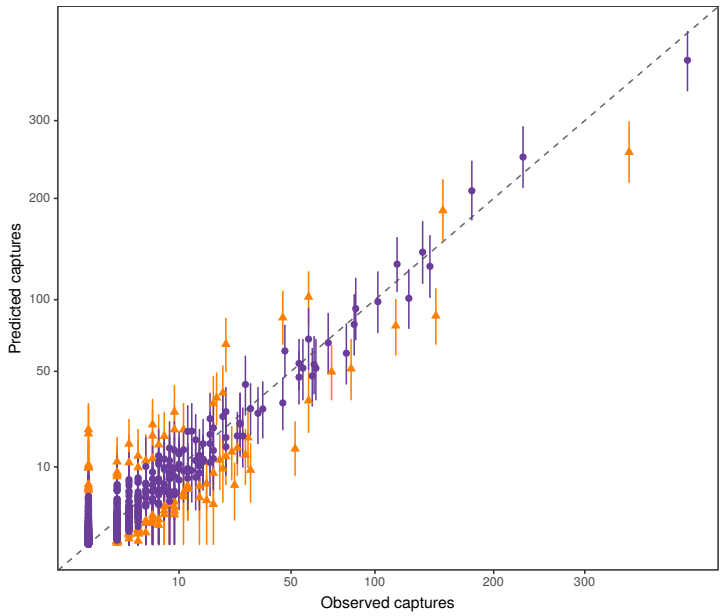

Figure 1: Comparison of the number of seabird captures recorded by government observers and predicted by the model used to estimate the number of fishery-related deaths. Each point represents a stratum of species group, fishery group, capture status (live or dead), and time period (before or after 2010–11). Strata for which the number of observed captures was within the 95% credible interval of the predicted number are shown in purple, other strata are shown in orange.

Table 3: Model strata with over 40 observed seabird captures for which the number of observed captures was outside the estimated 95% credible interval (c.i.). Strata (listed in decreasing order of the number of observed captures) were fishery group, species group, time period (before or after 2010–11), and capture status. Shown are the number of observed captures, and the mean and 95% c.i. of the estimated number of captures. BLL, bottom longline; IWL, integrated weight line.

Fishery group	Species group	Period	Live/dead	Observed captures	Predicted captures	
					Mean	95% c.i.
Trawl - squid	White-chinned petrel	Late	Live	356	257	219–298
Trawl - large processor	Sooty shearwater	Late	Dead	153	186	154–222
Trawl - squid	Sooty shearwater	Early	Dead	147	87	67–109
Trawl - squid	White-capped albatross	Early	Dead	115	80	60–100
BLL - large vessels without IWL	White-chinned petrel	Late	Dead	84	52	35–70
Trawl - squid	Sooty shearwater	Early	Live	72	50	35–66
Trawl - squid	White-chinned petrel	Late	Dead	59	102	81–124
BLL - ling and ribaldo	White-chinned petrel	Late	Dead	59	35	21–50
Trawl - scampi	White-chinned petrel	Late	Dead	52	15	8–25
Trawl - squid	White-chinned petrel	Early	Live	46	86	67–107

3.2 Vulnerability

The estimation of risk in the current assessment approach included the estimation of vulnerability, reflecting the probability of capture or death per encounter between seabird distributions and fishing (see details in Appendix E). The species with the highest mean species-group vulnerability was black petrel, closely followed by Salvin's albatross (Table 4). For black petrel, the vulnerability was 26.4 (95% c.i.: 5.1–83.5) times higher than the vulnerability of white-chinned petrel, for Salvin's albatross it was 25.2 (95% c.i.: 6.1–72.0) times higher. Vulnerability was also high for Buller's albatrosses, New Zealand white-capped albatross, Campbell black-browed albatross, and Westland petrel (i.e., the mean vulnerability and 95% c.i. exceeded the mean value for white-chinned petrel). In contrast, *Pterodroma* petrels and the species group gulls, terns and skua had the lowest values for species-group vulnerability.

Across the different fishery groups, the vulnerability of seabirds to capture or death (noting that vulnerability includes observable captures and also cryptic mortality) was highest in surface longlining, followed by trawl fisheries (Table 5). Within the same fishing method (i.e., restricting the comparisons to the same units of effort), the vulnerability for most trawl fisheries was comparable to that of the reference group, with 95% credible intervals that were not significantly different and included 1 (Table E-10).

Table 4: Vulnerability (v_g; mean and 95% credible interval, c.i.) of seabirds to capture or cryptic death in trawl, longline, and set-net fisheries used in the estimation of observable captures, for each species group.

Species group	Vulnerability	
	Mean	95% c.i.
Black petrel	26.43	5.05–83.52
Salvin's albatross	25.18	6.09–72.00
Buller's albatrosses	11.49	3.02–30.52
White-capped albatross	6.86	1.82–19.04
Campbell black-browed albatross	5.61	1.16–16.29
Westland petrel	5.47	1.17–17.32
Flesh-footed shearwater	4.42	0.96–12.35
Chatham albatross	4.1	0.54–13.70
Giant petrel	3.75	0.60–12.31
Grey petrel	3.26	0.76–9.17
Wandering albatrosses	2.57	0.45–7.99
Royal albatrosses	1.48	0.29–4.76
Cape petrel	1.05	0.13–3.92
White-chinned petrel	1	1.00–1.00
Yellow-eyed penguin	0.58	0.04–2.39
Grey-headed albatross	0.3	0.02–1.29
Group foraging shags	0.15	0.02–0.55
Light-mantled sooty albatross	0.13	0.00–0.63
Sooty shearwater	0.08	0.02–0.26
Solitary shags	0.08	0.00–0.33
Storm petrels	0.07	0.01–0.21
Diving petrels	0.05	0.01–0.15
Little penguins	0.04	0.00–0.14
Crested penguins	0.03	0.00–0.12
Large *Pterodroma* petrels	0.02	0.00–0.07
Boobies and gannets	0.02	0.00–0.08
Shearwaters	0.02	0.00–0.06
Prions	0.01	0.00–0.03
Small *Pterodroma* petrels	0	0.00–0.02
Gulls, terns & skua	0	0.00–0.01

Table 5: Vulnerability (v_{0m}; mean and 95% credible interval, c.i.) of seabirds to capture or cryptic death in trawl, longline, and set-net fisheries used in the estimation of observable captures, for each fishing method.

Method	Vulnerability	
	Mean	95% c.i.
Trawl	0.011	0.003–0.026
Surface longline	0.075	0.020–0.198
Bottom longline	0.009	0.002–0.025
Set net	0.003	0.001–0.008

3.3 Total fishery-related deaths

Total fishery-related deaths (D) were estimated by applying the vulnerability to the total annual overlap (including unobserved fishing) for the three most recent years of data, the period between 2014–15 and 2016–17. In this period, there was an estimated total mean of 12 900 (95% c.i.: 10 900–15 400) fishery-related deaths of the 71 seabird taxa (Table 6). Estimating the fishery-related deaths by fishery, the highest number of fishery-related deaths was in trawl fisheries, with a mean of 8840 (95% c.i.: 6940–11 300) seabirds per year (Appendix F). Note however that cryptic mortality (i.e. unobservable deaths) accounts for a large proportion of total deaths in trawl fisheries, and may be poorly estimated for some fisheries and species. Until such time as the structural assumptions underlying the estimation of cryptic mortality multipliers have been revisited, estimates of total fisheries deaths in trawl fisheries should be interpreted with caution.

In bottom-longline fisheries, there were 2840 (95% c.i.: 2300–3460) fishery-related deaths, compared with 1100 (95% c.i.: 892–1330) fishery-related deaths in surface-longline fisheries. Set-net fisheries had the lowest estimate of fishery-related deaths of 128 (95% c.i.: 76–205) birds per year.

Table 6: Total fishery-related deaths (D) of seabirds in trawl, bottom-longline (BLL), surface-longline (SLL), and set-net (SN) fisheries by target fishery, for the period between 2014–15 and 2016–17. Mean and 95% credible interval (c.i.), sorted in descending order within each fishing method.

Method	Fishery	D	
		Mean	95% c.i.
Trawl	Inshore	3 640	2 380–5 390
	Hoki	1 240	929–1 620
	Flatfish	1 020	679–1 500
	Middle depth	889	667–1 170
	Squid	829	609–1 100
	Scampi	708	464–1 020
	Deepwater	207	113–355
	Ling	159	101–272
	Hake	61	40–85
	Southern blue whiting	59	30–98
	Jack mackerel	22	10–39
BLL	Small vessel, ling	1 150	893–1 460
	Snapper	782	538–1 100
	Large vessel, ling	428	327–539
	Minor targets	229	155–330
	Hapuka	154	91–252
	Bluenose	96	33–172
SLL	Small vessel, southern bluefin	488	392–597
	Bigeye	334	261–414
	Swordfish	252	165–357
	Large vessel, southern bluefin	12	5–20
	Minor targets	10	4–17
	Albacore	5	1–9
SN	Shark	56	34–83
	Flatfish	36	17–68
	Minor targets	29	14–54
	Mullet	5	1–13
Total	Total	12 900	10 900–15 400

The estimation of fishery-related deaths included estimation of the probability that a capture incident was observable, the cryptic multiplier. The latter varied depending on the fishery and species group, with the lowest values in mackerel trawl fisheries, where estimates varied from 1.3 (95% c.i.: 1.1–1.6) for diving seabirds to 4.0 (95% c.i.: 1.2–10.1) for small-sized seabirds (Table 7). For other fisheries and bird groups, estimates of the cryptic multiplier were comparably higher but frequently included higher

uncertainty, such as for medium-sized seabirds in small inshore trawl fisheries. The highest estimated cryptic multiplier for this seabird group was in the small-vessel inshore fleet (vessel lengths between 17 and 28 m), with a mean of 89.0 (95% c.i.: 27.6–221.1). Fisheries New Zealand is currently undertaking new research to improve the parameterisation of seabird risk assessments, with a particular focus on assumptions affecting the estimation of cryptic mortality. Until this work is completed, risk estimates in trawl fisheries with large cryptic multipliers should be interpreted with appropriate caution.

Table 7: Cryptic multiplier (mean and credible interval, c.i.) by species group and modelled trawl fishery group, summarised from the posterior distributions after model fitting. The "mollymawks" species group included giant petrel.

Trawl fishery	Large albatrosses		Mollymawks		Medium-sized seabirds		Small-sized seabirds		Diving seabirds	
	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.
Small inshore < 17 m	15.4	7.5–26.7	17.1	10.1–26.6	7.4	2.0–18.9	76.3	17.2–210.9	1.3	1.1–1.6
Small inshore 17 to 28 m	18.3	10.9–28.2	18.1	11.7–27.1	13.7	4.8–30.5	89.0	27.6–221.1	1.3	1.1–1.6
Southern blue whiting	11.5	5.3–21.0	13.5	8.1–20.6	5.4	2.1–11.7	25.7	6.6–69.7	1.3	1.1–1.6
Scampi	6.0	2.4–12.1	6.2	3.7–9.7	2.1	1.3–3.3	17.7	4.6–47.6	1.3	1.1–1.6
Mackerel	3.3	1.4–6.8	3.5	1.6–6.4	1.7	1.2–2.3	4.0	1.2–10.1	1.3	1.1–1.6
Squid	4.7	2.0–9.0	5.6	3.8–7.8	1.9	1.3–2.8	6.9	2.1–17.1	1.3	1.1–1.6
Large processor	6.4	2.6–12.5	6.6	4.6–9.3	2.3	1.4–3.6	10.9	3.2–27.5	1.3	1.1–1.6
Large fresher	8.7	2.9–18.8	8.3	3.7–15.7	4.7	1.6–11.1	31.5	5.1–103.1	1.3	1.1–1.6
Deepwater	16.3	9.1–26.4	17.8	11.4–26.4	18.7	5.2–49.0	73.4	20.5–188.4	1.3	1.1–1.6

3.4 Risk to seabirds

Within the current risk assessment framework, fishery-related deaths were derived by applying the vulnerability to the total annual overlap (including unobserved fishing) for the period between 2014–15 and 2016–17. The risk ratio was then derived as the ratio of fishery-related deaths to the PST for the 71 seabird taxa included in the risk assessment (Table 8).

The species with the highest risk ratio was black petrel, with an estimated median risk ratio of 1.23 (95% c.i.: 0.55–2.11) (Table 8, Figure 2). The mean estimated PST was 447 (95% c.i.: 225–831) individuals and the mean number of fishery-related deaths was estimated at 513 (95% c.i.: 325–803). The estimated number of fishery-related deaths was high, even though observed captures of black petrel have typically been low, reflecting low observer coverage in the fisheries where this species is caught. Between the 2006–07 and 2016–17 fishing years, there were 28 observed captures of black petrel in trawl fisheries, 84 observed captures in bottom-longline fisheries, and 26 observed captures in surface-longline fisheries (see Appendix C, Table C-8).

Salvin's albatross had the second-highest risk ratio, with an estimated median risk ratio of 0.65 (95% c.i.: 0.42–0.94). The mean PST of this species was estimated at 3465 (95% c.i.: 2633–4734) individuals compared with the estimated mean number of fishery-related deaths of 2246 (95% c.i.: 1636–3055). Most of the risk was in inshore trawl (mean risk ratio of 0.23, 95% c.i.: 0.12–0.40) and hoki trawl (mean risk ratio of 0.11, 95% c.i.: 0.06–0.17).

The third-highest ranking species, Westland petrel, had a estimated median risk ratio of 0.54 (95% c.i.: 0.26–1.12). Its mean PST was estimated at 351 (95% c.i.: 233–532) individuals and the mean number of fishery-related deaths at 194 (95% c.i.: 103–361). There was a considerable increase in the number of observed captures of Westland petrel in recent years, with 18 observed captures in 2015–16 and 2016–17, compared with four observed captures in the nine years from 2006–07 to 2014–15.

Based on the median and upper 95% credible limit of the risk ratio, seabird taxa were ranked into different risk categories, from "very high risk" to "negligible risk" (Table 8). From the samples of the risk ratio, the probability that the risk was greater than 1 was calculated, indicating species for which the number of fishery-related deaths exceeded the PST.

Black petrel was the only species ranked in the "very high risk" category (Table 8, Figure 2). For this species, the probability that the risk ratio was larger than 1 was 70%. The next highest ranking, the "high risk" category, contained five species, Salvin's albatross, Westland petrel, flesh-footed shearwater, southern Buller's albatross, and Gibson's albatross. For birds in the "high risk" category, the probability that the risk ratio is larger than 1 was 5% or less, dependent on the species. There were seven populations in the "medium risk" category, New Zealand white-capped albatross, Chatham Island albatross, northern Buller's albatross, yellow-eyed penguin (when only considering the mainland and Stewart Island population and assigning all fishery-related deaths to this population), Antipodean albatross, northern giant petrel, and Otago shag. The "low risk" category contained five populations: spotted shag, yellow-eyed penguin (whole New Zealand population), white-chinned petrel, Campbell black-browed albatross, and northern royal albatross. The remaining 54 taxa were in the "negligible risk" category.

Across the different risk categories, large-sized seabirds featured prominently in the top risk rankings: of the six species in the "very high risk" or "high risk" categories, there were three albatrosses and the remainder were *Procellaria* petrels or large shearwater species. Similarly, the seven species in the "medium risk" category included four albatross and one petrel species. These species are characterised by low productivity (with a late age at first breeding, and a single egg produced every one or two years) and a propensity to interact with commercial fisheries.

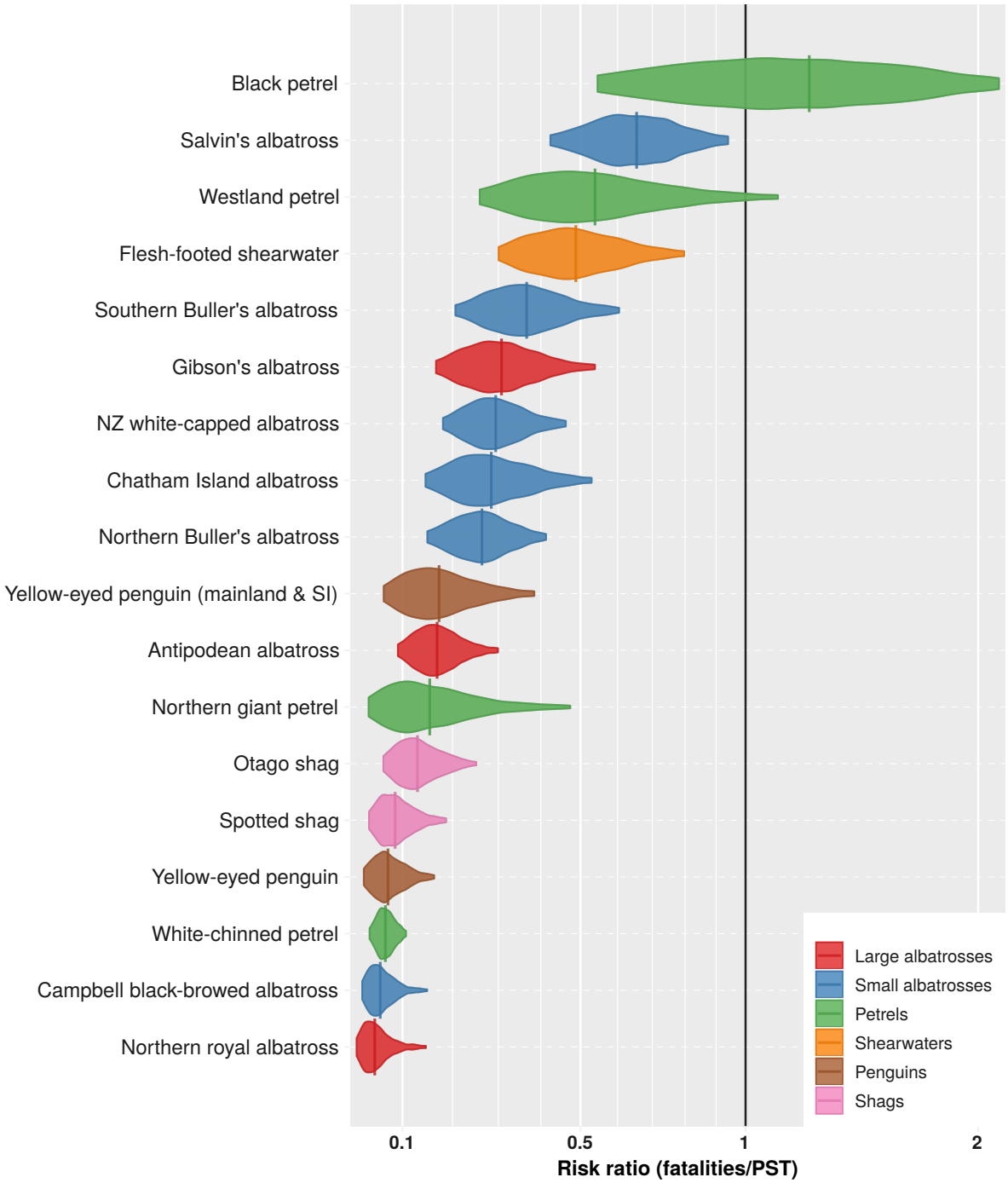

Figure 2: Risk ratio for different seabird taxa, based on data between 2006–07 and 2016–17. The risk ratio is displayed on a logarithmic scale, with the threshold of the number of fishery-related deaths equalling the Population Sustainability Threshold (PST) represented by the black vertical line, and the distribution of the risk ratios within their 95% credible interval indicated by the coloured shapes, including the median risk ratio (vertical line). Seabird taxa are listed in decreasing order of the median risk ratio. Taxa with a risk ratio of almost zero were not included (95% upper limit less than 0.05). The risk to yellow-eyed penguin was assessed for the entire New Zealand population, but also for the mainland and Stewart Island population only, based on the assumption that all estimated fishery-related deaths were of the mainland and Stewart Island population, and the number of annual breeding pairs was between 600 and 800 during the period in which the observed captures occurred. The reality is much more complex, with different breeding populations experiencing various population changes during the period in question; for this reason, time-averaged species-level outputs for yellow-eyed penguin should be interpreted with appropriate caution.

Table 8: Population Sustainability Threshold (PST), total fishery-related deaths (D) in trawl, longline, and set-net fisheries, risk ratio with $f = 1$ (RR = D/PST), and the probability that D > PST for seabird taxa in the current risk assessment. Taxa are ordered in decreasing order of the median risk ratio. The risk to yellow-eyed penguin was assessed for the entire New Zealand population, but also for the mainland and Stewart Island population only, based on the assumption that all estimated fishery-related deaths were of the mainland and Stewart Island population, and the number of annual breeding pairs was between 600 and 800. Taxa names are coloured according to their risk category. Red: risk ratio with a median over 1 or upper 95% credible limit (u.c.l.) over 2; dark orange: median over 0.3 or u.c.l. over 1; light orange: median over 0.1 or u.c.l. over 0.3; yellow: u.c.l. over 0.1. PST and D values were rounded to three significant digits.

	PST		D		Risk ratio		P(D > PST)
	Mean	95% c.i.	Mean	95% c.i.	Median	95% c.i.	
Black petrel	447	225–831	513	325–803	1.23	0.55–2.11	0.70
Salvin's albatross	3 460	2 630–4 730	2 250	1 640–3 060	0.65	0.42–0.94	0.01
Westland petrel	351	233–532	194	103–361	0.54	0.26–1.12	0.05
Flesh-footed shearwater	1 450	1 010–2 050	710	496–1 020	0.49	0.30–0.80	0.00
Southern Buller's albatross	1 360	896–2 160	486	358–664	0.37	0.21–0.60	0.00
Gibson's albatross	497	327–743	151	95–221	0.31	0.17–0.54	0.00
NZ white-capped albatross	10 800	7 680–15 700	3 160	2 290–4 330	0.29	0.18–0.46	0.00
Chatham Island albatross	428	292–632	123	69–196	0.28	0.14–0.53	0.00
Northern Buller's albatross	1 640	1 070–2 630	414	321–524	0.26	0.15–0.41	0.00
Yellow-eyed penguin (mainland)	120	79–180	21	8–41	0.17	0.06–0.38	0.00
Antipodean albatross	369	258–517	63	37–97	0.17	0.09–0.30	0.00
Northern giant petrel	337	159–792	51	16–113	0.15	0.04–0.47	0.00
Otago shag	283	184–418	37	20–58	0.13	0.06–0.25	0.00
Spotted shag	3 730	1 790–7 080	304	198–439	0.09	0.04–0.19	0.00
Yellow-eyed penguin	285	189–424	21	8–41	0.07	0.03–0.16	0.00
White-chinned petrel	25 800	16 100–41 300	1 680	1 390–2 010	0.07	0.04–0.11	0.00
Campbell black-browed albatross	2 000	993–3 570	117	65–223	0.06	0.03–0.15	0.00
Northern royal albatross	723	345–1 360	36	14–81	0.05	0.02–0.15	0.00
Foveaux shag	208	132–317	7	2–14	0.03	0.01–0.08	0.00
Grey petrel	5 460	3 190–9 130	139	86–217	0.03	0.01–0.05	0.00
Southern royal albatross	854	600–1 190	22	9–42	0.02	0.01–0.05	0.00
Snares Cape petrel	1 570	605–3 670	24	5–68	0.01	0.00–0.06	0.00
Fluttering shearwater	35 900	15 300–73 700	393	197–665	0.01	0.00–0.03	0.00
Northern little penguin	1 500	905–2 310	13	4–26	0.01	0.00–0.02	0.00
White-flippered little penguin	467	270–742	4	0–9	0.01	0.00–0.02	0.00
Little black shag	338	155–644	3	0–9	0.01	0.00–0.03	0.00
Pied shag	1 120	707–1 680	8	0–25	0.01	0.00–0.02	0.00
Grey-headed albatross	695	335–1 270	5	0–21	0.01	0.00–0.04	0.00
Fiordland crested penguin	626	283–1 180	4	0–15	0.00	0.00–0.03	0.00
Southern little penguin	1 500	910–2 380	7	1–15	0.00	0.00–0.01	0.00
Common diving petrel	137 000	46 900–309 000	383	63–1 430	0.00	0.00–0.01	0.00
Grey-faced petrel	30 000	19 200–50 200	62	27–117	0.00	0.00–0.00	0.00
Sooty shearwater	622 000	296 000–1 180 000	1 210	681–2 220	0.00	0.00–0.01	0.00
Light-mantled sooty albatross	873	668–1 140	2	0–13	0.00	0.00–0.01	0.00
Hutton's shearwater	14 900	9 160–23 300	17	3–68	0.00	0.00–0.00	0.00
Chatham Island little penguin	1 500	926–2 390	1	0–8	0.00	0.00–0.01	0.00
Buller's shearwater	56 200	34 300–102 000	17	6–35	0.00	0.00–0.00	0.00
Little shearwater	21 600	13 800–32 900	6	1–12	0.00	0.00–0.00	0.00
White-headed petrel	34 400	16 300–67 600	9	2–19	0.00	0.00–0.00	0.00
NZ white-faced storm petrel	331 000	139 000–683 000	85	17–239	0.00	0.00–0.00	0.00
Australasian gannet	9 400	4 120–18 500	3	0–12	0.00	0.00–0.00	0.00
Southern black-backed gull	333 000	138 000–689 000	54	18–117	0.00	0.00–0.00	0.00
Fairy prion	326 000	209 000–493 000	89	10–462	0.00	0.00–0.00	0.00
Snares crested penguin	6 860	4 800–9 660	1	0–5	0.00	0.00–0.00	0.00
Broad-billed prion	68 400	45 400–104 000	9	1–29	0.00	0.00–0.00	0.00
Black-bellied storm petrel	15 400	8 650–25 900	2	0–9	0.00	0.00–0.00	0.00
Cook's petrel	48 900	27 400–87 100	7	0–36	0.00	0.00–0.00	0.00
Antarctic prion	154 000	77 000–284 000	10	2–26	0.00	0.00–0.00	0.00
Mottled petrel	47 200	30 400–77 100	4	0–21	0.00	0.00–0.00	0.00
Auckland Island shag	485	198–988	0	0–1	0.00	0.00–0.00	0.00
Bounty Island shag	26	15–43	0	0–0	0.00	0.00–0.00	0.00
Subantarctic skua	67	44–103	0	0–0	0.00	0.00–0.00	0.00
Caspian tern	172	95–294	0	0–0	0.00	0.00–0.00	0.00
Chatham Island shag	76	47–116	0	0–3	0.00	0.00–0.05	0.00
Campbell Island shag	476	222–906	0	0–0	0.00	0.00–0.00	0.00
Eastern rockhopper penguin	11 100	6 800–17 300	1	0–3	0.00	0.00–0.00	0.00
Erect-crested penguin	17 800	12 600–24 700	1	0–4	0.00	0.00–0.00	0.00
White-bellied storm petrel	228	106–441	0	0–0	0.00	0.00–0.00	0.00
White tern	26	15–43	0	0–0	0.00	0.00–0.00	0.00
South Georgian diving petrel	10	5–18	0	0–1	0.00	0.00–0.07	0.00
NZ king shag	39	24–60	0	0–2	0.00	0.00–0.06	0.00
Kerm. storm petrel	12	4–26	0	0–0	0.00	0.00–0.00	0.00
Masked booby	53	28–94	0	0–0	0.00	0.00–0.00	0.00
NZ storm petrel	53	6–207	0	0–1	0.00	0.00–0.02	0.00
Pitt Island shag	103	63–161	0	0–2	0.00	0.00–0.02	0.00
Chatham petrel	42	23–76	0	0–0	0.00	0.00–0.00	0.00
Chatham Island taiko	2	1–4	0	0–0	0.00	0.00–0.00	0.00
Pycroft's petrel	412	247–718	0	0–1	0.00	0.00–0.00	0.00
Soft-plumaged petrel	497	136–1 290	0	0–0	0.00	0.00–0.00	0.00
Wedge-tailed shearwater	6 020	3 040–10 600	0	0–0	0.00	0.00–0.00	0.00
Kerm. petrel	779	500–1 300	0	0–1	0.00	0.00–0.00	0.00
White-naped petrel	7 080	3 340–14 200	0	0–0	0.00	0.00–0.00	0.00

3.5 Risk by fishery and area

The sum of risk ratios across all taxa by fishery group and fishery management area (FMA) were used to identify the fisheries and areas where seabirds are the most at risk (Figure 3). The three largest risk estimates among fishery groups and FMAs were in FMA 1 (north-eastern North Island) in inshore trawl fisheries (mean risk ratio 0.74, 95% c.i.: 0.30–1.65), surface-longline fisheries targeting big-eye tuna (mean risk ratio 0.30), and bottom-longline fisheries targeting snapper (mean risk ratio 0.28).

In other FMAs, the largest estimates of total risk were in the small-vessel surface-longline fleet targeting southern bluefin tuna in FMA 7 (off the South Island west coast; mean risk ratio 0.26) and in the small-vessel bottom-longline fishery targeting ling in FMA 4 (Chatham Rise; mean risk ratio 0.22).

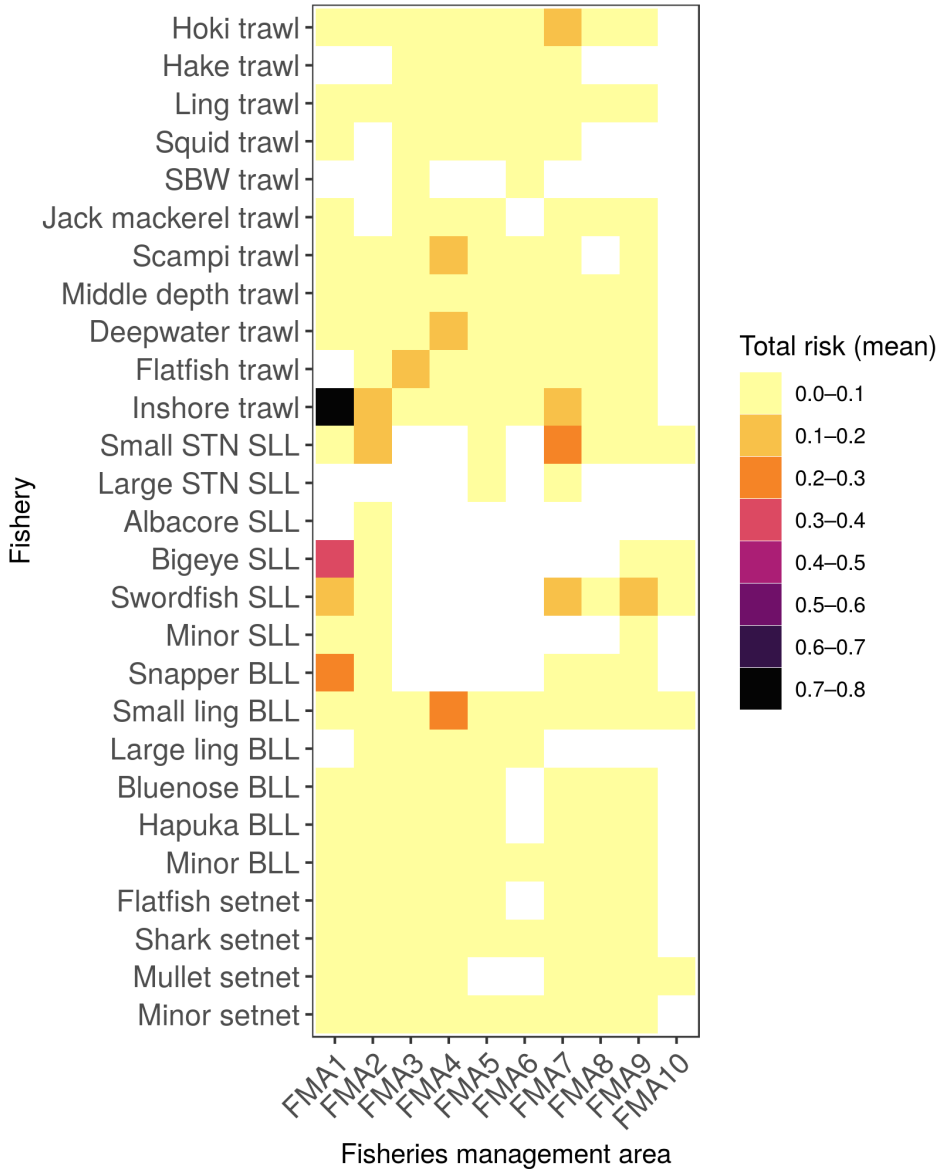

Figure 3: Total mean risk across 71 seabird taxa included in the current risk assessment by fishery group and fishery management area (FMA). Blank cells indicate the combinations of fishery group and FMA with no fishing effort. SBW; southern blue whiting; STN, southern bluefin tuna; SLL, surface longline; BLL, bottom longline.

3.6 Data corrections and updates

To evaluate the impact of data corrections on the estimated risk ratios, the estimation was first conducted for the same period (2012–13 to 2014–15) as the preceding risk assessment by Richard et al. (2017a), before updating it with additional years of fishing and capture data to include the period from 2014–15 to 2016–17 (Appendix G). For some seabird taxa and fishery groups, there were notable changes in median risk ratio following the data corrections, but there were no significant differences in overall risk ratio at the species level (Figures G-3,G-4), Nevertheless, for one species, spotted shag, the increase in risk ratio was sufficient to change its risk category from "low risk" to "medium risk".

Updating the risk assessment with two additional years of fishing and capture data resulted in a change in risk category for four seabird taxa: the risk ranking decreased from "high risk" to "medium risk" for both New Zealand white-capped albatross and Chatham Island albatross, and from "medium risk" to "low risk" for spotted shag (Table 9). In contrast, the risk category increased for white-chinned petrel, from "negligible risk" to "low risk". Overall, there were 22 seabird taxa with an updated median risk ratio above 0.1, i.e., the risk ranking was at least "low risk" or higher (see Figure G-5 for the ten taxa with the largest changes).

Table 9: Taxa with a change in risk category following the addition of two more years of data on fishing effort and observed captures, after corrections to the data from the previous risk assessment by Richard et al. (2017a). Shown are median risk ratio with limits of the 95% credible interval (c.i.) and the risk category, for the four taxa with the largest change.

Taxa	2012–13 to 2014–15			2014–15 to 2016–17		
	Median	95% c.i.	Risk	Median	95% c.i.	Risk
NZ white-capped albatross	0.380	0.225–0.616	High	0.294	0.180–0.462	Medium
Chatham Island albatross	0.326	0.168–0.596	High	0.284	0.145–0.529	Medium
Spotted shag	0.106	0.047–0.227	Medium	0.086	0.038–0.187	Low
White-chinned petrel	0.054	0.031–0.089	Negligible	0.068	0.039–0.107	Low

For individual fishery groups, the largest change in the cumulative risk ratio for all seabird taxa were decreases for trawl fisheries with inshore and flatfish targets, and bottom-longline fisheries targeting snapper (Table G-20). For the small-vessel surface-longline fleet targeting southern bluefin tuna, there was a significant increase in the cumulative risk ratio.

The largest change in the risk ratio, by species and fishery group, was an increase in the risk of inshore trawl fishing to black petrel, from 0.30 (95% c.i.: 0.07–0.89) to 0.53 (95% c.i.: 0.17–1.15) (Figure 4). Between 2006–07 and 2016–17, there were a total of 28 observed black petrel captures in inshore trawl fisheries in the Northland-Hauraki and Bay of Plenty areas. Observer coverage of these fisheries increased markedly, from an average of 1% between 2006–07 and 2012–13, to an average of 16% between 2013–14 and 2016–17. Consequently, many of the observed captures of black petrel (19 of the 28) occured in the two years (2015–16, 2016–17) that were included in the updated assessment, but not in the previous update. Of these captures, 13 were on a single trip that primarily targetting tarakihi and snapper. The captures included six records that were identified by the observer as *Procellaria* spp., and that were set to black petrel during the imputation process. The addition of two more years of data increased the observed capture rate of black petrel in inshore trawl fisheries in the Northland-Hauraki and Bay of Plenty area from 0.29 captures per 100 tows, to 0.56 captures per 100 tows, a increase of close to a factor of two. Most of the increase in the risk to black petrel from inshore trawl fisheries is associated with this increase in the observed capture rate. There was also a smaller increase relative to the assessment of Richard et al. (2017a) caused by changes to the data (see Appendix G, Figure G-4) as a result of changes in the processing of data from handheld electronic devices (NOMADs), used by observers on small vessels (Abraham & Berkenbusch 2019).

The risk to black petrel in inshore fisheries included a large cryptic multiplier (a prior of 11.61, 95% c.i.: 2.81–37.06, for vessels less than 17 m long; and 20.27, 95% c.i.: 5.91–51.91, for vessels between 17 m

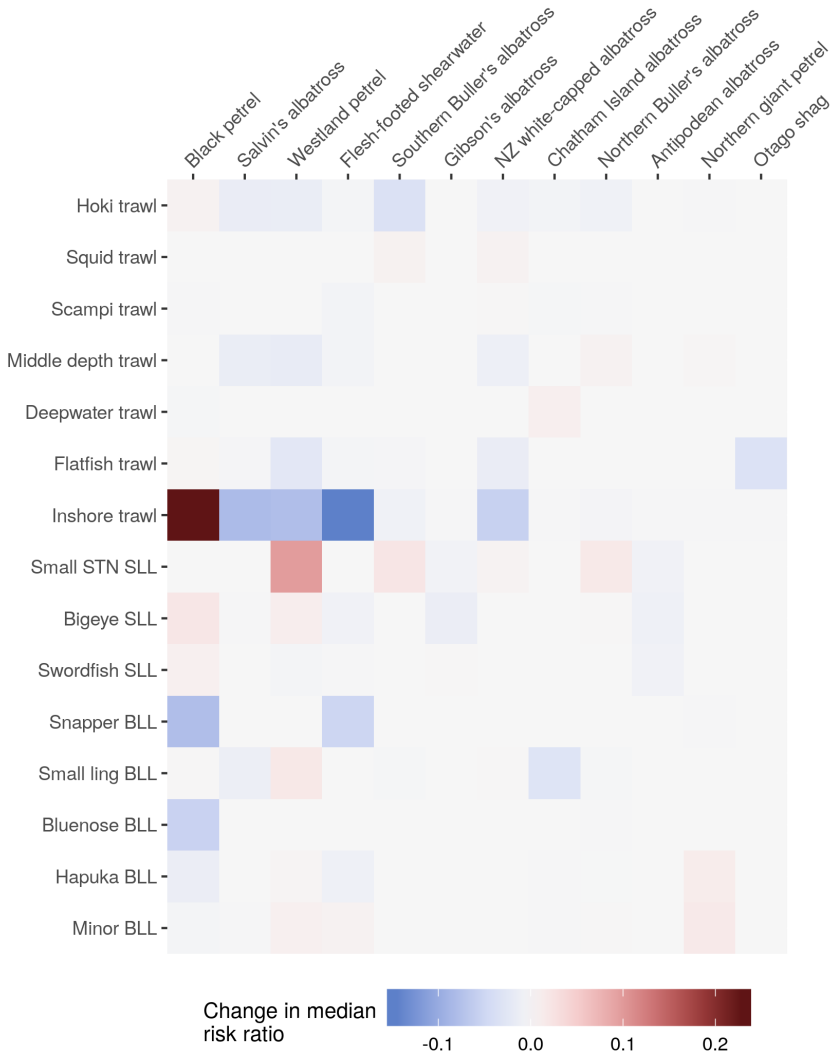

Figure 4: Change in the median risk ratio by taxa and fishery, when estimated for the period 2012–13 to 2014–15 compared with the period 2014–15 to 2016–17. Shown are only the taxa and fisheries with a median total risk ratio over 0.1. SLL, surface longline; BLL, bottom-longline.

and 28 m). Both of these cryptic multiplier priors were lower than previously (c.f. Richard et al. 2017a). After fitting the model, there was some reduction in the cryptic multipliers (to a posterior mean of 7.45, 95% c.i.: 2.04–18.89, for vessels less than 17 m long; and 13.67, 95% c.i.: 12.34–30.51, for vessels 17 m to 28 m).

There was a decrease in the risk to black petrel from surface longline fishing (Figure 4). This decrease was due to a trip that had previously been though to have been surface longline fishing, but that was reclassified as a bottom longline trip (Abraham & Berkenbusch 2019). There was also a notable increase in risk ratio for Westland petrel in the small-vessel surface-longline fishery targeting southern bluefin tuna (associated with an increase in the number of observed captures of Westland petrel in the Westland area, with 18 observed captures during 2015–16 and 2016–17, compared with 6 observed captures between 2006–07 and 2014–15). There was a decrease in median risk ratio for flesh-footed shearwater in inshore trawl fisheries.

4. DISCUSSION

The current update of the seabird risk assessment included two additional years of fishing effort and capture data, from 2015–16 and 2016–17. In addition, it incorporated data corrections following the identification of inconsistencies and discrepancies during the preparation of data for the 2016–17 fishing year (see details in Abraham & Berkenbusch 2019).

4.1 Changes following data corrections

To distinguish the general update of the risk assessment from changes resulting from the data corrections, the present study first applied the risk assessment framework to the corrected data set for the same period as the preceding risk assessment (Richard et al. 2017a). This part of the analysis highlighted changes to the estimated risk ratios for some of the fishery groups and seabird taxa. While the changes caused shifts in risk between fisheries (most notably a decrease in risk for black petrel in surface longline fisheries), none of the overall changes in risk were significant for any of the 71 seabird taxa included in the risk assessment.

4.2 Updates to the risk assessment

Updating the risk assessment for the fishing years from 2014–15 to 2016–17 with additional data and incorporating corrections led to a change in risk category for four seabird species: the risk ranking decreased from "high risk" to "medium risk" for Chatham Island and New Zealand white-capped albatrosses, and from "medium risk" to "low risk" for spotted shag; it increased from "negligible risk" to "low risk" for white-chinned petrel.

Black petrel remained at the top of the risk ranking, as the only species in the "very high risk" category. The estimated median risk ratio of this species was 1.23 (95% c.i.: 0.55–2.11), with an estimated mean 513 (95% c.i.: 325–803) fisheries-related deaths, exceeding the mean PST of 447 (95% c.i.: 225–831) individuals. There was a large increase in estimated risk to black petrel from inshore trawl fisheries. The two additional years of data resulted in the observed capture rate of black petrel almost doubling in inshore trawl fisheries in the Bay of Plenty and Northland-Hauraki areas, which led to the increase in the risk. The portion of this risk attributed to inshore trawl fisheries (a mean risk ratio of 0.56, 95% c.i.: 0.17–1.15) is sensitive to structural assumptions about cryptic mortality that have not been critically examined with specific reference to black petrel; additional research is in progress to address these issues.

There were five taxa that remained in the "high" risk category – Salvin's albatross, Westland petrel, flesh-footed shearwater, southern Buller's and Gibson's albatrosses. Two other species that were previously in the "high risk" category, Chatham Island and New Zealand white-capped albatrosses, moved to the "medium" risk ranking. The latter risk category included another five taxa that remained at "medium risk" — northern Buller's albatross, yellow-eyed penguin (mainland and Stewart Island population),

Antipodean albatross, northern giant petrel and Otago Shag. There were five taxa in the "low" risk category, with spotted shag, yellow-eyed penguin (whole New Zealand population), Campbell black-browed albatross and northern Royal albatross remaining in this category, with one newly-added species, white-chinned petrel.

4.3 Cryptic multipliers

A key component of estimating the risk is the cryptic multiplier. This accounts for direct mortalities that would not be recorded by an observer (such as birds that strike the warp of a trawl vessel, but are not recovered on the vessel). There is little quantitative information available to inform estimates of cryptic mortality. For black petrel, the seabird with the highest risk, the same cryptic multiplier was estimated for all medium-sized seabirds. In trawl fisheries, the multipliers are largely associated with warp captures, however, no warp captures of black petrel have been observed. It is possible that, if a species-specific cryptic multiplier was developed for black petrel, then the cryptic multiplier and the estimated risk to black petrel would be reduced.

More generally, the cryptic mortality (i.e. unobservable deaths) accounts for a large proportion of total deaths in trawl fisheries, and may be poorly estimated for some fisheries and species. Until such time as the structural assumptions underlying the estimation of cryptic mortality multipliers have been revisited; estimates of total fishing-related deaths in trawl fisheries should be interpreted with caution. Work to refine estimates of cryptic mortality will result in a better understanding of the direct impact of fishing on seabirds.

4.4 Yellow-eyed penguin

For most seabirds, the risk was estimated at the species (or subspecies) level. For yellow-eyed penguin the risk was estimated for the whole species, as well as for the population that breeds on the New Zealand mainland and on Stewart Island (on the assumption that all fisheries related deaths are from this population). In this update of the risk assessment, no new information on seabird distributions or demography was used. The estimated number of breeding pairs in the mainland and Stewart Island population was assumed to be between 600 and 800, during the full period over which observed captures were used to estimate catchability, captures, and risk.

In the South Island, yellow-eyed populations have been declining, with a 50% decline in the number of breeding pairs over the previous 20 years (Efford et al. 1994). The most recent counts of breeding pairs were 252 pairs in the South Island mainland (in 2017), 112 pairs on Stewart Island/Rakiura (in 2008), and 16 pairs on Codfish Island/Whenua Hou (in 2017), a total of 380 breeding pairs (Efford et al. 1994). This population decline was not considered in this analysis.

This update of the risk assessment applied the same yellow eyed penguin spatial distribution as was used previously (Richard et al. 2017b), without reference to new tracking data. A species-specific assessment of risk to yellow-eyed penguin that uses updated spatial foraging data, and considers changing local population sizes affecting spatial overlap with fisheries, may provide more reliable estimates of fisheries risk at finer spatial and temporal scales.

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Most data for this project were collected by government fisheries observers. We are grateful for their ongoing work to collect the independent information that enhances our understanding of interactions between seabirds and New Zealand fisheries.

The technical completion of this work relied on open-source software, especially PostgreSQL, R, JAGS, Python, Latex, Linux and Emacs. We are extremely grateful to the many people who contribute to these software projects.

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APPENDIX A: ESTIMATION OF CRYPTIC MORTALITIES

Not all seabirds that are killed during fishing operations are recorded by observers, even when observers are on-board a vessel. For example, birds may be killed but not brought on-board the fishing vessel, and observers may also not record captures if they are off duty or in an area of the vessel where captures are not visible.

These cryptic deaths are not included in the number of observable captures, but need to be included in the assessment of the risk to seabirds from fishing. The current risk assessment process included multipliers for cryptic mortalities ("cryptic multipliers") in the estimation of observable captures. The cryptic multipliers were derived from a number of data sources, as there are limited data available to support the quantification of cryptic mortalities.

The total number of fishing-related deaths, D, is calculated as the sum of observable captures, C, and unobservable or cryptic deaths, U:

$$D = C + U. \tag{A-1}$$

Some of the observable captures, C, involve birds that were released alive. The probability that a captured bird was released alive, p_{alive}, varied across species groups and fishery groups (see below, Appendix B).

Cryptic multipliers, $M = D/C$, were estimated separately for longline and trawl fisheries, following previous risk assessments. The number of total deaths was expressed as the product of the cryptic multiplier and the number of observable captures. Cryptic multipliers were estimated separately for longline and trawl fisheries. For longline fisheries, a single cryptic multiplier was estimated for all taxa, whereas for trawl fisheries, different multipliers were estimated for five different species groups (large albatrosses, mollymawks and giant petrel, medium-sized seabirds, small-sized seabirds, and diving seabirds), and for nine fishery groups. Because no data exist on cryptic mortality in set-net fisheries to allow the estimation of a multiplier, the number of fishing-related deaths was assumed to be equal to the estimated number of observable captures in these fisheries.

A.1 Cryptic multiplier for longline fisheries

A multi-year study conducted in Australia compared the number of individual birds hooked during the set and haul processes with observed captures that were subsequently recorded (Brothers et al. 2010). This study revealed that of 176 seabirds observed caught on hooks, only 85 carcasses were retrieved. These values were used here to deduce the probability distribution of capturing a bird in longline fisheries, given it was caught on the line, from the likelihood of the binomial distribution:

$$\mathcal{L} = \frac{n!}{k!(n-k)!} p^k (1-p)^{n-k}, \tag{A-2}$$

where n is the number of birds observed hooked, k is the number of retrieved carcasses, and p is the probability of a bird being retrieved on-board, given that it was hooked. The cryptic multiplier for longline fisheries is then $M = 1/p$. Using $n = 176$ and $k = 85$ in Equation A-2 led to a mean of M of 2.08, with a 95% credible interval of 1.8 to 2.44.

This distribution was used for all seabird taxa and all surface-longline fisheries. Each sample of estimated observable captures was multiplied by a sample from this distribution to estimate the total fishing-related deaths. In the absence of other information, the same distribution for the cryptic multiplier was used for bottom-longline fisheries. The uncertainty was the statistical uncertainty associated with the study by Brothers et al. (2010). Structural uncertainty associated with applying these values to different fisheries, impacting a different assemblage of seabird species, was not considered.

A.2 Cryptic multiplier for trawl fisheries

To estimate total deaths in trawl fisheries, three types of seabird-trawler interactions were considered:

- Net entanglement. Birds that become entrapped or entangled in the net during shooting or hauling gear.

- Surface warp strike. Birds resting or hovering on the surface of the water that are overtaken and potentially entangled or drowned by a moving warp line, or that are struck by warp movement arising from the lateral movement of the vessel.

- Aerial warp strike. Flying birds that collide with the warp.

The number of deaths per observed fishing event can then be defined as:

$$D_{tot} = D_{net} + D_{surf} + D_{air} \quad \text{(A-3)}$$

$$= C_{net}M_{net} + C_{surf}M_{surf} + C_{air}M_{air} \quad \text{(A-4)}$$

where D_{net}, D_{surf}, and D_{air} are the total deaths in the net, due to surface warp strikes and aerial warp strikes respectively, C_{net}, C_{surf}, and C_{air} the corresponding observed captures, and M_{net}, M_{surf}, and M_{air}, the corresponding cryptic multipliers.

To determine the relationship between captures and deaths, different probabilities were estimated (illustrated in Figure A-1). Uncertainties were estimated by drawing 5000 samples from a probability distribution for the underlying data. When the data were given as a number of interactions in a number of trials, a binomial distribution was assumed (Equation A-2). When estimated proportions were reported as a mean and 95% confidence interval (e.g., the number of strikes per capture), a log-normal distribution was assumed and defined to match the 95% confidence interval. From a mean μ and a standard deviation σ, mortality rates were assumed to follow a beta distribution, with its two shape parameters α and β defined using the equations (Samaranayaka; Fletcher 2010):

$$\alpha = \mu\left(\frac{\mu(1-\mu)}{\sigma^2} - 1\right), \quad \text{(A-5)}$$

$$\beta = \frac{(1-\mu)\alpha}{\mu}. \quad \text{(A-6)}$$

A.2.1 Net entanglement

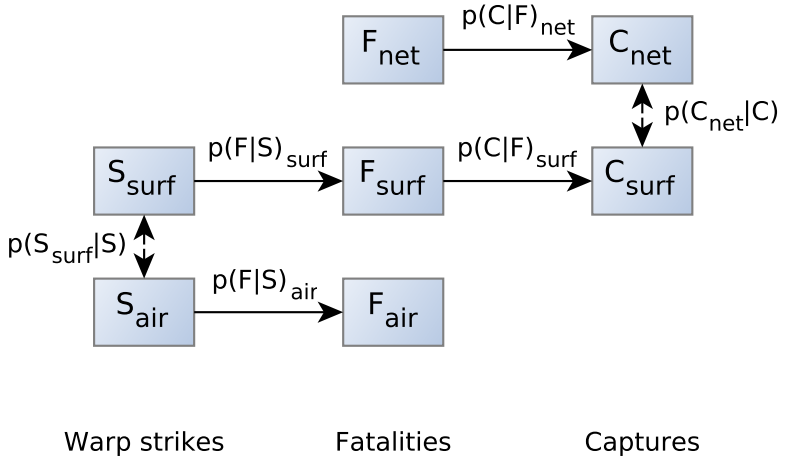
Net entanglements can occur either when shooting or hauling the net, with the majority of net captures occurring during hauling. Birds can become enmeshed in the trawl wings during setting, trapped inside the net as it closes (i.e., primarily diving species) or trapped on the outside of the net as the mesh tightens and closes during hauling. In the latter instance, birds may be released alive. In this analysis, these live captures were treated as deaths, as long-term impacts resulting from the capture are unknown. Cryptic net deaths U_{net} arise when birds become entangled in the trawl wings during setting or on the outside of the net during hauling, but subsequently fall off and are not recorded. Cryptic net deaths also include birds caught inside the net that are subsequently lost through the slack mesh during the haul.

In preparation of a previous risk assessment (Richard et al. 2011), it was agreed that the number of cryptic net deaths, U_{net}, is likely to be lower than the number of observable captures, C_{net}. A ratio of cryptic to observable captures of $U_{net}/C_{net} = 0.3$ was used in the earlier assessment by Richard et al. (2011). To consider uncertainty around this ratio, we assumed that U_{net}/C_{net} followed a log-normal distribution with a 95% confidence interval of 0.1 to 0.7, and mean of 0.3. This range was not based on data.

The total number of deaths due to net entanglements is the sum of observed and unobserved deaths, therefore

$$M_{net} = D_{net}/C_{net} = 1 + U_{net}/C_{net}. \quad \text{(A-7)}$$

Figure A-1: Diagram of the parameters and processes involving seabird deaths in trawl fisheries. Seabirds can be struck by warps either on the surface of the water, S_{surf}, or when flying, S_{air}. These warp strikes can lead to deaths (D_{surf}, D_{air}). Deaths of seabirds can also occur from their entanglement or capture in nets, D_{net}. Captures of seabirds recovered on-board the fishing vessel were assumed to be only from interactions with the net, C_{net}, or from surface warp strikes, C_{surf}.



A.2.2 Warp strikes

Limited data for estimating cryptic mortality from warp strikes are provided by two studies. Watkins et al. (2008) provide data on the number of warp strikes and subsequent deaths, based on 190 hours of dedicated observations in the South African deepwater hake fishery in 2004 and 2005. Another study by Abraham (2010) provides estimates of the number of warp strikes per observed capture, using 7266 observations of warp strikes collected in New Zealand trawl fisheries in the fishing years between 2004–05 and 2008–09.

To relate observed warp captures to estimated warp deaths, it is first necessary to distinguish between types of warp interactions and species- or guild-specific differences likely to affect the outcome of warp-bird interactions.

Seabird taxa were categorised according to their size and their diving behaviour (diving seabirds are assumed to not be affected by collisions with warps while at the surface) (Table 1). The species types were: large albatrosses (*Diomedea* species), mollymawks (*Thalassarche* and *Phoebetria* species) and giant petrel, diving seabirds (penguins, shags, boobies, and gannets), medium-sized seabirds (non-diving seabirds and non-albatross seabirds at least larger than white-naped petrel), and small seabirds (other seabirds like Cape petrel and smaller).

Due to behavioural and anatomical differences affecting warp-bird interactions, estimates of warp strike parameters were calculated independently for large versus small seabirds. Small birds were further differentiated into "fast-flying", "slow-flying", or "diving" species, with distinct assumptions about their relative susceptibilities to different kinds of capture. In general, fast-flying birds are larger than slow-flying birds; they are slower to accelerate from the surface of the water, turn less quickly, and may fly with considerable forward momentum. Diving birds (shags and penguins) do not forage while flying and were assumed to be killed only in the net.

A.2.3 Surface warp strikes

The total cryptic deaths from surface warp strikes are:

$$D_{surf} = C_{surf} + U_{surf}. \tag{A-8}$$

Surface warp strikes occur when birds resting or hovering on the surface of the water are overtaken by the moving warp, or struck by warp movement arising from lateral movement of the vessel. Watkins et al. (2008) report that surface warp strike rates are strongly correlated with large swell conditions due to the resulting erratic movement of the warps relative to resting seabirds. Surface strikes leading to capture or death occur primarily when bird wings become entangled, and they are dragged underwater by the force of the water passing over the warp. Birds dragged underwater may resurface, or they may drown. Drowned birds may subsequently fall off the warp during the setting and hauling processes (U_{surf}); alternatively, they may be impaled on a sprag (loose warp splice) or pulled all the way to the trawl door, and subsequently retrieved (i.e., C_{surf}). Non-lethal warp captures are not observed.

Large birds such as albatrosses are particularly susceptible to being dragged underwater by surface warp strikes, because they habitually sit or hover on the surface with their wings spread; when struck from behind by a moving warp, the wing tends to wrap around the warp leading to entanglement. In contrast, because small birds habitually sit on the water with their wings closed, they are seldom entangled in the warps, and only very rarely observed as warp captures. Both fast-flying and slow-flying small birds were assumed to be susceptible to surface warp capture; the lower susceptibility of the slow-flying birds was expected to be reflected in lower observed capture rates. In contrast, diving birds (penguins and shags) were assumed not to be captured or killed in warp interactions; all diving bird deaths were assumed to occur in the net, with no cryptic surface or aerial warp deaths ($U_{surf}^{diving} = U_{air}^{diving} = 0$).

The probability that a bird hit by the warp (aerial or surface strike) is recovered on-board the vessel is the product of the probability of entanglement (or impalement; D) given the strike (S) and the probability that the bird is recovered (C) given it gets entangled (or impaled). In mathematical terms,

$$p(C|S) \quad = \quad p(C|D)p(D|S). \tag{A-9}$$

Assuming that fatal aerial warp strikes do not result in captures ($C_{air} = 0$), the number of deaths from surface warp strikes per warp capture (D_{surf}/C_{warp}) is the probability that a surface warp strike is fatal, $p(D_{surf}|S_{surf})$, times the number of surface warp strikes per warp capture (S_{surf}/C_{warp}). In the earlier studies, Abraham (2010) found that for large birds, there were an estimated 244 (95% c.i.: 190–330) warp strikes for each capture (S_{warp}/C_{warp}); Watkins et al. (2008) report that of a total 376 observed strikes, 139 were surface warp strikes for large birds, leading to the mean probability that a strike is at the surface, $p(S_{surf}|S_{warp})$, of 0.37 (95% c.i.: 0.32–0.42). The ratio S_{surf}/C_{warp} was then estimated to be 93.67 (95% c.i.: 67.61–126.24). Watkins et al. (2008) also report that 24 deaths were observed following 139 surface warp strikes, resulting in a probability of observing a death from a surface warp strike of 0.18 (95% c.i.: 0.12–0.24).

The same authors reported that 16 albatrosses were seen dragged under the water without resurfacing, so that their fate was unknown. The deaths of large albatrosses, mollymawks, and giant petrel, following the observed surface warp strikes were then estimated to be 26.82 (95% c.i.: 24–30), and the probability of a surface warp strike being fatal was estimated as 0.2 (95% c.i.: 0.14–0.27). From the product of $p(D_{surf}|S_{surf})$ and S_{surf}/C_{warp}, the number of deaths per surface warp capture, D_{surf}/C_{warp}, was estimated to be 18.49 (95% c.i.: 11.23–28.67).

For small birds, there were an estimated 6440 (95% c.i.: 3400–20 000) strikes per warp capture (Abraham 2010). There were 124 surface warp strikes out of 615 observed strikes, and they resulted in 6 deaths (and 10 that were unsure) (Watkins et al. 2008). Repeating the calculations, the mean number of small-bird deaths per surface warp capture, D_{surf}/C_{warp}, was estimated to be 111.88 (95% c.i.: 28.22–309.84). This estimate was used for small and medium-sized taxa.

A.2.4 Aerial warp strikes

Aerial warp strikes occur when flying birds collide with the moving warps. Aerial strikes are defined as any heavy contact between the bird and the warp, sufficient to deflect the bird's flight trajectory; wing contacts are only included if they occur above the wrist (Abraham 2010), coinciding with the definition

of "heavy" collisions used by Watkins et al. (2008).

Because impacts occur primarily on the front surface of the wings, aerial strikes do not result in entanglement in the warp, and captures on warps due to aerial strikes can be assumed to be non-existent. Deaths from aerial strikes are only cryptic, and thus a multiplier cannot be defined relative to aerial captures. Nevertheless, as in the previous analysis of surface warp strikes, the number of aerial strikes can be estimated relative to the number of surface strikes; the latter is estimated relative to the number of warp captures.

The number of deaths due to aerial strikes per warp capture, D_{air}/C_{warp}, is the probability that an aerial warp strike is fatal, $p(D_{air}|S_{air})$, times the number of aerial strikes per warp capture, S_{air}/C_{warp}.

Aerial strike death is expected to arise primarily from damage to wing bones or tendons, but empirical data to estimate the subsequent death rate among affected birds are not currently available. Watkins et al. (2008) report that aerial strikes "usually had little apparent impact on birds" and recorded only one confirmed broken wing for a small fast-flying bird (white-chinned petrel) in 728 observed heavy collisions. Death rates for aerial warp strikes are thought to be low (e.g., 0 to 5%), and expected to be highest for large birds, and moderate for small, fast-flying birds, which may collide under their own forward momentum; they are expected to be low for small, slow-flying birds, which have a minimal forward momentum and for which strikes are more likely to arise from the lateral movement of the warp itself. For small diving birds, it was assumed that there are no cryptic warp deaths, i.e., $D_{air} = 0$. It is important to note, however, that without dedicated efforts to assess the post-collision status of affected birds, any conclusion about associated death rates is highly speculative. We assumed that the death rate due to aerial warp strikes, $p(D_{air}|S_{air})$, followed a beta distribution, with a coefficient of variation of 0.2, and we applied the following mean death rate estimates previously proposed by Sharp et al. (2011) (see Richard et al. 2011): 2% for large birds, 1% for small, fast-flying birds, and 0.5% for small, slow-flying birds.

The ratio S_{air}/C_{warp} is the number of warp strikes per warp capture, S_{warp}/C_{warp}, times the proportion of aerial strikes among warp strikes, $p(S_{air}|S_{warp}) = 1-p(S_{surf}|S_{warp})$, as calculated in the analysis of surface warp strikes above. Using this ratio led to the number of deaths due to aerial strike per observed capture of 3.19 (95% c.i.: 1.87–5.01) for large birds, 72.62 (95% c.i.: 24.79–174.45) for medium-sized seabirds, and 36.58 (95% c.i.: 12.11–88.93) for small-sized seabirds. These estimates are speculative.

A.3 Estimation of total deaths in trawl fisheries

The total number of deaths in trawl fisheries, D_{trawl}, is the number of deaths due to entanglements in the net, D_{net}, due to surface warp strikes, D_{surf}, and due to aerial warp strikes, D_{air}. Following the previous calculations,

$$\begin{aligned} D_{trawl} &= D_{net} + D_{surf} + D_{air}, && \text{(A-10)} \\ &= M_{net}C_{net} + (M_{surf} + M_{air})C_{warp}, && \text{(A-11)} \\ &= M_{net}p(C_{net}|C_{trawl}) + (M_{surf} + M_{air})(1 - p(C_{net}|C_{trawl}))C_{trawl}, && \text{(A-12)} \end{aligned}$$

where $p(C_{net}|C_{trawl})$ is the proportion of trawl captures that are retrieved in the net. This proportion can be estimated as observers in New Zealand trawl fisheries record whether captured birds were retrieved in the net or on the warps. The proportion of warp versus net captures varied among trawl fishery groups and species groups. For example, the proportion of observed net versus warp captures of mollymawks and giant petrel recorded in the net varied from approximately 7% in small inshore trawl fisheries to 80% in trawl fisheries targeting squid (Table A-1).

From the number of observed captures occurring in the net, the proportion of net or warp captures p_{net} for each fishing group and species group was estimated using a simple Bayesian binomial and logistic regression model (Table A-2).

In the model, the number of observed net captures C'_{net} was a binomial draw from the total number of

Table A-1: Number of seabirds recorded caught on warps or in the net, in trawl fisheries, between the fishing years 2006–07 and 2016–17. Shown are the total number of captures and the proportion of captures recorded in the net.

Fishery	Large albatrosses		Mollymawks & giant petrel		Medium-sized seabirds		Small-sized seabirds		Diving seabirds	
	Total	%(net)	Total	%(net)	Total	%(net)	Total	%(net)	Total	%(net)
Small inshore < 17 m	0		7	0.0	27	100.0	0		32	100
Small inshore 17 to 28 m	0		58	10.3	41	90.2	0		0	
Southern blue whiting	2	50.0	22	36.4	46	95.7	6	100	0	
Scampi	0		56	71.4	136	100.0	2	100	0	
Mackerel	0		26	92.3	36	97.2	6	100	1	100
Squid	6	83.3	663	78.6	1 747	99.7	17	100	0	
Large processor	5	80.0	575	71.8	675	99.1	30	80	0	
Large fresher	0		9	55.6	0		0		0	
Deepwater	1	0.0	21	14.3	5	100.0	2	50	0	

observed captures C'_{tot} in the net or on warps, of species group s in the fishery group g, with probability p_{net}. The logit of p_{net} for each fishery group and species group was the addition of a fishery group effect β_{g} and a species group effect β_{s}:

$$C'_{\text{net}} \sim Binom(p_{\text{net}}, C'_{\text{tot}}), \tag{A-13}$$

$$\text{logit}(p_{\text{net}}) = \beta_{\text{g}} + \beta_{\text{s}}. \tag{A-14}$$

A normally-distributed uninformative prior was used for β_{g} and β_{s} (mean of 0 and standard deviation of 10 000). The model was run with three chains, a burn-in period of 150 000 iterations, and the posterior distributions drawn from 10 000 iterations, keeping a sample value every 10 iterations.

This model structure was selected during preliminary analyses, when a combination of alternative models was tested. In these models, a time effect was considered, with the period 2006–07 to 2016–17 split into three periods of three years. Alternative splits of all trawl fisheries were also tested, into inshore and other trawls, or into inshore, low-vulnerability fisheries (mackerel, scampi, deepwater, large fresher trawls), and other trawls. Interactions between the fishery group, the species group, and time period were also tested.

The models were compared using the Bayesian leave-one-out cross validation measure (LOO; Vehtari et al. 2016a, 2016b). The LOO measure estimates the error in point-wise out-of-sample predictions from the model. A lower LOO measure indicates a more accurate model. Here, the model with the lowest LOO score was the additive model of an effect of the seabird risk assessment fishery groups and of the species group, without time variation.

From the parameters involving seabird deaths in trawl fisheries (summarised in Table A-3), and from Equation A-12, the number of deaths in trawl fisheries relative to the number of observable captures was estimated for each seabird group (Table 7).

After fitting the best model, the posterior distributions of the probability p_{net} were used to derive the cryptic multiplier for each trawl fishery group and species type (Table A-4).

To allow cryptic mortalities to be estimated in trawl fisheries, the following simplifying assumptions were made:

- all bird captures on warps result in mortality, and only captures in the net include live captures;
- all bird captures on warps are only due to surface warp strikes;
- small diving birds are killed only in the net;
- the mortality rate for surface warp strikes in New Zealand trawl fisheries can be approximated by applying the mortality rate observed in South African deepwater hake fisheries.

Table A-2: Proportion of seabird captures in net or on warps in trawl fisheries that occurred in net (p_{net}), as estimated by a generalised linear model fitted to seabird captures observed between 2006–07 and 2016–17. Shown are the mean, 95% credible interval (c.i.), and the posterior distribution between 0 and 1.

Species type	Fishery	p_{net}		Posterior
		Mean	95% c.i.	
Large albatrosses	Small inshore < 17m	0.30	0.06–0.71	
	Small inshore < 28m	0.17	0.04–0.44	
	Southern blue whiting	0.49	0.19–0.81	
	Scampi	0.78	0.51–0.95	
	Mackerel	0.91	0.70–0.99	
	Squid	0.83	0.62–0.96	
	Large processor	0.76	0.52–0.94	
	Large fresher	0.63	0.23–0.94	
	Deepwater	0.23	0.04–0.58	
Mollymawks & giant petrel	Small inshore < 17m	0.22	0.07–0.48	
	Small inshore < 28m	0.11	0.05–0.18	
	Southern blue whiting	0.40	0.24–0.57	
	Scampi	0.73	0.61–0.84	
	Mackerel	0.89	0.76–0.98	
	Squid	0.79	0.76–0.82	
	Large processor	0.71	0.67–0.74	
	Large fresher	0.56	0.25–0.85	
	Deepwater	0.15	0.05–0.30	
Medium-sized seabirds	Small inshore < 17m	0.94	0.85–0.99	
	Small inshore < 28m	0.89	0.82–0.95	
	Southern blue whiting	0.98	0.96–0.99	
	Scampi	0.99	0.99–1.00	
	Mackerel	1.00	1.00–1.00	
	Squid	1.00	0.99–1.00	
	Large processor	0.99	0.99–1.00	
	Large fresher	0.99	0.96–1.00	
	Deepwater	0.92	0.80–0.97	
Small-sized seabirds	Small inshore < 17m	0.52	0.18–0.85	
	Small inshore < 28m	0.34	0.14–0.61	
	Southern blue whiting	0.72	0.50–0.89	
	Scampi	0.91	0.81–0.97	
	Mackerel	0.97	0.91–1.00	
	Squid	0.94	0.87–0.98	
	Large processor	0.91	0.82–0.97	
	Large fresher	0.82	0.52–0.97	
	Deepwater	0.42	0.16–0.73	
Diving seabirds	Small inshore < 17m	1.00	0.99–1.00	
	Small inshore < 28m	1.00	0.97–1.00	
	Southern blue whiting	1.00	0.99–1.00	
	Scampi	1.00	1.00–1.00	
	Mackerel	1.00	1.00–1.00	
	Squid	1.00	1.00–1.00	
	Large processor	1.00	1.00–1.00	
	Large fresher	1.00	1.00–1.00	
	Deepwater	1.00	0.98–1.00	

Table A-3: Transition probabilities (%; mean and 95% credible interval, c.i.) for the calculation of cryptic mortality of seabirds in trawl fisheries for different types of birds. C, observed captures; D, deaths; S, warp strike; indices $surf$, air, and net refer to surface and air warp strikes and net entanglement or captures; "all" includes large, small slow-flying, small fast-flying, and small diving seabirds.

Transition probability	Seabird type	Mean	95% c.i.
$p(C\|F)_{surf}$	Large	5.73	3.49–8.91
	Medium & small	1.31	0.35–3.69
$p(F\|S)_{surf}$	Large	523.75	367.83–740.36
	Medium & small	1 957.60	919.12–4 133.71
$p(F\|S)_{air}$	Large	5 189.90	3 516.92–7 692.41
	Medium-sized	10 422.05	6 979.33–15 705.10
	Small-sized	20 874.69	14 190.37–30 864.86
$p(S_{surf}\|S)$	Large	37.05	32.21–42.00
	Medium & small	20.29	17.22–23.58
$p(C\|F)_{net}$	All	77.92	58.84–90.75

Table A-4: Cryptic multipliers (mean and 95% credible interval, c.i.) used to relate total fishing-related mortalities (D) to the number of observable captures, by seabird species group and fishery group (BLL, bottom longlining; SLL, surface longlining; SN, set netting). These multipliers were used as priors in the risk assessment model.

Method	Species group	Fishery group	Cryptic multiplier	
			Mean	95% c.i.
Trawl	Large albatrosses	Small inshore < 17 m	15.51	6.74–26.09
		Small inshore < 28 m	18.16	10.41–28.20
		Southern blue whiting	11.74	4.92–21.13
		Scampi	5.74	2.20–12.13
		Mackerel	3.09	1.43–7.64
		Squid	4.81	2.08–9.84
		Large processor	6.14	2.47–12.58
		Large fresher	8.82	2.53–18.83
		Deepwater	17.12	9.01–27.58
	Mollymawks & giant petrel	Small inshore < 17 m	17.06	9.69–26.66
		Small inshore < 28 m	19.35	12.29–28.21
		Southern blue whiting	13.46	7.99–20.91
		Scampi	6.75	3.99–10.68
		Mackerel	3.48	1.70–6.79
		Squid	5.56	3.83–7.85
		Large processor	7.19	4.80–10.21
		Large fresher	10.22	4.03–18.70
		Deepwater	18.40	11.34–27.45
	Medium-sized seabirds	Small inshore < 17 m	11.61	2.81–37.06
		Small inshore < 28 m	20.27	5.91–51.91
		Southern blue whiting	5.21	2.11–12.86
		Scampi	2.22	1.42–3.91
		Mackerel	1.60	1.21–2.45
		Squid	1.94	1.39–2.99
		Large processor	2.28	1.50–3.91
		Large fresher	3.77	1.50–10.79
		Deepwater	16.07	3.92–50.30
	Small-sized seabirds	Small inshore < 17 m	72.25	13.68–207.15
		Small inshore < 28 m	98.13	27.63–262.68
		Southern blue whiting	42.38	10.26–123.46
		Scampi	14.10	3.41–43.89
		Mackerel	5.72	1.68–17.88
		Squid	10.73	3.04–30.90
		Large processor	15.18	4.05–42.96
		Large fresher	27.75	4.07–98.27
		Deepwater	85.46	21.00–235.37
	Diving seabirds	All trawl	1.30	1.10–1.70
BLL	All seabirds	All BLL	2.08	1.80–2.44
SLL	All seabirds	All SLL	2.08	1.80–2.44
SN	All seabirds	All SN	1.00	1.00–1.00

APPENDIX B: SEABIRD POPULATION DATA

B.1 Demographic parameters

Table B-5: Summary of demographic parameters (mean and 95% credible interval, c.i.) for each seabird taxon, used for the calculation of the Population Sustainability Threshold (PST), including current and optimal adult annual survival rate (S_{curr} and S_{opt}, respectively), current age at first reproduction (A), the proportion of adults breeding (P_B), and the number of annual breeding pairs (N_{BP}), rounded to three significant digits. At-risk taxa are in bold and coloured according to the associated risk category as defined in the "National Plan of Action – 2013 to reduce the incidental catch of seabirds in New Zealand fisheries" (Ministry for Primary Industries 2013): Red: very high risk; dark orange: high risk; light orange: medium risk; yellow: low risk.

Taxon	S_{curr}		S_{opt}		A		P_B		N_{BP}	
	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.
Gibson's albatross	0.96	0.94–0.98	0.96	0.94–0.98	11.01	10.05–11.95	0.60	0.50–0.69	4 804	3 963–5 838
Antipodean albatross	0.96	0.94–0.97	0.96	0.94–0.97	11.52	10.08–12.93	0.60	0.50–0.69	3 347	2 717–4 081
Southern royal albatross	0.95	0.93–0.96	0.95	0.93–0.96	9.53	8.54–10.54	0.60	0.50–0.69	7 911	6 474–9 633
Northern royal albatross	0.94	0.91–0.97	0.94	0.91–0.97	9.54	8.55–10.54	0.61	0.51–0.70	6 091	3 301–10 558
Campbell albatross	0.94	0.93–0.96	0.94	0.93–0.96	9.48	6.20–12.82	0.89	0.75–0.96	21 810	11 637–37 654
NZ white-capped albatross	0.96	0.94–0.98	0.96	0.93–0.98	11.99	9.13–14.85	0.68	0.58–0.77	95 701	85 350–106 338
Salvin's albatross	0.97	0.94–0.98	0.97	0.94–0.98	12.01	9.14–14.84	0.89	0.75–0.96	41 483	41 025–41 935
Chatham Island albatross	0.97	0.94–0.98	0.97	0.94–0.98	12.02	9.15–14.87	0.89	0.75–0.96	5 287	4 303–6 444
Grey-headed albatross	0.95	0.93–0.97	0.95	0.93–0.97	10.03	7.16–12.85	0.75	0.64–0.84	6 921	3 674–11 873
Southern Buller's albatross	0.96	0.93–0.98	0.95	0.93–0.98	11.98	9.15–14.84	0.89	0.76–0.97	13 713	11 199–16 699
Northern Buller's albatross	0.95	0.93–0.98	0.96	0.93–0.98	11.98	9.13–14.86	0.89	0.76–0.96	16 394	13 440–19 761
Light-mantled sooty albatross	0.97	0.96–0.98	0.97	0.96–0.98	11.97	9.14–14.84	0.60	0.50–0.69	6 835	6 773–6 897
Northern giant petrel	0.89	0.81–0.96	0.89	0.81–0.96	8.01	6.10–9.90	0.89	0.75–0.96	2 612	2 163–3 108
Grey petrel	0.94	0.90–0.97	0.93	0.90–0.97	7.00	5.10–8.90	0.80	0.69–0.88	49 597	32 643–71 453
Black petrel	0.93	0.90–0.95	0.95	0.93–0.97	6.60	6.23–6.97	0.80	0.68–0.88	4 627	1 972–9 777
Westland petrel	0.95	0.92–0.97	0.95	0.92–0.97	6.50	4.12–8.86	0.89	0.76–0.96	3 941	3 004–5 059
White-chinned petrel	0.93	0.90–0.97	0.94	0.90–0.97	6.51	4.12–8.89	0.89	0.75–0.96	278 318	208 030–363 162
Flesh-footed shearwater	0.94	0.93–0.94	0.93	0.85–0.98	6.49	4.13–8.88	0.89	0.75–0.96	12 314	10 094–14 849
Wedge-tailed shearwater	0.92	0.89–0.96	0.92	0.89–0.96	3.99	3.05–4.95	0.89	0.74–0.97	52 466	27 833–90 191
Buller's shearwater	0.92	0.84–0.96	0.92	0.84–0.96	6.50	4.11–8.85	0.89	0.75–0.96	346 699	302 033–397 140
Sooty shearwater	0.92	0.86–0.98	0.92	0.86–0.98	5.99	5.06–6.95	0.89	0.76–0.96	5 295 027	2 806 914–9 109 413
Fluttering shearwater	0.92	0.89–0.96	0.92	0.89–0.96	5.01	4.05–5.94	0.89	0.75–0.96	248 527	103 841–483 076
Hutton's shearwater	0.92	0.89–0.96	0.92	0.89–0.96	4.99	4.05–5.94	0.89	0.75–0.96	115 654	77 301–169 287
Little shearwater	0.92	0.89–0.96	0.92	0.89–0.96	5.00	4.05–5.96	0.89	0.75–0.96	157 462	116 550–206 929
Snares Cape petrel	0.86	0.78–0.93	0.85	0.77–0.93	5.48	3.12–7.87	0.89	0.75–0.96	8 816	4 674–15 098
Fairy prion	0.84	0.77–0.89	0.84	0.77–0.89	4.49	4.02–4.98	0.89	0.75–0.96	1 509 522	1 233 120–1 829 228
Antarctic prion	0.84	0.78–0.89	0.84	0.77–0.89	5.49	5.02–5.97	0.89	0.75–0.96	620 992	359 715–978 828
Broad-billed prion	0.84	0.78–0.89	0.84	0.77–0.89	4.50	4.03–4.97	0.89	0.75–0.96	351 527	284 072–428 408
Pycroft's petrel	0.93	0.84–0.98	0.93	0.85–0.98	6.49	6.02–6.98	0.89	0.75–0.96	2 466	2 020–2 966
Cook's petrel	0.93	0.85–0.98	0.93	0.85–0.98	6.50	6.02–6.97	0.89	0.76–0.96	307 908	220 410–412 157
Chatham petrel	0.93	0.85–0.98	0.93	0.85–0.98	6.49	6.02–6.97	0.89	0.76–0.96	254	170–368
Mottled petrel	0.93	0.85–0.98	0.93	0.85–0.98	6.49	6.02–6.97	0.89	0.76–0.96	347 297	302 608–396 950
White-naped petrel	0.93	0.85–0.98	0.93	0.84–0.98	6.50	6.03–6.97	0.89	0.75–0.96	52 734	27 387–89 675
Kerm. petrel	0.93	0.85–0.98	0.93	0.85–0.98	6.50	6.03–6.98	0.89	0.75–0.96	5 964	5 039–6 941
Grey-faced petrel	0.93	0.85–0.98	0.93	0.85–0.98	6.51	6.02–6.98	0.89	0.75–0.96	247 213	202 151–297 202
Chatham Island taiko	0.93	0.85–0.98	0.93	0.85–0.98	6.50	6.02–6.97	0.89	0.76–0.96	17	14–21
White-headed petrel	0.93	0.85–0.98	0.93	0.85–0.98	5.49	4.07–6.92	0.60	0.50–0.69	209 103	113 529–355 799
Soft-plumaged petrel	0.93	0.85–0.98	0.93	0.85–0.98	6.50	6.03–6.97	0.89	0.76–0.96	3 926	1 062–9 557
Common diving petrel	0.81	0.75–0.87	0.81	0.75–0.87	2.49	2.02–2.97	0.89	0.76–0.96	942 078	314 058–2 055 269
South Georgian diving petrel	0.81	0.75–0.87	0.81	0.75–0.87	2.50	2.02–2.97	0.89	0.75–0.96	66	35–115
NZ white-faced storm petrel	0.90	0.82–0.95	0.89	0.82–0.95	3.99	3.05–4.95	0.89	0.75–0.96	1 583 260	727 675–2 900 025
White-bellied storm petrel	0.90	0.82–0.95	0.90	0.82–0.94	4.51	4.03–4.98	0.89	0.75–0.96	1 043	561–1 822
Black-bellied storm petrel	0.90	0.82–0.94	0.90	0.82–0.95	4.49	4.03–4.97	0.89	0.75–0.96	71 897	50 802–98 136
Kerm. storm petrel	0.90	0.83–0.94	0.90	0.82–0.95	3.99	3.05–4.95	0.89	0.75–0.96	56	21–114
NZ storm petrel	0.90	0.83–0.94	0.90	0.82–0.95	4.50	4.02–4.97	0.89	0.76–0.96	256	22–906
Yellow-eyed penguin	0.87	0.80–0.92	0.87	0.80–0.92	2.99	2.04–3.95	0.68	0.58–0.77	1 659	1 459–1 876
Northern little penguin	0.83	0.79–0.87	0.83	0.79–0.87	2.50	2.03–2.97	0.89	0.75–0.96	7 179	5 093–9 803
White-flippered little penguin	0.83	0.79–0.87	0.83	0.79–0.87	2.49	2.02–2.98	0.89	0.75–0.96	2 239	1 508–3 242
Southern little penguin	0.83	0.79–0.87	0.83	0.79–0.87	2.49	2.03–2.98	0.89	0.75–0.96	7 178	5 089–9 813
Chatham Island little penguin	0.83	0.79–0.87	0.83	0.79–0.87	2.50	2.03–2.97	0.89	0.76–0.96	7 198	5 086–9 851
Eastern rockhopper penguin	0.84	0.82–0.86	0.84	0.82–0.86	4.46	3.07–5.92	0.89	0.76–0.96	48 120	39 365–57 900
Fiordland crested penguin	0.84	0.82–0.86	0.84	0.82–0.86	4.50	3.07–5.93	0.89	0.76–0.97	3 128	1 645–5 404
Snares crested penguin	0.84	0.82–0.86	0.84	0.82–0.86	5.50	5.02–5.97	0.89	0.75–0.96	27 562	24 777–30 508
Erect-crested penguin	0.84	0.82–0.86	0.84	0.82–0.86	5.50	5.02–5.97	0.89	0.75–0.96	80 942	77 172–84 830
Australasian gannet	0.93	0.84–0.98	0.93	0.85–0.98	4.98	3.10–6.90	0.89	0.75–0.96	48 385	25 563–83 251
Masked booby	0.85	0.78–0.90	0.85	0.78–0.90	3.01	2.06–3.96	0.89	0.75–0.96	247	165–356
Pied shag	0.88	0.86–0.90	0.88	0.86–0.90	2.67	2.03–3.30	1.00	1.00–1.00	6 413	5 279–7 733
Little black shag	0.88	0.86–0.90	0.88	0.86–0.90	1.98	1.05–2.94	0.89	0.75–0.96	1 578	847–2 745
NZ king shag	0.88	0.86–0.90	0.88	0.86–0.90	3.99	3.04–4.96	0.89	0.75–0.96	188	154–227
Otago shag	0.88	0.86–0.90	0.88	0.86–0.90	4.00	3.05–4.95	0.89	0.75–0.96	1 314	1 234–1 395
Foveaux shag	0.88	0.86–0.90	0.88	0.86–0.90	4.00	3.05–4.95	0.89	0.75–0.96	956	846–1 073
Chatham Island shag	0.88	0.86–0.90	0.88	0.86–0.90	3.99	3.05–4.95	0.89	0.75–0.96	357	290–432
Bounty Island shag	0.88	0.86–0.90	0.88	0.86–0.90	3.99	3.05–4.95	0.89	0.75–0.96	123	81–177
Auckland Island shag	0.88	0.86–0.90	0.88	0.86–0.90	3.99	3.05–4.96	0.89	0.75–0.96	2 157	987–3 951
Campbell Island shag	0.88	0.86–0.90	0.88	0.86–0.90	4.01	3.04–4.95	0.89	0.75–0.96	2 074	1 104–3 518
Spotted shag	0.88	0.86–0.90	0.88	0.86–0.90	2.00	1.05–2.95	0.89	0.75–0.96	18 238	10 290–29 117
Pitt Island shag	0.88	0.86–0.90	0.88	0.86–0.90	4.00	3.06–4.94	0.89	0.75–0.97	390	321–469
Subantarctic skua	0.94	0.91–0.97	0.94	0.91–0.97	8.03	7.64–8.42	0.89	0.76–0.96	460	450–470
Southern black-backed gull	0.81	0.74–0.86	0.81	0.75–0.86	3.99	3.06–4.96	0.89	0.75–0.96	1 574 418	720 582–2 898 967
Caspian tern	0.88	0.82–0.93	0.88	0.82–0.93	3.01	2.05–3.96	0.89	0.75–0.96	1 023	674–1 491
White tern	0.80	0.78–0.83	0.80	0.78–0.83	4.00	3.06–4.95	0.89	0.75–0.96	78	61–99

Table B-6: Summary of the input parameters to the calculation of the Population Sustainability Threshold (PST) for seabird taxa breeding in New Zealand, including the total population size (in individuals; N) and the estimated maximum growth rate r_{max} (mean and 95% credible interval, c.i.); r_{max} was rounded to three significant digits. At-risk taxa are in bold and coloured according to the associated risk category as defined in the "National Plan of Action – 2013 to reduce the incidental catch of seabirds in New Zealand fisheries" (Ministry for Primary Industries 2013): Red: very high risk; dark orange: high risk; light orange: medium risk; yellow: low risk.

Taxon	Population size, N		Maximum growth rate, r_{max}	
	Mean	95% c.i.	Mean	95% c.i.
Gibson's albatross	42 800	29 800–62 800	0.046	0.039–0.055
Antipodean albatross	31 900	23 200–42 800	0.046	0.039–0.055
Southern royal albatross	74 200	54 700–99 000	0.046	0.038–0.054
Northern royal albatross	62 100	30 700–116 000	0.047	0.039–0.055
Campbell black-browed albatross	137 000	69 900–246 000	0.058	0.051–0.066
NZ white-capped albatross	768 000	559 000–1 090 000	0.056	0.049–0.064
Salvin's albatross	245 000	193 000–328 000	0.057	0.049–0.064
Chatham Island albatross	30 200	21 200–43 800	0.057	0.049–0.064
Grey-headed albatross	48 900	24 000–88 200	0.057	0.050–0.065
Southern Buller's albatross	88 300	59 600–137 000	0.062	0.054–0.069
Northern Buller's albatross	106 000	70 900–169 000	0.061	0.054–0.069
Light-mantled sooty albatross	57 000	45 200–72 600	0.061	0.054–0.069
Northern giant petrel	24 500	11 800–57 500	0.055	0.048–0.063
Grey petrel	275 000	163 000–464 000	0.080	0.071–0.089
Black petrel	19 700	10 000–37 000	0.091	0.080–0.103
Westland petrel	18 000	12 200–26 900	0.078	0.070–0.087
White-chinned petrel	1 360 000	869 000–2 170 000	0.076	0.068–0.085
Flesh-footed shearwater	61 400	44 300–83 300	0.094	0.082–0.108
Wedge-tailed shearwater	229 000	118 000–402 000	0.105	0.090–0.122
Buller's shearwater	2 030 000	1 300 000–3 640 000	0.111	0.094–0.130
Sooty shearwater	28 300 000	13 700 000–53 800 000	0.088	0.078–0.099
Fluttering shearwater	1 140 000	503 000–2 280 000	0.126	0.104–0.151
Hutton's shearwater	542 000	345 000–829 000	0.110	0.093–0.129
Little shearwater	682 000	459 000–998 000	0.127	0.103–0.153
Snares Cape petrel	59 700	23 500–140 000	0.105	0.090–0.122
Fairy prion	8 910 000	6 200 000–12 800 000	0.146	0.116–0.183
Antarctic prion	4 350 000	2 260 000–7 790 000	0.142	0.114–0.176
Broad-billed prion	2 060 000	1 440 000–3 020 000	0.132	0.109–0.162
Pycroft's petrel	11 700	7 620–20 100	0.140	0.113–0.173
Cook's petrel	1 460 000	871 000–2 510 000	0.134	0.108–0.163
Chatham petrel	1 190	683–2 130	0.139	0.112–0.172
Mottled petrel	1 620 000	1 110 000–2 620 000	0.116	0.097–0.137
White-naped petrel	272 000	129 000–541 000	0.104	0.090–0.121
Kerm. petrel	30 800	20 500–50 500	0.101	0.088–0.117
Grey-faced petrel	1 270 000	839 000–2 100 000	0.094	0.082–0.107
Chatham Island taiko	88	58–145	0.102	0.088–0.119
White-headed petrel	1 490 000	711 000–2 880 000	0.092	0.081–0.105
Soft-plumaged petrel	17 300	4 800–44 600	0.115	0.096–0.135
Common diving petrel	3 570 000	1 260 000–7 830 000	0.153	0.120–0.192
South Georgian diving petrel	258	134–455	0.153	0.119–0.193
NZ white-faced storm petrel	6 320 000	2 880 000–12 200 000	0.209	0.149–0.286
White-bellied storm petrel	4 500	2 250–8 000	0.203	0.145–0.280
Black-bellied storm petrel	310 000	194 000–485 000	0.199	0.144–0.269
Kerm. storm petrel	221	85–470	0.209	0.148–0.287
NZ storm petrel	946	106–3 560	0.226	0.158–0.318
Yellow-eyed penguin	8 470	6 190–11 700	0.135	0.105–0.170
Northern little penguin	27 900	18 600–40 700	0.215	0.164–0.277
White-flippered little penguin	8 700	5 540–13 000	0.215	0.165–0.279
Southern little penguin	27 900	18 500–41 400	0.215	0.164–0.278
Chatham Island little penguin	27 900	18 600–41 300	0.215	0.165–0.280
Eastern rockhopper penguin	262 000	175 000–381 000	0.169	0.132–0.215
Fiordland crested penguin	16 900	8 000–30 800	0.149	0.117–0.187
Snares crested penguin	178 000	138 000–232 000	0.154	0.121–0.195
Erect-crested penguin	527 000	421 000–669 000	0.135	0.106–0.171
Australasian gannet	200 000	97 300–376 000	0.189	0.132–0.261
Masked booby	1 070	654–1 710	0.197	0.138–0.272
Pied shag	21 800	16 900–28 400	0.205	0.143–0.284
Little black shag	5 490	2 860–9 650	0.246	0.172–0.346
NZ king shag	860	626–1 160	0.182	0.129–0.252
Otago shag	6 020	4 660–7 910	0.188	0.133–0.263
Foveaux shag	4 400	3 350–5 860	0.189	0.135–0.263
Chatham Island shag	1 640	1 190–2 240	0.186	0.132–0.252
Bounty Island shag	564	353–865	0.185	0.132–0.257
Auckland Island shag	9 750	4 480–18 800	0.199	0.140–0.277
Campbell Island shag	9 450	4 830–16 400	0.202	0.140–0.284
Spotted shag	64 000	34 800–109 000	0.233	0.162–0.329
Pitt Island shag	1 790	1 310–2 450	0.231	0.161–0.323
Subantarctic skua	2 230	1 650–3 140	0.120	0.090–0.157
Southern black-backed gull	9 380 000	4 080 000–18 900 000	0.142	0.107–0.185
Caspian tern	4 280	2 580–6 780	0.161	0.120–0.209
White tern	482	315–721	0.218	0.160–0.295

B.2 Population Sustainability Threshold parameters

Table B-7: Description of the distribution of the processed parameters used for the calculation of the Population Sustainability Threshold (PST) for 71 seabird taxa to assess the risk of commercial fisheries. S_{curr}, S_{opt}: current and optimal adult annual survival rate, respectively; A: current age at first reproduction; P_B: proportion of adults breeding; N_{BP}: annual breeding pairs. $\mathcal{U}$: uniform distribution; Log-$\mathcal{U}$: uniform distribution on the logarithmic scale; Logit-$\mathcal{N}$: normal distribution on the logit scale; Log-$\mathcal{N}$: normal distribution on the logarithmic scale. "Posterior distribution" indicates a distribution obtained from the posterior distribution of external studies (see Section 2, Methods). μ, σ: mean and standard deviation on the natural scale (not transformed); s: standard deviation on the transformed scale (log or logit). At-risk taxa are in bold and coloured according to the associated risk category as defined in the "National Plan of Action – 2013 to reduce the incidental catch of seabirds in New Zealand fisheries" (Ministry for Primary Industries 2013): Red: very high risk; dark orange: high risk; light orange: medium risk; yellow: low risk.

Taxon	S_{curr}		S_{opt}		A	P_B		N_{BP}
Gibson's albatross	$\mathcal{U}$	0.938 – 0.985	$\mathcal{U}$	0.938 – 0.985	$\mathcal{U}$	10.00 – 12.00	Logit-$\mathcal{N}$ μ=0.600; σ=0.05	Log-$\mathcal{N}$ μ= 4 792; s=0.1
Antipodean albatross	Logit-$\mathcal{N}$	μ=0.957; σ=0.007	Logit-$\mathcal{N}$	μ=0.957; σ=0.007	$\mathcal{U}$	10.00 – 13.00	Logit-$\mathcal{N}$ μ=0.600; σ=0.05	Log-$\mathcal{N}$ μ= 3 320; s=0.1
Southern royal albatross	Logit-$\mathcal{N}$	μ=0.949; σ=0.008	Logit-$\mathcal{N}$	μ=0.949; σ=0.008	$\mathcal{U}$	8.50 – 10.60	Logit-$\mathcal{N}$ μ=0.600; σ=0.05	Log-$\mathcal{N}$ μ= 7 886; s=0.1
Northern royal albatross	$\mathcal{U}$	0.908 – 0.969	$\mathcal{U}$	0.908 – 0.969	$\mathcal{U}$	8.50 – 10.60	Logit-$\mathcal{N}$ μ=0.610; σ=0.05	Log-$\mathcal{N}$ μ= 5 832; s=0.3
Campbell albatross	Logit-$\mathcal{N}$	μ=0.945; σ=0.007	Logit-$\mathcal{N}$	μ=0.945; σ=0.007	$\mathcal{U}$	6.00 – 13.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 21 000; s=0.3
NZ white-capped albatross	Logit-$\mathcal{N}$	μ=0.960; σ=0.010	Logit-$\mathcal{N}$	μ=0.960; σ=0.010	$\mathcal{U}$	9.00 – 15.00	Logit-$\mathcal{N}$ μ=0.680; σ=0.05	- Posterior distribution
Salvin's albatross	Logit-$\mathcal{N}$	μ=0.967; σ=0.010	Logit-$\mathcal{N}$	μ=0.967; σ=0.010	$\mathcal{U}$	9.00 – 15.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 41 004 – 41 958
Chatham Island albatross	Logit-$\mathcal{N}$	μ=0.967; σ=0.010	Logit-$\mathcal{N}$	μ=0.967; σ=0.010	$\mathcal{U}$	9.00 – 15.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 5 245; s=0.1
Grey-headed albatross	Logit-$\mathcal{N}$	μ=0.953; σ=0.009	Logit-$\mathcal{N}$	μ=0.953; σ=0.009	$\mathcal{U}$	7.00 – 13.00	Logit-$\mathcal{N}$ μ=0.750; σ=0.05	Log-$\mathcal{N}$ μ= 6 600; s=0.3
Southern Buller's albatross	$\mathcal{U}$	0.930 – 0.980	$\mathcal{U}$	0.930 – 0.980	$\mathcal{U}$	9.00 – 15.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 13 625; s=0.1
Northern Buller's albatross	$\mathcal{U}$	0.930 – 0.980	$\mathcal{U}$	0.930 – 0.980	$\mathcal{U}$	9.00 – 15.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 16 346; s=0.1
Light-mantled sooty albatross	$\mathcal{U}$	0.960 – 0.980	$\mathcal{U}$	0.960 – 0.980	$\mathcal{U}$	9.00 – 15.00	Logit-$\mathcal{N}$ μ=0.600; σ=0.05	Log-$\mathcal{U}$ 6 770 – 6 900
Northern giant petrel	$\mathcal{U}$	0.808 – 0.965	$\mathcal{U}$	0.808 – 0.965	$\mathcal{U}$	6.00 – 10.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 2 140 – 3 140
Grey petrel	$\mathcal{U}$	0.900 – 0.970	$\mathcal{U}$	0.900 – 0.970	$\mathcal{U}$	5.00 – 9.00	Logit-$\mathcal{N}$ μ=0.800; σ=0.05	Log-$\mathcal{U}$ 32 000 – 73 000
Black petrel	Logit-$\mathcal{N}$	μ=0.927; σ=0.012	Logit-$\mathcal{N}$	μ=0.950; σ=0.010	$\mathcal{U}$	6.21 – 6.99	Logit-$\mathcal{N}$ μ=0.800; σ=0.05	- Posterior distribution
Westland petrel	$\mathcal{U}$	0.918 – 0.975	$\mathcal{U}$	0.918 – 0.975	$\mathcal{U}$	4.00 – 9.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 2 954 – 5 137
White-chinned petrel	$\mathcal{U}$	0.900 – 0.970	$\mathcal{U}$	0.900 – 0.970	$\mathcal{U}$	4.00 – 9.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 204 725 – 368 125
Flesh-footed shearwater	$\mathcal{U}$	0.931 – 0.940	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	$\mathcal{U}$	4.00 – 9.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 10 000 – 15 000
Wedge-tailed shearwater	$\mathcal{U}$	0.889 – 0.958	$\mathcal{U}$	0.889 – 0.958	$\mathcal{U}$	3.00 – 5.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 50 000; s=0.3
Buller's shearwater	Logit-$\mathcal{N}$	μ=0.920; σ=0.030	Logit-$\mathcal{N}$	μ=0.920; σ=0.030	$\mathcal{U}$	4.00 – 9.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 300 000 – 400 000
Sooty shearwater	$\mathcal{U}$	0.860 – 0.979	$\mathcal{U}$	0.860 – 0.979	$\mathcal{U}$	5.00 – 7.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ=5 000 000; s=0.3
Fluttering shearwater	$\mathcal{U}$	0.889 – 0.958	$\mathcal{U}$	0.889 – 0.958	$\mathcal{U}$	4.00 – 6.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 100 000 – 500 000
Hutton's shearwater	$\mathcal{U}$	0.889 – 0.958	$\mathcal{U}$	0.889 – 0.958	$\mathcal{U}$	4.00 – 6.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 114 000; s=0.2
Little shearwater	$\mathcal{U}$	0.889 – 0.958	$\mathcal{U}$	0.889 – 0.958	$\mathcal{U}$	4.00 – 6.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 115 000 – 210 000
Snares Cape petrel	$\mathcal{U}$	0.771 – 0.939	$\mathcal{U}$	0.771 – 0.939	$\mathcal{U}$	3.00 – 8.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 8 420; s=0.3
Fairy prion	Logit-$\mathcal{N}$	μ=0.840; σ=0.030	Logit-$\mathcal{N}$	μ=0.840; σ=0.030	$\mathcal{U}$	4.00 – 5.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ=1 500 000; s=0.1
Antarctic prion	Logit-$\mathcal{N}$	μ=0.840; σ=0.030	Logit-$\mathcal{N}$	μ=0.840; σ=0.030	$\mathcal{U}$	5.00 – 6.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 350 000 – 1 000 000
Broad-billed prion	Logit-$\mathcal{N}$	μ=0.840; σ=0.030	Logit-$\mathcal{N}$	μ=0.840; σ=0.030	$\mathcal{U}$	4.00 – 5.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 350 000; s=0.1
Pycroft's petrel	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	$\mathcal{U}$	6.00 – 7.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 2 000 – 3 000
Cook's petrel	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	$\mathcal{U}$	6.00 – 7.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 216 000 – 419 000
Chatham petrel	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	$\mathcal{U}$	6.00 – 7.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 250; s=0.2
Mottled petrel	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	$\mathcal{U}$	6.00 – 7.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 300 000 – 400 000
White-naped petrel	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	$\mathcal{U}$	6.00 – 7.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 50 000; s=0.3
Kerm. petrel	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	$\mathcal{U}$	6.00 – 7.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 5 000 – 7 000
Grey-faced petrel	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	$\mathcal{U}$	6.00 – 7.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 200 000 – 300 000
Chatham Island taiko	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	$\mathcal{U}$	6.00 – 7.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 17; s=0.1
White-headed petrel	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	$\mathcal{U}$	4.00 – 7.00	Logit-$\mathcal{N}$ μ=0.600; σ=0.05	Log-$\mathcal{N}$ μ= 200 000; s=0.3
Soft-plumaged petrel	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	$\mathcal{U}$	6.00 – 7.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 1 000 – 9 999
Common diving petrel	$\mathcal{U}$	0.750 – 0.870	$\mathcal{U}$	0.750 – 0.870	$\mathcal{U}$	2.00 – 3.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 300 000 – 2 150 000
South Georgian diving petrel	$\mathcal{U}$	0.750 – 0.870	$\mathcal{U}$	0.750 – 0.870	$\mathcal{U}$	2.00 – 3.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 64; s=0.3
NZ white-faced storm petrel	Logit-$\mathcal{N}$	μ=0.900; σ=0.030	Logit-$\mathcal{N}$	μ=0.900; σ=0.030	$\mathcal{U}$	3.00 – 5.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 700 000 – 3 000 000
White-bellied storm petrel	Logit-$\mathcal{N}$	μ=0.900; σ=0.030	Logit-$\mathcal{N}$	μ=0.900; σ=0.030	$\mathcal{U}$	4.00 – 5.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 1 000; s=0.3
Black-bellied storm petrel	Logit-$\mathcal{N}$	μ=0.900; σ=0.030	Logit-$\mathcal{N}$	μ=0.900; σ=0.030	$\mathcal{U}$	4.00 – 5.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 50 000 – 100 000
Kerm. storm petrel	Logit-$\mathcal{N}$	μ=0.900; σ=0.030	Logit-$\mathcal{N}$	μ=0.900; σ=0.030	$\mathcal{U}$	3.00 – 5.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 20 – 120
NZ storm petrel	Logit-$\mathcal{N}$	μ=0.900; σ=0.030	Logit-$\mathcal{N}$	μ=0.900; σ=0.030	$\mathcal{U}$	4.00 – 5.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 20 – 1 000
Yellow-eyed penguin	Logit-$\mathcal{N}$	μ=0.870; σ=0.030	Logit-$\mathcal{N}$	μ=0.870; σ=0.030	$\mathcal{U}$	2.00 – 4.00	Logit-$\mathcal{N}$ μ=0.688; σ=0.05	Log-$\mathcal{U}$ 1 450 – 1 890
Northern little penguin	Logit-$\mathcal{N}$	μ=0.830; σ=0.020	Logit-$\mathcal{N}$	μ=0.830; σ=0.020	$\mathcal{U}$	2.00 – 3.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 5 000 – 10 000
White-flippered little penguin	Logit-$\mathcal{N}$	μ=0.830; σ=0.020	Logit-$\mathcal{N}$	μ=0.830; σ=0.020	$\mathcal{U}$	2.00 – 3.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 2 200; s=0.2
Southern little penguin	Logit-$\mathcal{N}$	μ=0.830; σ=0.020	Logit-$\mathcal{N}$	μ=0.830; σ=0.020	$\mathcal{U}$	2.00 – 3.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 5 000 – 10 000
Chatham Island little penguin	Logit-$\mathcal{N}$	μ=0.830; σ=0.020	Logit-$\mathcal{N}$	μ=0.830; σ=0.020	$\mathcal{U}$	2.00 – 3.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 5 000 – 10 000
Eastern rockhopper penguin	Logit-$\mathcal{N}$	μ=0.840; σ=0.011	Logit-$\mathcal{N}$	μ=0.840; σ=0.011	$\mathcal{U}$	3.00 – 6.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 38 961 – 58 500
Fiordland crested penguin	Logit-$\mathcal{N}$	μ=0.840; σ=0.011	Logit-$\mathcal{N}$	μ=0.840; σ=0.011	$\mathcal{U}$	3.00 – 6.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 3 000; s=0.3
Snares crested penguin	Logit-$\mathcal{N}$	μ=0.840; σ=0.011	Logit-$\mathcal{N}$	μ=0.840; σ=0.011	$\mathcal{U}$	5.00 – 6.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 24 666 – 30 672
Erect-crested penguin	Logit-$\mathcal{N}$	μ=0.840; σ=0.011	Logit-$\mathcal{N}$	μ=0.840; σ=0.011	$\mathcal{U}$	5.00 – 6.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 77 000 – 85 000
Australasian gannet	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	Logit-$\mathcal{N}$	μ=0.940; σ=0.030	$\mathcal{U}$	3.00 – 7.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 46 004; s=0.3
Masked booby	Logit-$\mathcal{N}$	μ=0.850; σ=0.030	Logit-$\mathcal{N}$	μ=0.850; σ=0.030	$\mathcal{U}$	2.00 – 4.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 240; s=0.2
Pied shag	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	2.00 – 3.33	Logit-$\mathcal{N}$ μ=1.000; σ=0.00	Log-$\mathcal{N}$ μ= 6 400; s=0.1
Little black shag	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	1.00 – 3.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 1 500; s=0.3
NZ king shag	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	3.00 – 5.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 187; s=0.1
Otago shag	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	3.00 – 5.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 1 230 – 1 400
Foveaux shag	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	3.00 – 5.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 840 – 1 080
Chatham Island shag	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	3.00 – 5.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 355; s=0.1
Bounty Island shag	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	3.00 – 5.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 120; s=0.2
Auckland Island shag	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	3.00 – 5.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 956 – 4 098
Campbell Island shag	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	3.00 – 5.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 2 000; s=0.3
Spotted shag	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	1.00 – 3.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 10 000 – 30 000
Pitt Island shag	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	0.859 – 0.897	$\mathcal{U}$	3.00 – 5.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 388; s=0.1
Subantarctic skua	$\mathcal{U}$	0.910 – 0.970	$\mathcal{U}$	0.910 – 0.970	$\mathcal{U}$	7.62 – 8.44	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 450 – 470
Southern black-backed gull	Logit-$\mathcal{N}$	μ=0.810; σ=0.030	Logit-$\mathcal{N}$	μ=0.810; σ=0.030	$\mathcal{U}$	3.00 – 5.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 700 000 – 3 000 000
Caspian tern	$\mathcal{U}$	0.816 – 0.937	$\mathcal{U}$	0.816 – 0.937	$\mathcal{U}$	2.00 – 4.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{N}$ μ= 1 000; s=0.2
White tern	$\mathcal{U}$	0.780 – 0.830	$\mathcal{U}$	0.780 – 0.830	$\mathcal{U}$	3.00 – 5.00	Logit-$\mathcal{N}$ μ=0.900; σ=0.05	Log-$\mathcal{U}$ 60 – 100

APPENDIX C: SEABIRD CAPTURES

C.1 Observed capture data and overlap

Table C-8: Number of observed seabird captures (C), live captures (Live), and the proportion of overlap observed (P) with trawl, bottom-longline (BLL), surface-longline (SLL), and set-net fisheries between 2006–07 and 2016–17. At-risk taxa are in bold and coloured according to the associated risk category as defined in the "National Plan of Action – 2013 to reduce the incidental catch of seabirds in New Zealand fisheries" (Ministry for Primary Industries 2013): Red: very high risk; dark orange: high risk; light orange: medium risk; yellow: low risk.

Species	Trawl			BLL			SLL			Set net		
	C	Live	P (%)	C	Live	P (%)	C	Live	P (%)	C	Live	P (%)
Gibson's albatross	1	0	13.90	0	0	3.30	33	6	15.10	0	0	2.70
Antipodean albatross	0	0	11.90	0	0	3.90	31	12	10.70	0	0	2.60
Southern royal albatross	11	3	18.80	5	4	4.90	8	4	13.40	0	0	3.10
Northern royal albatross	0	0	10.70	0	0	3.90	1	0	11.10	0	0	4.10
Campbell black-browed albatross	15	2	23.50	4	1	8.50	27	6	13.20	0	0	4.10
NZ white-capped albatross	799	236	19.50	5	2	3.50	159	22	13.00	0	0	2.70
Salvin's albatross	352	111	12.80	40	4	3.80	7	0	7.50	0	0	2.90
Chatham Island albatross	10	1	18.60	13	0	3.90	0	0	4.90	0	0	2.40
Grey-headed albatross	0	0	17.20	0	0	4.50	1	0	14.40	0	0	3.50
Southern Buller's albatross	318	80	15.80	12	6	2.80	349	120	44.80	0	0	7.50
Northern Buller's albatross	1	0	14.60	0	0	2.00	0	0	5.50	0	0	1.10
Light-mantled sooty albatross	0	0	17.60	0	0	4.40	0	0	16.70	0	0	3.70
Northern giant petrel	10	5	16.00	3	2	3.70	0	0	12.90	0	0	2.50
Grey petrel	54	9	15.70	11	0	5.60	32	0	13.50	0	0	2.20
Black petrel	28	19	7.00	84	50	4.20	26	2	3.20	0	0	0.20
Westland petrel	23	8	13.00	4	1	2.10	27	2	10.40	3	3	1.70
White-chinned petrel	1 473	549	16.60	199	8	4.50	28	0	15.70	1	1	4.10
Flesh-footed shearwater	52	15	6.90	86	26	3.00	7	6	5.00	2	0	0.30
Wedge-tailed shearwater	0	0	55.40	0	0	0.00	0	0	43.00	0	0	0.00
Buller's shearwater	0	0	7.80	12	3	2.50	0	0	10.50	0	0	2.30
Sooty shearwater	1 116	356	15.10	16	0	3.60	2	1	14.00	10	8	6.80
Fluttering shearwater	0	0	7.50	4	2	1.70	0	0	11.10	2	1	0.00
Hutton's shearwater	0	0	3.00	0	0	2.40	0	0	4.50	0	0	4.50
Little shearwater	0	0	10.00	0	0	2.20	0	0	12.00	0	0	0.50
Snares Cape petrel	9	4	22.30	0	0	3.70	0	0	13.10	0	0	6.40
Fairy prion	13	9	6.30	0	0	0.80	0	0	13.30	0	0	1.10
Antarctic prion	7	5	32.20	0	0	4.20	0	0	8.90	0	0	3.40
Broad-billed prion	1	0	15.90	0	0	1.30	0	0	12.80	0	0	2.80
Pycroft's petrel	0	0	7.10	0	0	3.60	0	0	5.20	0	0	0.00
Cook's petrel	0	0	6.20	0	0	2.90	0	0	6.20	0	0	0.30
Chatham petrel	0	0	17.10	0	0	0.70	0	0	0.00	0	0	0.00
Mottled petrel	0	0	8.40	0	0	6.40	0	0	26.20	0	0	11.00
White-naped petrel	0	0		0	0	0.70	0	0	26.30	0	0	0.00
Kerm. petrel	0	0	9.80	0	0	2.60	0	0	12.10	0	0	1.70
Grey-faced petrel	1	1	7.50	6	0	2.20	6	1	8.40	0	0	1.00
Chatham Island taiko	0	0	21.50	0	0	2.30	0	0	0.00	0	0	0.00
White-headed petrel	0	0	22.50	0	0	5.00	0	0	11.80	0	0	3.20
Soft-plumaged petrel	0	0	12.20	0	0	4.90	0	0	12.10	0	0	2.90
Common diving petrel	24	17	6.60	0	0	3.30	0	0	13.30	0	0	5.90
South Georgian diving petrel	0	0	6.20	0	0	8.10	0	0	0.00	0	0	12.60
NZ white-faced storm petrel	5	3	15.30	1	1	0.60	0	0	6.10	0	0	0.70
White-bellied storm petrel	0	0	34.60	0	0	1.40	0	0	11.40	0	0	0.00
Black-bellied storm petrel	1	0	11.90	0	0	3.20	0	0	11.80	0	0	2.80
Kerm. storm petrel	0	0	100.00	0	0	0.40	0	0	14.30	0	0	0.00
NZ storm petrel	0	0	6.80	0	0	2.30	0	0	7.60	0	0	0.20
Yellow-eyed penguin	0	0	3.50	0	0	2.60	0	0		12	0	5.90
Northern little penguin	0	0	4.70	0	0	2.20	0	0	5.90	0	0	1.80
White-flippered little penguin	0	0	5.30	0	0	4.40	0	0		0	0	1.60
Southern little penguin	0	0	4.00	0	0	1.60	0	0	16.90	0	0	7.10
Chatham Island little penguin	0	0	15.40	0	0	1.00	0	0		0	0	0.00
Eastern rockhopper penguin	0	0	29.10	0	0	15.70	0	0	27.90	0	0	4.60
Fiordland crested penguin	0	0	3.50	0	0	0.30	0	0	13.90	3	0	11.20
Snares crested penguin	0	0	27.40	0	0	6.50	0	0	28.90	0	0	7.80
Erect-crested penguin	0	0	37.90	0	0	14.10	0	0	0.00	0	0	0.00
Australasian gannet	1	1	4.40	0	0	2.60	0	0	6.60	0	0	0.40
Masked booby	0	0	12.40	0	0	3.20	0	0	12.80	0	0	2.60
Pied shag	0	0	2.50	0	0	2.30	0	0	1.80	1	0	1.20
Little black shag	0	0	2.20	0	0	2.20	0	0	7.10	0	0	0.40
NZ king shag	0	0	0.50	0	0	0.00	0	0		0	0	1.10
Otago shag	0	0	1.20	0	0	0.10	0	0		3	0	5.70
Foveaux shag	0	0	0.70	0	0	0.50	0	0		1	0	8.40
Chatham Island shag	0	0	2.40	0	0	0.70	0	0		0	0	
Bounty Island shag	0	0	68.20	0	0	20.80	0	0		0	0	
Auckland Island shag	0	0	36.00	0	0	100.00	0	0		0	0	0.00
Campbell Island shag	0	0		0	0		0	0		0	0	
Spotted shag	32	0	1.50	0	0	2.40	0	0	17.90	2	0	1.60
Pitt Island shag	0	0	1.00	0	0	0.60	0	0		0	0	
Subantarctic skua	0	0	11.40	0	0	0.90	0	0	13.00	0	0	6.80
Southern black-backed gull	0	0	2.30	8	4	2.40	0	0	6.20	0	0	2.10
Caspian tern	0	0	2.60	0	0	2.40	0	0	6.80	0	0	2.30
White tern	0	0	9.90	0	0	2.30	0	0	10.00	0	0	1.80

C.2 Necropsy data

Table C-9: Number and proportion of adults among all seabird captures identified and aged by experts based on necropsies. The captures occurred in commercial trawl, bottom-longline, surface-longline and set-net fisheries between 2010–11 and 2016–17.

Taxon	Total	Adults	Not adults	% of adults
White-chinned petrel	677	673	4	99.4
Sooty shearwater	351	351	0	100.0
New Zealand white-capped albatross	350	331	19	94.6
Southern Buller's albatross	256	256	0	100.0
Salvin's albatross	155	144	11	92.9
Flesh-footed shearwater	43	43	0	100.0
Grey petrel	38	37	1	97.4
Westland petrel	28	26	2	92.9
Black petrel	23	23	0	100.0
Campbell black-browed albatross	15	12	3	80.0
Southern royal albatross	11	11	0	100.0
Common diving petrel	10	10	0	100.0
Little penguin	8	8	0	100.0
Gibson's albatross	7	7	0	100.0
Cape petrel	7	7	0	100.0
Snares Cape petrel	5	4	1	80.0
Antipodean albatross	4	4	0	100.0
Short-tailed shearwater	4	4	0	100.0
Grey-faced petrel	4	3	1	75.0
Fairy prion	4	4	0	100.0
Black-browed albatross	4	2	2	50.0
Chatham Island albatross	3	3	0	100.0
Grey-backed storm petrel	3	3	0	100.0
Yellow-eyed penguin	3	3	0	100.0
Northern giant petrel	2	1	1	50.0
Southern black-backed gull	2	0	2	0.0
New Zealand white-faced storm petrel	2	2	0	100.0
Stewart Island shag	2	1	1	50.0
Fiordland crested penguin	2	2	0	100.0
Grey-headed albatross	1	1	0	100.0
Cook's petrel	1	1	0	100.0
Double-banded plover	1	1	0	100.0
Antarctic prion	1	1	0	100.0
White-headed petrel	1	1	0	100.0
Northern Buller's albatross	1	1	0	100.0
Black-bellied storm petrel	1	1	0	100.0
Broad-billed prion	1	1	0	100.0
All	2 031	1 983	48	97.6

APPENDIX D: ESTIMATION OF LIVE RELEASES

Figure D-2: Mean probability that a seabird is released alive estimated in the model, by species and fishery group, summarised from the posterior distributions after model fitting. Fishery groups including trawl, bottom-longline (BLL), surface-longline (SLL) and set-net (SN) fisheries. (Uncertainty associated with the parameters is not shown.)

APPENDIX E: VULNERABILITY

E.1 Vulnerability by fishery group

Table E-10: Vulnerability (v_g; mean and 95% credible interval, c.i.) of seabirds to capture in trawl and longline fisheries used in the estimation of observable captures, for each fishery group. Small vessel size classes for trawling were <17 m and 17 to 28 m length, for bottom longlining (BLL) <34 m length, and for surface longlining (SLL) <45 m length. Early and late time periods were 2006–07 to 2009–10 and 2010–11 to 2016–17, respectively (IWL, integrated weight line; SN, set net).

Method	Fishing group	Period	Vulnerability	
			Mean	95% c.i.
Trawl	Small inshore < 17m		0.59	0.11–1.93
	Small inshore < 28m		1.6	0.23–11.87
	Southern blue whiting	Early	1.85	0.33–6.04
		Late	3.61	0.69–11.51
	Scampi		1.12	0.23–3.11
	Mackerel	Early	0.24	0.05–0.79
		Late	0.41	0.09–1.29
	Squid	Early	0.78	0.71–0.85
		Late	1	1.00–1.00
	Large processor	Early	1.23	0.31–3.50
		Late	1.55	0.39–4.41
	Large fresher		0.26	0.03–0.94
	Deepwater		1.3	0.25–4.37
BLL	Bluenose		1.12	0.15–3.87
	Snapper		1	1.00–1.00
	Ling and ribaldo		3.45	0.67–10.75
	Other small BLL vessels		3.14	0.59–9.97
	Large vessels without IWL		2.17	0.31–7.18
	Large vessels with IWL		0.86	0.13–2.92
SLL	Swordfish		2.6	0.47–7.91
	Other small SLL vessels		2.25	0.45–7.02
	Large vessels	Early	1.73	1.36–2.19
		Late	1	1.00–1.00
SN	Set net		1	1.00–1.00

Table E-11: Vulnerability of seabirds to capture in trawl fisheries, distinguished by fishery group. Fishery groups distinguished vessel size classes (small inshore <17 m and 17 to 28 m, all other vessels ≥28 m length), target species, and the presence of a processor plant. Seabirds are listed in species groups used in the estimation of vulnerability.

Species group	Small inshore < 17m		Small inshore < 28m		Southern blue whiting		Scampi		Mackerel		Squid		Large processor		Large fresher		Deepwater	
	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.
Black petrel	3.85	0.91–10.16	1.68	0.51–3.89	4.83	0.01–41.29	0.05	0.00–0.25	0.06	0.00–0.34	0.68	0.00–4.68	0.23	0.00–1.26	0.08	0.00–0.53	0.26	0.00–1.62
Salvin's albatross	0.07	0.00–0.41	3.72	2.02–6.10	2.56	1.17–4.70	3.72	2.04–6.12	0.06	0.01–0.16	0.24	0.12–0.43	2.55	1.72–3.67	0.72	0.11–2.15	1.02	0.50–1.80
Buller's albatrosses	0.03	0.00–0.14	0.1	0.01–0.35	6.85	0.14–32.33	0.36	0.12–0.75	0.08	0.02–0.18	0.4	0.26–0.57	0.53	0.35–0.76	0.06	0.00–0.25	0.02	0.00–0.08
White-capped albatross	0.5	0.17–1.06	0.98	0.55–1.61	0.03	0.00–0.14	0.13	0.06–0.24	0.07	0.03–0.15	0.43	0.29–0.60	0.33	0.22–0.47	0.26	0.06–0.68	0.07	0.02–0.16
Campbell albatross	0.08	0.00–0.63	0.07	0.00–0.41	0.08	0.02–0.18	0.07	0.00–0.26	0.02	0.00–0.09	0.01	0.00–0.02	0.14	0.06–0.25	0.04	0.00–0.30	0.03	0.00–0.18
Westland petrel	0.03	0.00–0.21	0.23	0.02–0.77	0.65	0.00–5.23	0.03	0.00–0.17	0.01	0.00–0.04	0.08	0.00–0.51	0.04	0.02–0.08	0.02	0.00–0.15	0.08	0.00–0.47
Flesh-footed shearwater	0.15	0.03–0.45	0.1	0.03–0.25	0.81	0.00–6.54	0.14	0.07–0.24	0	0.00–0.02	0.15	0.00–1.11	0.04	0.00–0.13	0.01	0.00–0.09	0.04	0.00–0.27
Chatham albatross	0.11	0.00–0.86	0.13	0.00–1.14	0.42	0.00–3.08	0.04	0.00–0.28	0.03	0.00–0.22	0.09	0.00–0.64	0.11	0.02–0.27	0.03	0.00–0.23	0.5	0.18–1.04
Giant petrel	0.08	0.00–0.59	0.09	0.00–0.64	0.14	0.00–0.91	0.29	0.01–1.23	0.02	0.00–0.14	0.03	0.00–0.17	0.47	0.18–0.91	0.04	0.00–0.29	0.14	0.01–0.55
Grey petrel	0.02	0.00–0.13	0.02	0.00–0.13	0.95	0.34–2.12	0.04	0.00–0.13	0	0.00–0.02	0.01	0.00–0.03	0.01	0.00–0.02	0.01	0.00–0.10	0.03	0.00–0.14
Wandering albatrosses	0.04	0.00–0.30	0.04	0.00–0.29	0.07	0.00–0.44	0.03	0.00–0.18	0.01	0.00–0.06	0.01	0.00–0.06	0.01	0.00–0.04	0.02	0.00–0.15	0.1	0.00–0.36
Royal albatrosses	0.02	0.00–0.12	0.02	0.00–0.13	0.11	0.01–0.36	0.01	0.00–0.07	0	0.00–0.02	0.08	0.02–0.18	0.02	0.00–0.06	0.01	0.00–0.08	0.05	0.00–0.19
Cape petrel	0.02	0.00–0.17	0.04	0.00–0.31	2.32	0.23–8.63	0.03	0.00–0.26	0.01	0.00–0.05	0.01	0.00–0.05	0.09	0.02–0.29	0.02	0.00–0.13	0.04	0.00–0.34
White-chinned petrel	0.01	0.00–0.06	0.01	0.00–0.03	0.01	0.00–0.06	0.26	0.15–0.43	0.04	0.02–0.07	0.33	0.22–0.47	0.13	0.08–0.21	0	0.00–0.02	0.02	0.00–0.06
Yellow-eyed penguin	0	0.00–0.01	0.01	0.00–0.03	0.13	0.00–0.99	0.02	0.00–0.20	0	0.00–0.02	0	0.00–0.02	0	0.00–0.01	0	0.00–0.04	0.04	0.00–0.32
Grey-headed albatross	0.01	0.00–0.06	0.01	0.00–0.10	0.02	0.00–0.14	0.01	0.00–0.08	0	0.00–0.03	0	0.00–0.03	0.01	0.00–0.03	0	0.00–0.04	0.01	0.00–0.09
Group foraging shags	0.01	0.01–0.02	0	0.00–0.00	0.03	0.00–0.22	0	0.00–0.03	0	0.00–0.02	0	0.00–0.01	0	0.00–0.01	0	0.00–0.00	0.01	0.00–0.05
LM sooty albatross	0.01	0.00–0.04	0.01	0.00–0.05	0.01	0.00–0.09	0	0.00–0.04	0	0.00–0.01	0	0.00–0.01	0	0.00–0.02	0	0.00–0.01	0.01	0.00–0.05
Sooty shearwater	0	0.00–0.00	0.01	0.00–0.01	0	0.00–0.03	0.01	0.00–0.01	0	0.00–0.00	0	0.00–0.01	0	0.00–0.00	0	0.00–0.00	0	0.00–0.01
Solitary shags	0	0.00–0.00	0	0.00–0.00	0.02	0.00–0.12	0	0.00–0.01	0	0.00–0.01	0.01	0.00–0.04	0	0.00–0.02	0	0.00–0.00	0	0.00–0.03
Storm petrels	0	0.00–0.01	0	0.00–0.01	0.01	0.00–0.07	0	0.00–0.00	0	0.00–0.01	0.01	0.00–0.04	0	0.00–0.00	0	0.00–0.00	0	0.00–0.01
Diving petrels	0	0.00–0.01	0.01	0.00–0.04	0.01	0.00–0.06	0	0.00–0.01	0	0.00–0.01	0.01	0.00–0.02	0	0.00–0.01	0	0.00–0.00	0	0.00–0.01
Little penguins	0	0.00–0.00	0	0.00–0.00	0.01	0.00–0.08	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00
Crested penguins	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00
Large *Pterodroma* petrels	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00
Boobies and gannets	0	0.00–0.00	0	0.00–0.00	0.01	0.00–0.05	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00
Shearwaters	0	0.00–0.00	0	0.00–0.00	0	0.00–0.02	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00
Prions	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00
Small *Pterodroma* petrels	0	0.00–0.00	0	0.00–0.00	0	0.00–0.01	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00
Gulls, terns & skua	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00

Table E-12: Vulnerability of seabirds to capture in bottom-longline (BLL) fisheries, distinguished by fishery group. Fishery groups distinguished small vessels (<34 m length) by target species, and large vessels (≥34 m length) by the use of integrated weight line (IWL). Seabirds are listed in species groups used in the estimation of vulnerability.

Species group	Bluenose		Snapper		Ling and ribaldo		Other small BLL vessels		Large vessels without IWL		Large vessels with IWL	
	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.
Black petrel	4.31	3.07–5.85	1.28	0.84–1.82	0.37	0.00–1.99	1.38	0.45–2.89	1.18	0.00–9.09	0.74	0.00–5.92
Salvin's albatross	0.12	0.00–0.61	0.05	0.00–0.24	4.78	3.09–6.85	0.24	0.02–0.79	1.21	0.58–2.12	0.03	0.00–0.13
Buller's albatrosses	0.23	0.04–0.55	0.03	0.00–0.16	0.3	0.09–0.65	0.05	0.00–0.26	0.3	0.10–0.61	0.03	0.00–0.12
White-capped albatross	0.03	0.00–0.15	0.01	0.00–0.06	0.21	0.07–0.43	0.03	0.00–0.12	0.03	0.00–0.12	0.01	0.00–0.03
Campbell albatross	2.2	0.15–7.08	0.08	0.00–0.51	0.11	0.00–0.64	0.7	0.02–2.91	0.14	0.00–0.94	0.03	0.00–0.11
Westland petrel	0.1	0.00–0.72	0.04	0.00–0.23	0.48	0.06–1.41	0.69	0.08–2.04	0.1	0.00–0.64	0.07	0.00–0.48
Flesh-footed shearwater	0.02	0.00–0.08	0.18	0.13–0.24	0.06	0.00–0.33	1.11	0.69–1.62	0.12	0.00–0.85	0.13	0.00–0.94
Chatham albatross	0.05	0.00–0.34	0.1	0.00–0.72	2.29	1.15–3.88	0.12	0.00–0.84	0.1	0.01–0.38	0.02	0.00–0.14
Giant petrel	0.08	0.00–0.59	0.44	0.01–1.96	0.1	0.00–0.63	1.52	0.12–4.75	0.06	0.00–0.40	0.03	0.00–0.23
Grey petrel	0.05	0.00–0.34	0.02	0.00–0.13	0.76	0.28–1.55	0.05	0.00–0.26	0.58	0.15–1.32	0.02	0.00–0.07
Wandering albatrosses	0.06	0.00–0.49	0.04	0.00–0.32	0.06	0.00–0.36	0.09	0.00–0.60	0.05	0.00–0.28	0.02	0.00–0.13
Royal albatrosses	0.03	0.00–0.19	0.02	0.00–0.14	0.14	0.02–0.39	0.03	0.00–0.19	0.02	0.00–0.09	0.1	0.02–0.25
Cape petrel	0.04	0.00–0.32	0.02	0.00–0.17	0.05	0.00–0.35	0.05	0.00–0.38	0.05	0.00–0.36	0.01	0.00–0.08
White-chinned petrel	0.1	0.01–0.31	0.01	0.00–0.03	2.24	1.67–2.96	0.01	0.00–0.06	3.29	2.54–4.15	0.22	0.15–0.30
Yellow-eyed penguin	0.03	0.00–0.23	0.05	0.00–0.34	0.04	0.00–0.30	0.07	0.00–0.54	0.06	0.00–0.46	0.01	0.00–0.13
Grey-headed albatross	0.01	0.00–0.11	0.01	0.00–0.08	0.02	0.00–0.21	0.02	0.00–0.18	0.02	0.00–0.18	0.01	0.00–0.05
Group foraging shags	0.01	0.00–0.04	0	0.00–0.00	0.01	0.00–0.06	0.01	0.00–0.05	0.02	0.00–0.13	0	0.00–0.02
LM sooty albatross	0.01	0.00–0.04	0.01	0.00–0.04	0.01	0.00–0.11	0.01	0.00–0.11	0.01	0.00–0.07	0	0.00–0.03
Sooty shearwater	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.01
Solitary shags	0	0.00–0.03	0	0.00–0.00	0.01	0.00–0.04	0	0.00–0.03	0.05	0.00–0.27	0	0.00–0.02
Storm petrels	0	0.00–0.00	0	0.00–0.00	0	0.00–0.01	0	0.00–0.00	0	0.00–0.02	0.01	0.00–0.02
Diving petrels	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00
Little penguins	0	0.00–0.01	0	0.00–0.01	0	0.00–0.01	0	0.00–0.01	0	0.00–0.02	0	0.00–0.01
Crested penguins	0	0.00–0.01	0	0.00–0.02	0	0.00–0.02	0	0.00–0.02	0	0.00–0.02	0	0.00–0.01
Large *Pterodroma* petrels	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0.02	0.01–0.04	0	0.00–0.01	0	0.00–0.00
Boobies and gannets	0	0.00–0.00	0	0.00–0.00	0	0.00–0.01	0	0.00–0.01	0	0.00–0.01	0	0.00–0.01
Shearwaters	0	0.00–0.00	0.01	0.00–0.01	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00
Prions	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00
Small *Pterodroma* petrels	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00
Gulls, terns & skua	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00	0	0.00–0.00

Table E-13: Vulnerability of seabirds to capture in surface-longline (SLL) fisheries, distinguished by fishery group. Fishery groups distinguished small vessels (<45 m length) by target species, and large vessels (≥45 m length). Seabirds are listed in species groups used in the estimation of vulnerability.

Species group	Swordfish		Other small SLL vessels		Large vessels	
	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.
Black petrel	1.81	0.43–4.25	3.32	2.05–4.90	8.55	0.01–69.26
Salvin's albatross	0.54	0.01–2.34	0.83	0.25–1.74	0.91	0.21–2.22
Buller's albatrosses	0.5	0.01–2.36	15.21	11.98–18.93	7.62	5.77–9.76
White-capped albatross	0.63	0.14–1.48	2	1.54–2.54	1.12	0.78–1.51
Campbell albatross	5.47	0.62–16.21	8.39	5.09–12.80	1.42	0.36–3.22
Westland petrel	1.25	0.07–4.49	2.45	1.53–3.60	0.58	0.08–1.62
Flesh-footed shearwater	0.36	0.02–1.23	0.25	0.10–0.49	1.93	0.00–16.42
Chatham albatross	1.62	0.00–11.88	0.38	0.00–2.09	1.85	0.00–14.80
Giant petrel	0.82	0.00–5.53	0.21	0.00–1.08	0.15	0.00–0.83
Grey petrel	2.04	0.43–4.95	0.99	0.53–1.61	0.88	0.47–1.46
Wandering albatrosses	77.21	50.96–109.90	7.67	5.15–10.76	0.81	0.24–1.73
Royal albatrosses	0.24	0.00–1.53	1.18	0.53–2.08	0.04	0.00–0.21
Cape petrel	0.25	0.00–1.71	0.07	0.00–0.39	0.05	0.00–0.32
White-chinned petrel	1.02	0.40–1.95	0.14	0.06–0.27	0.12	0.06–0.20
Yellow-eyed penguin	0.52	0.00–4.42	0.72	0.00–4.27	0.26	0.00–2.16
Grey-headed albatross	0.15	0.00–1.20	0.32	0.01–1.32	0.03	0.00–0.22
Group foraging shags	0.15	0.00–1.07	0.04	0.00–0.25	0.1	0.00–0.55
LM sooty albatross	0.08	0.00–0.66	0.03	0.00–0.20	0.02	0.00–0.12
Sooty shearwater	0.01	0.00–0.03	0	0.00–0.00	0	0.00–0.00
Solitary shags	0.06	0.00–0.45	0.05	0.00–0.39	0.05	0.00–0.34
Storm petrels	0.01	0.00–0.06	0	0.00–0.02	0.01	0.00–0.04
Diving petrels	0	0.00–0.03	0	0.00–0.01	0	0.00–0.00
Little penguins	0.02	0.00–0.13	0	0.00–0.03	0.01	0.00–0.06
Crested penguins	0.02	0.00–0.20	0.01	0.00–0.08	0.01	0.00–0.04
Large *Pterodroma* petrels	0.02	0.00–0.06	0	0.00–0.01	0	0.00–0.01
Boobies and gannets	0.01	0.00–0.09	0	0.00–0.02	0	0.00–0.03
Shearwaters	0	0.00–0.02	0	0.00–0.01	0	0.00–0.00
Prions	0	0.00–0.01	0	0.00–0.00	0	0.00–0.00
Small *Pterodroma* petrels	0	0.00–0.01	0	0.00–0.00	0	0.00–0.00
Gulls, terns & skua	0	0.00–0.01	0	0.00–0.00	0	0.00–0.01

Table E-14: Vulnerability of seabirds to capture in set-net fisheries. Seabirds are listed in species groups used in the estimation of vulnerability (including lower and upper credible limit).

Species group	Set net	
	Mean	95% c.i.
Black petrel	0.13	0.00–0.92
Salvin's albatross	0.01	0.00–0.03
Buller's albatrosses	0	0.00–0.01
White-capped albatross	0	0.00–0.01
Campbell albatross	0.01	0.00–0.04
Westland petrel	0.09	0.02–0.23
Flesh-footed shearwater	0.04	0.01–0.13
Chatham albatross	0.03	0.00–0.22
Giant petrel	0.02	0.00–0.11
Grey petrel	0	0.00–0.03
Wandering albatrosses	0.01	0.00–0.04
Royal albatrosses	0	0.00–0.01
Cape petrel	0	0.00–0.02
White-chinned petrel	0	0.00–0.01
Yellow-eyed penguin	0.07	0.03–0.12
Grey-headed albatross	0	0.00–0.02
Group foraging shags	0	0.00–0.00
LM sooty albatross	0	0.00–0.01
Sooty shearwater	0	0.00–0.00
Solitary shags	0	0.00–0.00
Storm petrels	0	0.00–0.00
Diving petrels	0	0.00–0.00
Little penguins	0.01	0.00–0.01
Crested penguins	0	0.00–0.01
Large *Pterodroma* petrels	0	0.00–0.00
Boobies and gannets	0	0.00–0.00
Shearwaters	0	0.00–0.00
Prions	0	0.00–0.00
Small *Pterodroma* petrels	0	0.00–0.00
Gulls, terns & skua	0	0.00–0.00

APPENDIX F: TOTAL FISHERY-RELATED MORTALITIES BY TARGET FISHERIES

Table F-15: Estimated number of total fishing-related mortalities (D) in trawl, surface-longline (SLL), bottom-longline (BLL), and set-net (SN) fisheries. Values of D large enough for the risk to be non-negligible are in bold and coloured according to the associated risk category as defined in the "National Plan of Action – 2013 to reduce the incidental catch of seabirds in New Zealand fisheries" (Ministry for Primary Industries 2013): Red: very high risk; dark orange: high risk; light orange: medium risk; yellow: low risk. Numbers were rounded to three significant digits.

Species	Trawl		BLL		SLL		SN		All	
	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.
Gibson's albatross	8	0–36	3	0–12	**140**	88–205	0	0–2	**151**	95–221
Antipodean albatross	6	0–28	2	0–9	**54**	32–82	0	0–2	**63**	37–97
Southern royal albatross	10	2–26	4	0–11	8	2–18	0	0–1	22	9–42
Northern royal albatross	15	2–53	13	2–33	8	2–17	0	0–2	**36**	14–81
Campbell black-browed albatross	53	18–154	17	2–47	46	25–76	0	0–3	**117**	65–223
NZ white-capped albatross	**2 890**	2 010–4 050	56	20–110	220	161–287	1	0–6	**3 160**	2 290–4 330
Salvin's albatross	**1 930**	1 330–2 730	**303**	197–428	13	3–30	1	0–5	**2 250**	1 640–3 060
Chatham Island albatross	**44**	16–90	**77**	38–137	1	0–5	0	0–2	**123**	69–196
Grey-headed albatross	3	0–16	1	0–5	1	0–7	0	0–1	5	0–21
Southern Buller's albatross	**368**	245–543	24	8–46	**94**	68–125	1	0–3	**486**	358–664
Northern Buller's albatross	**148**	91–226	53	20–110	**213**	158–275	0	0–1	**414**	321–524
Light-mantled sooty albatross	2	0–10	0	0–3	0	0–2	0	0–1	2	0–13
Northern giant petrel	**24**	6–58	**26**	3–77	1	0–6	0	0–2	**51**	16–113
Grey petrel	37	12–91	59	26–110	43	20–72	1	0–5	139	86–217
Black petrel	**255**	96–529	**164**	92–253	**92**	52–140	2	0–15	**513**	325–803
Westland petrel	**92**	20–258	**34**	8–76	**61**	35–95	8	0–23	**194**	103–361
White-chinned petrel	604	439–812	1 020	799–1 290	49	22–88	2	0–7	**1 680**	1 390–2 010
Flesh-footed shearwater	**279**	122–570	**378**	271–504	24	8–49	29	2–97	**710**	496–1 020
Wedge-tailed shearwater	0	0–0	0	0–0	0	0–0	0	0–0	0	0–0
Buller's shearwater	4	0–18	13	4–25	1	0–4	0	0–1	17	6–35
Sooty shearwater	1 160	631–2 170	34	13–71	8	0–26	9	2–21	1 210	681–2 220
Fluttering shearwater	12	0–59	381	187–651	0	0–2	1	0–3	393	197–665
Hutton's shearwater	11	0–61	4	0–10	0	0–1	2	0–8	17	3–68
Little shearwater	0	0–3	5	1–11	0	0–1	0	0–0	6	1–12
Snares Cape petrel	20	4–62	2	0–10	1	0–5	0	0–1	24	5–68
Fairy prion	74	7–443	13	0–81	1	0–3	1	0–6	89	10–462
Antarctic prion	9	1–25	0	0–3	0	0–2	0	0–1	10	2–26
Broad-billed prion	5	0–17	3	0–19	0	0–2	0	0–0	9	1–29
Pycroft's petrel	0	0–0	0	0–0	0	0–0	0	0–0	0	0–1
Cook's petrel	5	0–32	1	0–7	1	0–4	0	0–2	7	0–36
Chatham petrel	0	0–0	0	0–0	0	0–0	0	0–0	0	0–0
Mottled petrel	3	0–20	0	0–2	0	0–1	0	0–1	4	0–21
White-naped petrel	0	0–0	0	0–0	0	0–0	0	0–0	0	0–0
Kerm. petrel	0	0–0	0	0–0	0	0–0	0	0–0	0	0–1
Grey-faced petrel	15	1–59	32	10–66	14	3–31	1	0–4	62	27–117
Chatham Island taiko	0	0–0	0	0–0	0	0–0	0	0–0	0	0–0
White-headed petrel	2	0–8	5	1–13	1	0–4	0	0–1	9	2–19
Soft-plumaged petrel	0	0–0	0	0–0	0	0–0	0	0–0	0	0–0
Common diving petrel	370	53–1 420	11	0–39	1	0–7	0	0–3	383	63–1 430
South Georgian diving petrel	0	0–1	0	0–0	0	0–0	0	0–0	0	0–1
NZ white-faced storm petrel	43	6–138	41	2–173	1	0–5	1	0–4	85	17–239
White-bellied storm petrel	0	0–0	0	0–0	0	0–0	0	0–0	0	0–0
Black-bellied storm petrel	2	0–8	0	0–2	0	0–2	0	0–1	2	0–9
Kerm. storm petrel	0	0–0	0	0–0	0	0–0	0	0–0	0	0–0
NZ storm petrel	0	0–1	0	0–0	0	0–0	0	0–0	0	0–1
Yellow-eyed penguin	3	0–15	1	0–6	0	0–0	**17**	6–32	**21**	8–41
Northern little penguin	1	0–5	1	0–8	1	0–4	10	2–21	13	4–26
White-flippered little penguin	0	0–2	0	0–1	0	0–0	3	0–8	4	0–9
Southern little penguin	1	0–6	0	0–4	0	0–2	5	0–11	7	1–15
Chatham Island little penguin	0	0–2	1	0–7	0	0–0	0	0–0	1	0–8
Eastern rockhopper penguin	0	0–2	0	0–2	0	0–1	0	0–1	1	0–3
Fiordland crested penguin	1	0–5	2	0–11	0	0–1	1	0–5	4	0–15
Snares crested penguin	0	0–3	0	0–2	0	0–1	1	0–3	1	0–5
Erect-crested penguin	0	0–2	1	0–3	0	0–0	0	0–0	1	0–4
Australasian gannet	1	0–5	1	0–7	0	0–4	0	0–3	3	0–12
Masked booby	0	0–0	0	0–0	0	0–0	0	0–0	0	0–0
Pied shag	2	0–9	2	0–12	0	0–1	4	0–16	8	0–25
Little black shag	1	0–3	1	0–4	0	0–0	1	0–7	3	0–9
NZ king shag	0	0–1	0	0–2	0	0–0	0	0–1	0	0–2
Otago shag	**36**	20–58	0	0–1	0	0–0	0	0–2	**37**	20–58
Foveaux shag	7	2–13	0	0–0	0	0–0	0	0–2	7	2–14
Chatham Island shag	0	0–0	0	0–3	0	0–0	0	0–0	0	0–3
Bounty Island shag	0	0–0	0	0–0	0	0–0	0	0–0	0	0–0
Auckland Island shag	0	0–1	0	0–0	0	0–0	0	0–0	0	0–1
Campbell Island shag	0	0–0	0	0–0	0	0–0	0	0–0	0	0–0
Spotted shag	**273**	172–401	8	0–37	0	0–2	23	7–49	**304**	198–439
Pitt Island shag	0	0–0	0	0–2	0	0–0	0	0–0	0	0–2
Subantarctic skua	0	0–0	0	0–0	0	0–0	0	0–0	0	0–0
Southern black-backed gull	14	0–67	38	12–79	1	0–4	1	0–5	54	18–117
Caspian tern	0	0–0	0	0–0	0	0–0	0	0–0	0	0–0
White tern	0	0–0	0	0–0	0	0–0	0	0–0	0	0–0
All birds	8 840	6 940–11 300	2 840	2 300–3 460	1 100	892–1 330	128	76–205	12 900	10 900–15 400

Table F-16: Estimated number of total fishing-related mortalities (D) in different trawl fisheries (see definition of target fisheries in Richard; Abraham 2013; SBW, southern blue whiting). Values of D large enough for the risk to be non-negligible are in bold and coloured according to the associated risk category as defined in the "National Plan of Action – 2013 to reduce the incidental catch of seabirds in New Zealand fisheries" (Ministry for Primary Industries 2013): Red: very high risk; dark orange: high risk; light orange: medium risk; yellow: low risk. Numbers were rounded to three significant digits. Fisheries are sorted by decreasing order of the mean D. [Continued on next page.]

Species	Inshore trawl		Hoki trawl		Flatfish trawl		Middle depth trawl	
	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.
Gibson's albatross	3	0–18	1	0–3	1	0–10	1	0–3
Antipodean albatross	2	0–13	0	0–3	1	0–8	0	0–3
Southern royal albatross	2	0–10	1	0–4	1	0–6	0	0–3
Northern royal albatross	4	0–25	3	0–9	2	0–16	1	0–7
Campbell black-browed albatross	10	0–54	14	4–29	9	0–63	4	0–15
NZ white-capped albatross	**1 220**	721–1 940	382	266–530	462	223–838	246	153–378
Salvin's albatross	**794**	409–1 340	**371**	233–552	94	45–170	**250**	156–370
Chatham Island albatross	3	0–21	5	0–14	1	0–7	3	0–8
Grey-headed albatross	1	0–8	0	0–2	1	0–4	0	0–2
Southern Buller's albatross	34	3–111	**152**	92–229	20	1–77	63	36–99
Northern Buller's albatross	19	1–65	41	22–64	1	0–4	35	18–55
Light-mantled sooty albatross	1	0–5	0	0–1	0	0–3	0	0–1
Northern giant petrel	3	0–18	8	1–19	1	0–8	3	0–9
Grey petrel	8	0–38	2	0–6	4	0–21	1	0–6
Black petrel	**233**	86–487	9	2–23	2	0–7	5	0–13
Westland petrel	**43**	4–138	**22**	7–49	**14**	1–44	8	0–25
White-chinned petrel	17	1–64	132	73–222	15	0–67	35	17–60
Flesh-footed shearwater	**213**	74–480	6	1–16	7	0–22	5	0–13
Wedge-tailed shearwater	0	0–0	0	0–0	0	0–0	0	0–0
Buller's shearwater	2	0–11	0	0–2	1	0–5	0	0–2
Sooty shearwater	631	207–1 490	62	34–102	58	17–140	181	107–294
Fluttering shearwater	9	0–52	0	0–2	0	0–1	0	0–1
Hutton's shearwater	4	0–31	1	0–5	3	0–22	1	0–5
Little shearwater	0	0–2	0	0–1	0	0–1	0	0–0
Snares Cape petrel	4	0–25	4	0–13	1	0–11	3	0–10
Fairy prion	34	0–235	8	1–27	17	0–138	12	0–52
Antarctic prion	1	0–6	1	0–5	0	0–3	0	0–2
Broad-billed prion	1	0–6	1	0–5	0	0–3	1	0–4
Pycroft's petrel	0	0–0	0	0–0	0	0–0	0	0–0
Cook's petrel	4	0–31	0	0–1	0	0–1	0	0–1
Chatham petrel	0	0–0	0	0–0	0	0–0	0	0–0
Mottled petrel	1	0–10	0	0–1	1	0–9	0	0–2
White-naped petrel	0	0–0	0	0–0	0	0–0	0	0–0
Kerm. petrel	0	0–0	0	0–0	0	0–0	0	0–0
Grey-faced petrel	13	0–51	1	0–3	0	0–3	1	0–3
Chatham Island taiko	0	0–0	0	0–0	0	0–0	0	0–0
White-headed petrel	1	0–5	0	0–1	0	0–2	0	0–1
Soft-plumaged petrel	0	0–0	0	0–0	0	0–0	0	0–0
Common diving petrel	238	16–1 020	12	2–33	46	3–188	17	2–57
South Georgian diving petrel	0	0–0	0	0–0	0	0–0	0	0–0
NZ white-faced storm petrel	6	0–44	1	0–4	1	0–6	4	0–19
White-bellied storm petrel	0	0–0	0	0–0	0	0–0	0	0–0
Black-bellied storm petrel	1	0–5	0	0–1	0	0–2	0	0–1
Kerm. storm petrel	0	0–0	0	0–0	0	0–0	0	0–0
NZ storm petrel	0	0–0	0	0–0	0	0–0	0	0–0
Yellow-eyed penguin	1	0–7	0	0–1	1	0–8	1	0–3
Northern little penguin	1	0–3	0	0–1	0	0–1	0	0–1
White-flippered little penguin	0	0–1	0	0–0	0	0–1	0	0–1
Southern little penguin	0	0–2	0	0–1	1	0–4	0	0–1
Chatham Island little penguin	0	0–0	0	0–0	0	0–0	0	0–1
Eastern rockhopper penguin	0	0–1	0	0–0	0	0–1	0	0–0
Fiordland crested penguin	1	0–4	0	0–1	0	0–1	0	0–1
Snares crested penguin	0	0–1	0	0–1	0	0–1	0	0–1
Erect-crested penguin	0	0–0	0	0–0	0	0–0	0	0–0
Australasian gannet	1	0–3	0	0–0	0	0–2	0	0–1
Masked booby	0	0–0	0	0–0	0	0–0	0	0–0
Pied shag	1	0–4	0	0–1	1	0–5	0	0–1
Little black shag	0	0–2	0	0–0	0	0–2	0	0–1
NZ king shag	0	0–1	0	0–0	0	0–1	0	0–1
Otago shag	3	0–7	0	0–0	**33**	18–53	0	0–1
Foveaux shag	1	0–2	0	0–0	6	2–12	0	0–0
Chatham Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Bounty Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Auckland Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Campbell Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Spotted shag	61	36–94	0	0–2	**206**	129–305	5	1–10
Pitt Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Subantarctic skua	0	0–0	0	0–0	0	0–0	0	0–0
Southern black-backed gull	7	0–34	0	0–3	5	0–31	1	0–4
Caspian tern	0	0–0	0	0–0	0	0–0	0	0–0
White tern	0	0–0	0	0–0	0	0–0	0	0–0
All birds	3 640	2 380–5 390	1 240	929–1 620	1 020	679–1 500	889	667–1 170

Table F-16: [Continued]

Species	Squid trawl		Scampi trawl		Deepwater trawl		Ling trawl	
	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.
Gibson's albatross	0	0–1	1	0–4	1	0–7	0	0–1
Antipodean albatross	0	0–1	0	0–3	1	0–6	0	0–1
Southern royal albatross	2	0–7	0	0–4	1	0–4	0	0–1
Northern royal albatross	1	0–5	1	0–5	2	0–8	0	0–1
Campbell black-browed albatross	0	0–3	6	0–23	1	0–4	1	0–5
NZ white-capped albatross	371	231–554	99	44–183	18	3–45	44	26–67
Salvin's albatross	8	2–18	**270**	141–449	70	31–128	36	20–55
Chatham Island albatross	0	0–1	2	0–12	**31**	9–69	0	0–1
Grey-headed albatross	0	0–1	0	0–2	0	0–2	0	0–1
Southern Buller's albatross	**74**	41–118	10	2–23	1	0–4	5	1–12
Northern Buller's albatross	0	0–2	47	15–99	5	0–19	0	0–1
Light-mantled sooty albatross	0	0–1	0	0–1	0	0–1	0	0–1
Northern giant petrel	0	0–1	4	0–20	3	0–13	0	0–2
Grey petrel	0	0–2	2	0–9	2	0–9	0	0–2
Black petrel	1	0–5	2	0–10	2	0–10	2	0–5
Westland petrel	0	0–1	1	0–4	1	0–7	1	0–5
White-chinned petrel	242	144–379	138	75–231	7	0–26	5	1–11
Flesh-footed shearwater	0	0–2	43	19–81	2	0–10	2	0–6
Wedge-tailed shearwater	0	0–0	0	0–0	0	0–0	0	0–0
Buller's shearwater	0	0–1	0	0–2	0	0–4	0	0–1
Sooty shearwater	116	68–183	70	33–123	18	1–61	19	8–35
Fluttering shearwater	0	0–1	2	0–14	0	0–1	0	0–1
Hutton's shearwater	0	0–0	0	0–1	2	0–16	0	0–0
Little shearwater	0	0–0	0	0–1	0	0–1	0	0–0
Snares Cape petrel	1	0–4	1	0–4	1	0–6	1	0–6
Fairy prion	0	0–2	0	0–3	0	0–3	0	0–1
Antarctic prion	5	0–18	0	0–4	0	0–1	0	0–1
Broad-billed prion	0	0–1	0	0–4	1	0–7	0	0–1
Pycroft's petrel	0	0–0	0	0–0	0	0–0	0	0–0
Cook's petrel	0	0–0	0	0–3	0	0–1	0	0–0
Chatham petrel	0	0–0	0	0–0	0	0–0	0	0–0
Mottled petrel	0	0–1	0	0–0	0	0–1	0	0–1
White-naped petrel	0	0–0	0	0–0	0	0–0	0	0–0
Kerm. petrel	0	0–0	0	0–0	0	0–0	0	0–0
Grey-faced petrel	0	0–0	0	0–3	0	0–3	0	0–1
Chatham Island taiko	0	0–0	0	0–0	0	0–0	0	0–0
White-headed petrel	0	0–1	0	0–2	0	0–2	0	0–1
Soft-plumaged petrel	0	0–0	0	0–0	0	0–0	0	0–0
Common diving petrel	5	0–16	2	0–17	9	0–45	39	5–146
South Georgian diving petrel	0	0–0	0	0–0	0	0–0	0	0–0
NZ white-faced storm petrel	0	0–1	3	0–19	27	2–105	0	0–1
White-bellied storm petrel	0	0–0	0	0–0	0	0–0	0	0–0
Black-bellied storm petrel	0	0–2	0	0–1	0	0–1	0	0–0
Kerm. storm petrel	0	0–0	0	0–0	0	0–0	0	0–0
NZ storm petrel	0	0–0	0	0–0	0	0–0	0	0–0
Yellow-eyed penguin	0	0–1	0	0–1	0	0–0	0	0–0
Northern little penguin	0	0–0	0	0–1	0	0–0	0	0–0
White-flippered little penguin	0	0–0	0	0–0	0	0–0	0	0–0
Southern little penguin	0	0–0	0	0–0	0	0–0	0	0–0
Chatham Island little penguin	0	0–0	0	0–2	0	0–0	0	0–0
Eastern rockhopper penguin	0	0–0	0	0–1	0	0–0	0	0–0
Fiordland crested penguin	0	0–0	0	0–0	0	0–0	0	0–0
Snares crested penguin	0	0–0	0	0–0	0	0–0	0	0–1
Erect-crested penguin	0	0–1	0	0–2	0	0–1	0	0–0
Australasian gannet	0	0–0	0	0–1	0	0–0	0	0–0
Masked booby	0	0–0	0	0–0	0	0–0	0	0–0
Pied shag	0	0–0	0	0–1	0	0–0	0	0–0
Little black shag	0	0–0	0	0–0	0	0–0	0	0–0
NZ king shag	0	0–0	0	0–0	0	0–0	0	0–0
Otago shag	0	0–0	0	0–0	0	0–0	0	0–0
Foveaux shag	0	0–0	0	0–0	0	0–0	0	0–0
Chatham Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Bounty Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Auckland Island shag	0	0–1	0	0–1	0	0–0	0	0–0
Campbell Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Spotted shag	0	0–0	0	0–1	0	0–0	0	0–1
Pitt Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Subantarctic skua	0	0–0	0	0–0	0	0–0	0	0–0
Southern black-backed gull	0	0–1	0	0–2	0	0–2	0	0–1
Caspian tern	0	0–0	0	0–0	0	0–0	0	0–0
White tern	0	0–0	0	0–0	0	0–0	0	0–0
All birds	829	609–1 100	708	464–1 020	207	113–355	159	101–272

[Continued on next page.]

Table F-16: [Continued]

Species	Hake trawl		Southern blue whiting trawl		Jack mackerel trawl	
	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.
Gibson's albatross	0	0–1	0	0–1	0	0–1
Antipodean albatross	0	0–0	0	0–1	0	0–0
Southern royal albatross	0	0–1	2	0–7	0	0–0
Northern royal albatross	0	0–1	0	0–1	0	0–1
Campbell black-browed albatross	0	0–2	7	1–17	0	0–1
NZ white-capped albatross	32	18–48	1	0–4	7	1–17
Salvin's albatross	10	4–19	24	9–49	1	0–5
Chatham Island albatross	0	0–0	0	0–1	0	0–1
Grey-headed albatross	0	0–0	0	0–2	0	0–0
Southern Buller's albatross	6	2–13	0	0–3	2	0–7
Northern Buller's albatross	0	0–1	1	0–4	0	0–2
Light-mantled sooty albatross	0	0–0	0	0–1	0	0–0
Northern giant petrel	0	0–2	0	0–2	0	0–1
Grey petrel	0	0–1	17	4–40	0	0–1
Black petrel	0	0–0	0	0–0	0	0–1
Westland petrel	2	0–5	0	0–1	0	0–2
White-chinned petrel	6	1–13	0	0–2	6	1–12
Flesh-footed shearwater	0	0–0	0	0–0	0	0–1
Wedge-tailed shearwater	0	0–0	0	0–0	0	0–0
Buller's shearwater	0	0–0	0	0–0	0	0–1
Sooty shearwater	2	0–5	0	0–1	1	0–4
Fluttering shearwater	0	0–0	0	0–1	0	0–0
Hutton's shearwater	0	0–0	0	0–0	0	0–0
Little shearwater	0	0–0	0	0–0	0	0–0
Snares Cape petrel	1	0–4	5	0–18	0	0–1
Fairy prion	0	0–1	0	0–1	2	0–7
Antarctic prion	0	0–1	0	0–0	0	0–0
Broad-billed prion	0	0–1	0	0–1	0	0–0
Pycroft's petrel	0	0–0	0	0–0	0	0–0
Cook's petrel	0	0–0	0	0–0	0	0–0
Chatham petrel	0	0–0	0	0–0	0	0–0
Mottled petrel	0	0–0	0	0–0	0	0–0
White-naped petrel	0	0–0	0	0–0	0	0–0
Kerm. petrel	0	0–0	0	0–0	0	0–0
Grey-faced petrel	0	0–0	0	0–0	0	0–1
Chatham Island taiko	0	0–0	0	0–0	0	0–0
White-headed petrel	0	0–0	0	0–1	0	0–0
Soft-plumaged petrel	0	0–0	0	0–0	0	0–0
Common diving petrel	0	0–2	1	0–6	1	0–3
South Georgian diving petrel	0	0–0	0	0–0	0	0–0
NZ white-faced storm petrel	0	0–0	0	0–0	0	0–3
White-bellied storm petrel	0	0–0	0	0–0	0	0–0
Black-bellied storm petrel	0	0–0	0	0–1	0	0–1
Kerm. storm petrel	0	0–0	0	0–0	0	0–0
NZ storm petrel	0	0–0	0	0–0	0	0–0
Yellow-eyed penguin	0	0–0	0	0–0	0	0–0
Northern little penguin	0	0–0	0	0–0	0	0–0
White-flippered little penguin	0	0–0	0	0–0	0	0–0
Southern little penguin	0	0–0	0	0–0	0	0–0
Chatham Island little penguin	0	0–0	0	0–0	0	0–0
Eastern rockhopper penguin	0	0–0	0	0–0	0	0–0
Fiordland crested penguin	0	0–0	0	0–0	0	0–0
Snares crested penguin	0	0–0	0	0–0	0	0–0
Erect-crested penguin	0	0–0	0	0–1	0	0–0
Australasian gannet	0	0–0	0	0–0	0	0–1
Masked booby	0	0–0	0	0–0	0	0–0
Pied shag	0	0–0	0	0–0	0	0–0
Little black shag	0	0–0	0	0–0	0	0–0
NZ king shag	0	0–0	0	0–0	0	0–0
Otago shag	0	0–0	0	0–0	0	0–0
Foveaux shag	0	0–0	0	0–0	0	0–0
Chatham Island shag	0	0–0	0	0–0	0	0–0
Bounty Island shag	0	0–0	0	0–0	0	0–0
Auckland Island shag	0	0–0	0	0–0	0	0–0
Campbell Island shag	0	0–0	0	0–0	0	0–0
Spotted shag	0	0–0	0	0–0	0	0–0
Pitt Island shag	0	0–0	0	0–0	0	0–0
Subantarctic skua	0	0–0	0	0–0	0	0–0
Southern black-backed gull	0	0–0	0	0–0	0	0–0
Caspian tern	0	0–0	0	0–0	0	0–0
White tern	0	0–0	0	0–0	0	0–0
All birds	61	40–85	59	30–98	22	10–39

Table F-17: Estimated number of total fishing-related deaths (D) in bottom-longline (BLL) fisheries (see definition of target fisheries in Richard; Abraham 2013; cut-off length for vessel size classes was 34 m). Values of D large enough for the risk to be non-negligible are in bold and coloured according to the associated risk category as defined in the "National Plan of Action – 2013 to reduce the incidental catch of seabirds in New Zealand fisheries" (Ministry for Primary Industries 2013): Red: very high risk; dark orange: high risk; light orange: medium risk; yellow: low risk. Numbers were rounded to three significant digits. Fisheries are sorted by decreasing order of the mean D. [Continued on next page.]

Species	Small ling BLL		Snapper BLL		Large ling BLL		Minor BLL	
	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.
Gibson's albatross	1	0–6	0	0–4	0	0–2	0	0–4
Antipodean albatross	1	0–5	0	0–2	0	0–2	0	0–3
Southern royal albatross	2	0–8	0	0–3	1	0–3	0	0–2
Northern royal albatross	9	0–27	0	0–2	2	0–5	1	0–6
Campbell black-browed albatross	2	0–13	1	0–6	1	0–7	4	0–17
NZ white-capped albatross	45	13–94	3	0–13	1	0–7	4	0–13
Salvin's albatross	**260**	165–378	2	0–11	22	8–41	13	4–29
Chatham Island albatross	**68**	32–119	0	0–3	2	0–8	4	0–17
Grey-headed albatross	0	0–3	0	0–1	0	0–1	0	0–2
Southern Buller's albatross	16	3–37	0	0–0	4	0–11	1	0–5
Northern Buller's albatross	25	5–56	2	0–10	8	1–18	7	0–30
Light-mantled sooty albatross	0	0–2	0	0–1	0	0–1	0	0–1
Northern giant petrel	1	0–9	3	0–14	0	0–3	**9**	0–31
Grey petrel	42	14–89	1	0–9	11	2–26	2	0–9
Black petrel	2	0–9	**72**	41–109	0	0–1	8	1–20
Westland petrel	**17**	1–52	1	0–8	0	0–2	8	0–26
White-chinned petrel	626	459–835	1	0–9	357	268–457	27	16–41
Flesh-footed shearwater	3	0–18	**260**	175–365	0	0–2	71	39–111
Wedge-tailed shearwater	0	0–0	0	0–0	0	0–0	0	0–0
Buller's shearwater	0	0–3	11	3–23	0	0–1	0	0–2
Sooty shearwater	4	0–18	5	0–19	11	4–22	8	0–29
Fluttering shearwater	1	0–5	377	183–647	0	0–1	3	0–10
Hutton's shearwater	1	0–4	3	0–7	0	0–0	1	0–4
Little shearwater	0	0–1	5	1–11	0	0–0	0	0–1
Snares Cape petrel	1	0–6	0	0–3	0	0–2	0	0–3
Fairy prion	1	0–8	0	0–4	0	0–1	7	0–48
Antarctic prion	0	0–1	0	0–1	0	0–1	0	0–1
Broad-billed prion	1	0–5	0	0–1	0	0–2	1	0–8
Pycroft's petrel	0	0–0	0	0–0	0	0–0	0	0–0
Cook's petrel	0	0–1	1	0–5	0	0–0	0	0–1
Chatham petrel	0	0–0	0	0–0	0	0–0	0	0–0
Mottled petrel	0	0–1	0	0–0	0	0–1	0	0–0
White-naped petrel	0	0–0	0	0–0	0	0–0	0	0–0
Kerm. petrel	0	0–0	0	0–0	0	0–0	0	0–0
Grey-faced petrel	1	0–10	1	0–9	0	0–1	18	5–39
Chatham Island taiko	0	0–0	0	0–0	0	0–0	0	0–0
White-headed petrel	0	0–2	0	0–1	0	0–1	3	0–7
Soft-plumaged petrel	0	0–0	0	0–0	0	0–0	0	0–0
Common diving petrel	2	0–10	2	0–12	1	0–7	3	0–15
South Georgian diving petrel	0	0–0	0	0–0	0	0–0	0	0–0
NZ white-faced storm petrel	9	0–55	1	0–6	3	0–16	11	0–57
White-bellied storm petrel	0	0–0	0	0–0	0	0–0	0	0–0
Black-bellied storm petrel	0	0–1	0	0–0	0	0–1	0	0–1
Kerm. storm petrel	0	0–0	0	0–0	0	0–0	0	0–0
NZ storm petrel	0	0–0	0	0–0	0	0–0	0	0–0
Yellow-eyed penguin	0	0–3	0	0–0	0	0–0	0	0–3
Northern little penguin	0	0–3	1	0–5	0	0–0	0	0–2
White-flippered little penguin	0	0–1	0	0–0	0	0–0	0	0–0
Southern little penguin	0	0–3	0	0–0	0	0–0	0	0–1
Chatham Island little penguin	0	0–2	0	0–0	0	0–1	0	0–3
Eastern rockhopper penguin	0	0–1	0	0–0	0	0–1	0	0–1
Fiordland crested penguin	1	0–8	0	0–0	0	0–0	0	0–1
Snares crested penguin	0	0–1	0	0–0	0	0–1	0	0–1
Erect-crested penguin	0	0–0	0	0–0	1	0–3	0	0–0
Australasian gannet	0	0–4	0	0–3	0	0–0	0	0–1
Masked booby	0	0–0	0	0–0	0	0–0	0	0–0
Pied shag	1	0–4	1	0–6	0	0–1	0	0–4
Little black shag	0	0–1	0	0–3	0	0–0	0	0–2
NZ king shag	0	0–0	0	0–0	0	0–0	0	0–1
Otago shag	0	0–0	0	0–0	0	0–0	0	0–1
Foveaux shag	0	0–0	0	0–0	0	0–0	0	0–0
Chatham Island shag	0	0–0	0	0–0	0	0–0	0	0–2
Bounty Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Auckland Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Campbell Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Spotted shag	3	0–19	2	0–10	0	0–0	2	0–15
Pitt Island shag	0	0–0	0	0–0	0	0–0	0	0–2
Subantarctic skua	0	0–0	0	0–0	0	0–0	0	0–0
Southern black-backed gull	3	0–16	23	4–56	0	0–2	8	1–23
Caspian tern	0	0–0	0	0–0	0	0–0	0	0–0
White tern	0	0–0	0	0–0	0	0–0	0	0–0
All birds	1 150	893–1 460	782	538–1 100	428	327–539	229	155–330

Table F-17: [Continued]

Species	Hapuka BLL		Bluenose BLL	
	Mean	95% c.i.	Mean	95% c.i.
Gibson's albatross	0	0–3	0	0–2
Antipodean albatross	0	0–3	0	0–1
Southern royal albatross	0	0–2	0	0–1
Northern royal albatross	1	0–6	0	0–2
Campbell black-browed albatross	3	0–15	6	0–21
NZ white-capped albatross	2	0–10	1	0–8
Salvin's albatross	5	0–18	1	0–8
Chatham Island albatross	3	0–22	0	0–2
Grey-headed albatross	0	0–1	0	0–1
Southern Buller's albatross	1	0–5	1	0–3
Northern Buller's albatross	8	0–34	3	0–12
Light-mantled sooty albatross	0	0–1	0	0–0
Northern giant petrel	**12**	0–41	0	0–2
Grey petrel	1	0–5	1	0–5
Black petrel	11	2–26	**71**	16–144
Westland petrel	6	0–19	1	0–5
White-chinned petrel	5	1–12	6	0–21
Flesh-footed shearwater	43	22–70	1	0–5
Wedge-tailed shearwater	0	0–0	0	0–0
Buller's shearwater	0	0–2	0	0–1
Sooty shearwater	5	0–18	0	0–4
Fluttering shearwater	0	0–1	0	0–2
Hutton's shearwater	0	0–1	0	0–1
Little shearwater	0	0–0	0	0–0
Snares Cape petrel	0	0–2	0	0–1
Fairy prion	5	0–32	0	0–1
Antarctic prion	0	0–1	0	0–0
Broad-billed prion	1	0–10	0	0–1
Pycroft's petrel	0	0–0	0	0–0
Cook's petrel	0	0–1	0	0–1
Chatham petrel	0	0–0	0	0–0
Mottled petrel	0	0–0	0	0–0
White-naped petrel	0	0–0	0	0–0
Kerm. petrel	0	0–0	0	0–0
Grey-faced petrel	11	3–25	0	0–3
Chatham Island taiko	0	0–0	0	0–0
White-headed petrel	2	0–6	0	0–1
Soft-plumaged petrel	0	0–0	0	0–0
Common diving petrel	3	0–18	0	0–3
South Georgian diving petrel	0	0–0	0	0–0
NZ white-faced storm petrel	17	0–87	1	0–4
White-bellied storm petrel	0	0–0	0	0–0
Black-bellied storm petrel	0	0–0	0	0–0
Kerm. storm petrel	0	0–0	0	0–0
NZ storm petrel	0	0–0	0	0–0
Yellow-eyed penguin	0	0–1	0	0–0
Northern little penguin	0	0–1	0	0–1
White-flippered little penguin	0	0–0	0	0–0
Southern little penguin	0	0–1	0	0–0
Chatham Island little penguin	0	0–4	0	0–0
Eastern rockhopper penguin	0	0–0	0	0–0
Fiordland crested penguin	0	0–4	0	0–0
Snares crested penguin	0	0–1	0	0–0
Erect-crested penguin	0	0–0	0	0–0
Australasian gannet	0	0–2	0	0–1
Masked booby	0	0–0	0	0–0
Pied shag	0	0–2	0	0–0
Little black shag	0	0–1	0	0–0
NZ king shag	0	0–1	0	0–0
Otago shag	0	0–0	0	0–0
Foveaux shag	0	0–0	0	0–0
Chatham Island shag	0	0–2	0	0–0
Bounty Island shag	0	0–0	0	0–0
Auckland Island shag	0	0–0	0	0–0
Campbell Island shag	0	0–0	0	0–0
Spotted shag	1	0–11	0	0–1
Pitt Island shag	0	0–1	0	0–0
Subantarctic skua	0	0–0	0	0–0
Southern black-backed gull	4	0–12	0	0–2
Caspian tern	0	0–0	0	0–0
White tern	0	0–0	0	0–0
All birds	154	91–252	96	33–172

Table F-18: Estimated number of total fishing-related deaths (D) in surface-longline (SLL) fisheries (see definition of target fisheries in Richard; Abraham 2013; cut-off length for vessel size classes was 45 m; STN: southern bluefin tuna). Values of D large enough for the risk to be non-negligible are in bold and coloured according to the associated risk category as defined in the "National Plan of Action – 2013 to reduce the incidental catch of seabirds in New Zealand fisheries" (Ministry for Primary Industries 2013): Red: very high risk; dark orange: high risk; light orange: medium risk; yellow: low risk. Fisheries are sorted by decreasing order of the mean D. [Continued on next page.]

Species	Small STN SLL		Bigeye SLL		Swordfish SLL		Large STN SLL	
	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.
Gibson's albatross	**33**	18–51	11	4–19	**96**	50–154	0	0–1
Antipodean albatross	14	6–25	5	1–11	**34**	16–57	0	0–1
Southern royal albatross	5	1–12	2	0–7	0	0–3	0	0–0
Northern royal albatross	5	1–12	2	0–6	0	0–2	0	0–0
Campbell black-browed albatross	28	13–46	12	5–22	6	0–20	0	0–1
NZ white-capped albatross	141	102–186	58	39–82	15	2–37	3	0–7
Salvin's albatross	4	0–11	6	1–15	2	0–12	0	0–1
Chatham Island albatross	0	0–2	0	0–2	0	0–3	0	0–0
Grey-headed albatross	1	0–4	1	0–3	0	0–2	0	0–0
Southern Buller's albatross	**85**	60–114	1	0–4	1	0–4	7	2–13
Northern Buller's albatross	82	58–110	**123**	89–163	2	0–9	0	0–0
Light-mantled sooty albatross	0	0–1	0	0–1	0	0–1	0	0–0
Northern giant petrel	0	0–3	0	0–1	0	0–4	0	0–0
Grey petrel	21	9–37	7	2–15	13	2–35	1	0–3
Black petrel	0	0–2	**73**	40–116	**18**	3–47	0	0–0
Westland petrel	**49**	27–78	6	2–13	5	0–20	0	0–1
White-chinned petrel	10	2–21	6	1–13	33	11–69	1	0–3
Flesh-footed shearwater	2	0–6	14	4–30	8	0–30	0	0–0
Wedge-tailed shearwater	0	0–0	0	0–0	0	0–0	0	0–0
Buller's shearwater	0	0–1	0	0–2	0	0–3	0	0–0
Sooty shearwater	1	0–4	1	0–4	7	0–24	0	0–0
Fluttering shearwater	0	0–1	0	0–1	0	0–1	0	0–0
Hutton's shearwater	0	0–0	0	0–0	0	0–0	0	0–0
Little shearwater	0	0–1	0	0–0	0	0–0	0	0–0
Snares Cape petrel	0	0–3	0	0–1	0	0–3	0	0–0
Fairy prion	0	0–2	0	0–1	0	0–2	0	0–0
Antarctic prion	0	0–1	0	0–1	0	0–1	0	0–0
Broad-billed prion	0	0–1	0	0–1	0	0–1	0	0–0
Pycroft's petrel	0	0–0	0	0–0	0	0–0	0	0–0
Cook's petrel	0	0–1	0	0–3	0	0–3	0	0–0
Chatham petrel	0	0–0	0	0–0	0	0–0	0	0–0
Mottled petrel	0	0–0	0	0–0	0	0–0	0	0–0
White-naped petrel	0	0–0	0	0–0	0	0–0	0	0–0
Kerm. petrel	0	0–0	0	0–0	0	0–0	0	0–0
Grey-faced petrel	5	0–13	3	0–8	6	0–19	0	0–0
Chatham Island taiko	0	0–0	0	0–0	0	0–0	0	0–0
White-headed petrel	0	0–2	0	0–1	1	0–3	0	0–0
Soft-plumaged petrel	0	0–0	0	0–0	0	0–0	0	0–0
Common diving petrel	0	0–3	0	0–3	1	0–4	0	0–0
South Georgian diving petrel	0	0–0	0	0–0	0	0–0	0	0–0
NZ white-faced storm petrel	0	0–1	0	0–2	1	0–4	0	0–0
White-bellied storm petrel	0	0–0	0	0–0	0	0–0	0	0–0
Black-bellied storm petrel	0	0–1	0	0–1	0	0–1	0	0–0
Kerm. storm petrel	0	0–0	0	0–0	0	0–0	0	0–0
NZ storm petrel	0	0–0	0	0–0	0	0–0	0	0–0
Yellow-eyed penguin	0	0–0	0	0–0	0	0–0	0	0–0
Northern little penguin	0	0–2	0	0–1	0	0–3	0	0–0
White-flippered little penguin	0	0–0	0	0–0	0	0–0	0	0–0
Southern little penguin	0	0–1	0	0–0	0	0–1	0	0–0
Chatham Island little penguin	0	0–0	0	0–0	0	0–0	0	0–0
Eastern rockhopper penguin	0	0–1	0	0–0	0	0–0	0	0–0
Fiordland crested penguin	0	0–1	0	0–0	0	0–1	0	0–0
Snares crested penguin	0	0–0	0	0–0	0	0–0	0	0–0
Erect-crested penguin	0	0–0	0	0–0	0	0–0	0	0–0
Australasian gannet	0	0–1	0	0–1	0	0–3	0	0–0
Masked booby	0	0–0	0	0–0	0	0–0	0	0–0
Pied shag	0	0–0	0	0–1	0	0–1	0	0–0
Little black shag	0	0–0	0	0–0	0	0–0	0	0–0
NZ king shag	0	0–0	0	0–0	0	0–0	0	0–0
Otago shag	0	0–0	0	0–0	0	0–0	0	0–0
Foveaux shag	0	0–0	0	0–0	0	0–0	0	0–0
Chatham Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Bounty Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Auckland Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Campbell Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Spotted shag	0	0–1	0	0–0	0	0–0	0	0–0
Pitt Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Subantarctic skua	0	0–0	0	0–0	0	0–0	0	0–0
Southern black-backed gull	0	0–2	0	0–1	0	0–2	0	0–0
Caspian tern	0	0–0	0	0–0	0	0–0	0	0–0
White tern	0	0–0	0	0–0	0	0–0	0	0–0
All birds	488	392–597	334	261–414	252	165–357	12	5–20

Table F-18: [Continued]

Species	Minor surface SLL		Albacore SLL	
	Mean	95% c.i.	Mean	95% c.i.
Gibson's albatross	0	0–2	0	0–1
Antipodean albatross	0	0–2	0	0–2
Southern royal albatross	0	0–1	0	0–1
Northern royal albatross	0	0–1	0	0–1
Campbell black-browed albatross	0	0–2	0	0–1
NZ white-capped albatross	2	0–5	1	0–3
Salvin's albatross	0	0–2	0	0–1
Chatham Island albatross	0	0–0	0	0–0
Grey-headed albatross	0	0–0	0	0–0
Southern Buller's albatross	1	0–3	0	0–1
Northern Buller's albatross	4	1–9	2	0–6
Light-mantled sooty albatross	0	0–0	0	0–0
Northern giant petrel	0	0–0	0	0–0
Grey petrel	0	0–2	0	0–1
Black petrel	0	0–1	0	0–0
Westland petrel	0	0–2	0	0–1
White-chinned petrel	0	0–1	0	0–1
Flesh-footed shearwater	0	0–1	0	0–1
Wedge-tailed shearwater	0	0–0	0	0–0
Buller's shearwater	0	0–0	0	0–0
Sooty shearwater	0	0–0	0	0–0
Fluttering shearwater	0	0–0	0	0–0
Hutton's shearwater	0	0–0	0	0–0
Little shearwater	0	0–0	0	0–0
Snares Cape petrel	0	0–0	0	0–0
Fairy prion	0	0–0	0	0–0
Antarctic prion	0	0–0	0	0–0
Broad-billed prion	0	0–0	0	0–0
Pycroft's petrel	0	0–0	0	0–0
Cook's petrel	0	0–0	0	0–0
Chatham petrel	0	0–0	0	0–0
Mottled petrel	0	0–0	0	0–0
White-naped petrel	0	0–0	0	0–0
Kerm. petrel	0	0–0	0	0–0
Grey-faced petrel	0	0–1	0	0–1
Chatham Island taiko	0	0–0	0	0–0
White-headed petrel	0	0–0	0	0–0
Soft-plumaged petrel	0	0–0	0	0–0
Common diving petrel	0	0–0	0	0–0
South Georgian diving petrel	0	0–0	0	0–0
NZ white-faced storm petrel	0	0–0	0	0–0
White-bellied storm petrel	0	0–0	0	0–0
Black-bellied storm petrel	0	0–0	0	0–0
Kerm. storm petrel	0	0–0	0	0–0
NZ storm petrel	0	0–0	0	0–0
Yellow-eyed penguin	0	0–0	0	0–0
Northern little penguin	0	0–0	0	0–0
White-flippered little penguin	0	0–0	0	0–0
Southern little penguin	0	0–0	0	0–0
Chatham Island little penguin	0	0–0	0	0–0
Eastern rockhopper penguin	0	0–0	0	0–0
Fiordland crested penguin	0	0–0	0	0–0
Snares crested penguin	0	0–0	0	0–0
Erect-crested penguin	0	0–0	0	0–0
Australasian gannet	0	0–0	0	0–0
Masked booby	0	0–0	0	0–0
Pied shag	0	0–0	0	0–0
Little black shag	0	0–0	0	0–0
NZ king shag	0	0–0	0	0–0
Otago shag	0	0–0	0	0–0
Foveaux shag	0	0–0	0	0–0
Chatham Island shag	0	0–0	0	0–0
Bounty Island shag	0	0–0	0	0–0
Auckland Island shag	0	0–0	0	0–0
Campbell Island shag	0	0–0	0	0–0
Spotted shag	0	0–1	0	0–0
Pitt Island shag	0	0–0	0	0–0
Subantarctic skua	0	0–0	0	0–0
Southern black-backed gull	0	0–1	0	0–0
Caspian tern	0	0–0	0	0–0
White tern	0	0–0	0	0–0
All birds	10	4–17	5	1–9

Table F-19: Estimated number of total fishing-related deaths (D) in set-net (SN) fisheries, by target species. Values of D large enough for the risk to be non-negligible are in bold and coloured according to the associated risk category as defined in the "National Plan of Action – 2013 to reduce the incidental catch of seabirds in New Zealand fisheries" (Ministry for Primary Industries 2013): Red: very high risk; dark orange: high risk; light orange: medium risk; yellow: low risk. Fisheries are sorted by decreasing order of the mean D.

Species	Shark SN		Flatfish SN		Minor SN		Mullet SN	
	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.	Mean	95% c.i.
Gibson's albatross	0	0–1	0	0–1	0	0–1	0	0–0
Antipodean albatross	0	0–1	0	0–1	0	0–1	0	0–0
Southern royal albatross	0	0–1	0	0–0	0	0–0	0	0–0
Northern royal albatross	0	0–1	0	0–1	0	0–1	0	0–0
Campbell black-browed albatross	0	0–2	0	0–1	0	0–1	0	0–0
NZ white-capped albatross	1	0–3	0	0–2	0	0–2	0	0–1
Salvin's albatross	1	0–3	0	0–2	0	0–2	0	0–1
Chatham Island albatross	0	0–1	0	0–1	0	0–1	0	0–0
Grey-headed albatross	0	0–1	0	0–0	0	0–0	0	0–0
Southern Buller's albatross	0	0–2	0	0–1	0	0–1	0	0–0
Northern Buller's albatross	0	0–1	0	0–1	0	0–1	0	0–0
Light-mantled sooty albatross	0	0–1	0	0–0	0	0–0	0	0–0
Northern giant petrel	0	0–1	0	0–1	0	0–1	0	0–0
Grey petrel	0	0–3	0	0–2	0	0–2	0	0–1
Black petrel	0	0–2	1	0–6	1	0–6	0	0–3
Westland petrel	3	0–10	3	0–8	2	0–6	0	0–3
White-chinned petrel	1	0–4	0	0–2	0	0–2	0	0–1
Flesh-footed shearwater	6	0–22	12	0–41	9	0–30	2	0–9
Wedge-tailed shearwater	0	0–0	0	0–0	0	0–0	0	0–0
Buller's shearwater	0	0–1	0	0–0	0	0–0	0	0–0
Sooty shearwater	7	1–16	0	0–2	2	0–5	0	0–1
Fluttering shearwater	0	0–1	0	0–2	0	0–2	0	0–0
Hutton's shearwater	2	0–6	0	0–0	1	0–3	0	0–0
Little shearwater	0	0–0	0	0–0	0	0–0	0	0–0
Snares Cape petrel	0	0–1	0	0–0	0	0–0	0	0–0
Fairy prion	1	0–5	0	0–1	0	0–2	0	0–0
Antarctic prion	0	0–0	0	0–0	0	0–0	0	0–0
Broad-billed prion	0	0–0	0	0–0	0	0–0	0	0–0
Pycroft's petrel	0	0–0	0	0–0	0	0–0	0	0–0
Cook's petrel	0	0–1	0	0–1	0	0–1	0	0–0
Chatham petrel	0	0–0	0	0–0	0	0–0	0	0–0
Mottled petrel	0	0–1	0	0–0	0	0–0	0	0–0
White-naped petrel	0	0–0	0	0–0	0	0–0	0	0–0
Kerm. petrel	0	0–0	0	0–0	0	0–0	0	0–0
Grey-faced petrel	0	0–2	0	0–2	0	0–1	0	0–0
Chatham Island taiko	0	0–0	0	0–0	0	0–0	0	0–0
White-headed petrel	0	0–1	0	0–0	0	0–0	0	0–0
Soft-plumaged petrel	0	0–0	0	0–0	0	0–0	0	0–0
Common diving petrel	0	0–2	0	0–0	0	0–1	0	0–0
South Georgian diving petrel	0	0–0	0	0–0	0	0–0	0	0–0
NZ white-faced storm petrel	0	0–1	0	0–3	0	0–1	0	0–0
White-bellied storm petrel	0	0–0	0	0–0	0	0–0	0	0–0
Black-bellied storm petrel	0	0–0	0	0–0	0	0–0	0	0–0
Kerm. storm petrel	0	0–0	0	0–0	0	0–0	0	0–0
NZ storm petrel	0	0–0	0	0–0	0	0–0	0	0–0
Yellow-eyed penguin	12	4–23	2	0–5	3	0–8	0	0–0
Northern little penguin	4	0–9	3	0–8	2	0–7	1	0–3
White-flippered little penguin	2	0–5	1	0–3	1	0–4	0	0–0
Southern little penguin	4	0–9	1	0–3	0	0–2	0	0–0
Chatham Island little penguin	0	0–0	0	0–0	0	0–0	0	0–0
Eastern rockhopper penguin	0	0–1	0	0–0	0	0–0	0	0–0
Fiordland crested penguin	1	0–4	0	0–1	0	0–2	0	0–0
Snares crested penguin	0	0–2	0	0–1	0	0–1	0	0–0
Erect-crested penguin	0	0–0	0	0–0	0	0–0	0	0–0
Australasian gannet	0	0–2	0	0–2	0	0–1	0	0–0
Masked booby	0	0–0	0	0–0	0	0–0	0	0–0
Pied shag	1	0–6	1	0–6	1	0–4	0	0–2
Little black shag	0	0–3	1	0–3	0	0–2	0	0–1
NZ king shag	0	0–0	0	0–0	0	0–1	0	0–0
Otago shag	0	0–2	0	0–0	0	0–0	0	0–0
Foveaux shag	0	0–2	0	0–0	0	0–1	0	0–0
Chatham Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Bounty Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Auckland Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Campbell Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Spotted shag	8	1–18	9	2–21	5	0–12	1	0–4
Pitt Island shag	0	0–0	0	0–0	0	0–0	0	0–0
Subantarctic skua	0	0–0	0	0–0	0	0–0	0	0–0
Southern black-backed gull	0	0–2	0	0–2	0	0–2	0	0–1
Caspian tern	0	0–0	0	0–0	0	0–0	0	0–0
White tern	0	0–0	0	0–0	0	0–0	0	0–0
All birds	56	34–83	36	17–68	29	14–54	5	1–13

APPENDIX G: DATA CORRECTIONS AND UPDATES

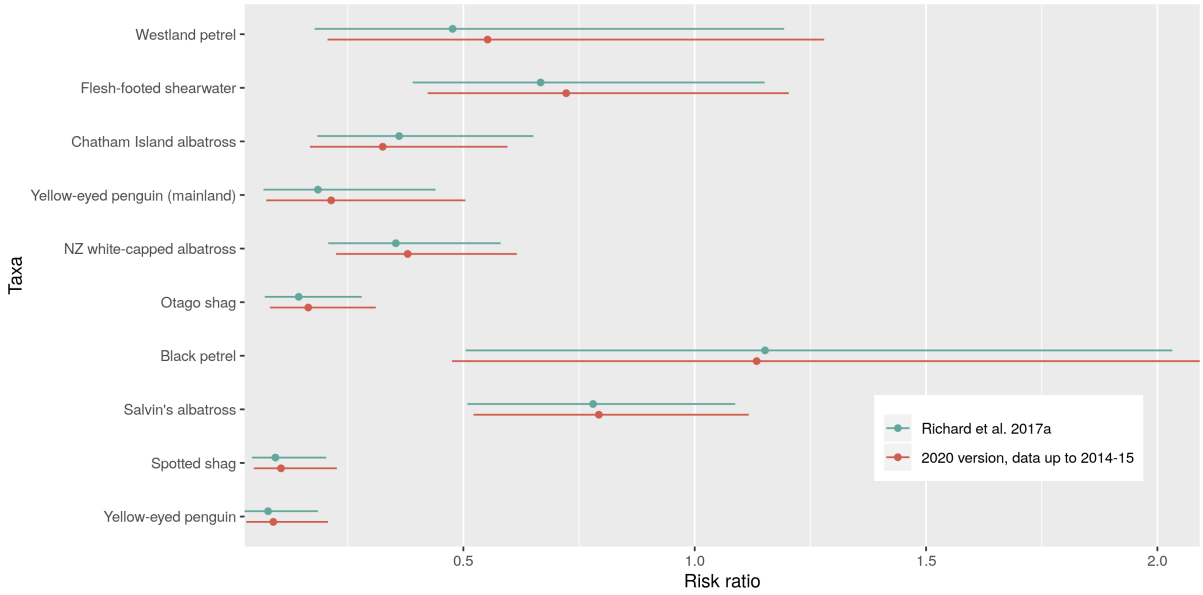


Figure G-3: Change in estimated risk ratio between the previous assessment by Richard et al. (2017a) and the current assessment (2020 version) following corrections to fishing and capture data. Shown are the ten seabird species that had the greatest changes in risk ratio, based on data from 2012–13 to 2014–15, in decreasing order of the change in median risk ratio.

Table G-20: Fisheries with a change in the cumulative risk ratio to all seabird taxa following the addition of two more years of data on fishing effort and observed captures, after corrections to the data from the previous risk assessment by Richard et al. (2017a). Shown are the median risk ratio with limits of the 95% credible interval (c.i.), and indicating the direction of change (+, increase; -, decrease) for the ten fisheries with the largest change.

Fishery	2012–13 to 2014–15		2014–15 to 2016–17		
	Median	95% c.i.	Median	95% c.i.	Change
Inshore trawl	1.514	0.906–2.485	1.290	0.736–2.189	-
Snapper BLL	0.524	0.333–0.845	0.389	0.248–0.608	-
Small STN SLL	0.291	0.203–0.417	0.423	0.307–0.578	+
Flatfish trawl	0.499	0.322–0.786	0.381	0.245–0.582	-
Hoki trawl	0.537	0.366–0.768	0.442	0.306–0.629	-
Bluenose BLL	0.231	0.059–0.599	0.171	0.043–0.430	-
Middle depth trawl	0.290	0.198–0.420	0.239	0.166–0.343	-
Minor BLL	0.131	0.073–0.255	0.160	0.090–0.303	+
Hapuka BLL	0.163	0.079–0.373	0.136	0.067–0.302	-
Small ling BLL	0.412	0.263–0.632	0.390	0.252–0.590	-

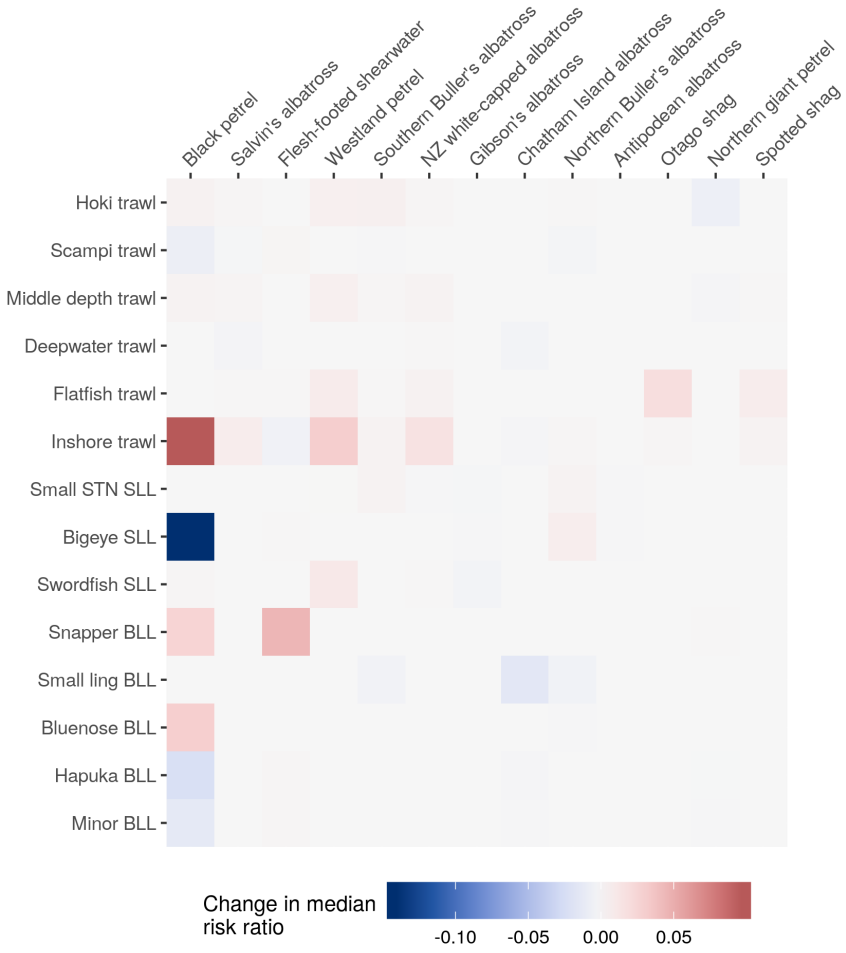


Figure G-4: Change in median risk ratio between the previous assessment by Richard et al. (2017a) and the current assessment, following corrections to fishing and capture data. Shown are only the taxa and fisheries with a median total risk ratio over 0.1, based on data from 2012–13 to 2014–15. STN, southern bluefin tuna; SLL, surface longline; BLL, bottom-longline.

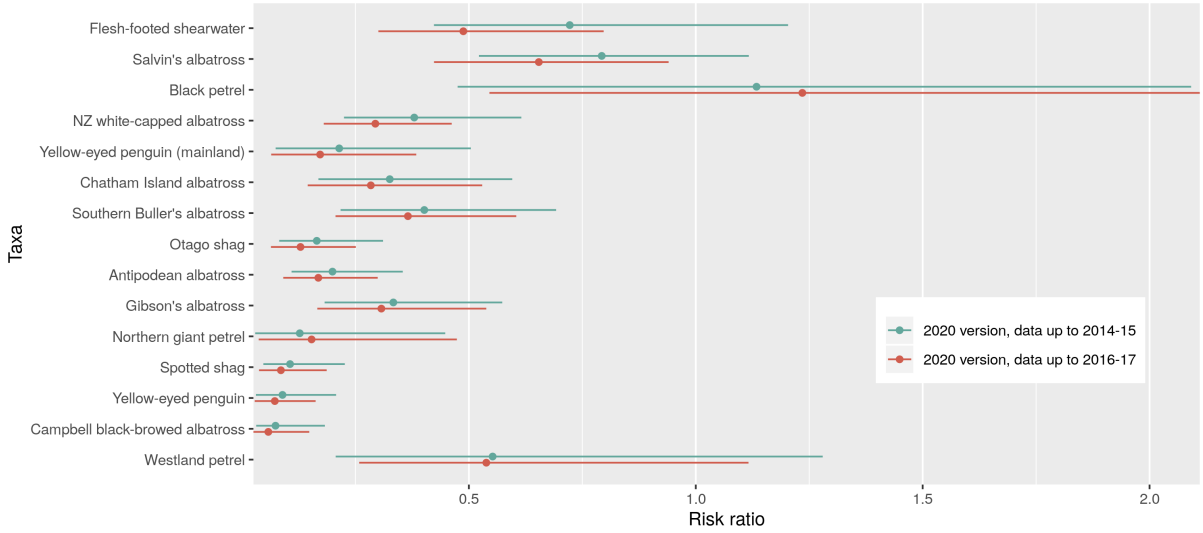


Figure G-5: Comparison of the estimated risk ratio using the current assessment framework (2020 version) for the periods from 2012–13 to 2014–15 and from 2014–15 to 2016–17. Shown are the ten seabird species with the greatest changes in risk ratio, in decreasing order of the change in median risk ratio.

Table G-21: Comparison of the total number of fishing-related deaths in trawl and longline fisheries estimated in the previous risk assessment (before updates; Richard et al. 2017a) and in the current assessment (after updates). Values were rounded to two significant digits. At-risk taxa are in bold and coloured according to the associated risk categories as defined in the "National Plan of Action – 2013 to reduce the incidental catch of seabirds in New Zealand fisheries" (Ministry for Primary Industries 2013): Red: very high risk; dark orange: high risk; light orange: medium risk; yellow: low risk. Numbers were rounded to three significant digits.

Taxon	Before updates		After updates	
	Mean	95% c.i.	Mean	95% c.i.
Gibson's albatross	166	106–242	151	95–221
Antipodean albatross	74	45–115	63	37–97
Southern royal albatross	19	6–41	22	9–42
Northern royal albatross	34	10–92	36	14–81
Campbell black-browed albatross	153	88–264	117	65–223
NZ white-capped albatross	3 830	2 690–5 380	3 160	2 290–4 330
Salvin's albatross	2 780	2 030–3 760	2 250	1 640–3 060
Chatham Island albatross	155	89–246	123	69–196
Grey-headed albatross	3	0–15	5	0–21
Southern Buller's albatross	528	371–745	486	358–664
Northern Buller's albatross	397	294–523	414	321–524
Light-mantled sooty albatross	3	0–15	2	0–13
Northern giant petrel	47	14–112	51	16–113
Grey petrel	203	123–340	139	86–217
Black petrel	468	316–666	513	325–803
Westland petrel	180	67–407	194	103–361
White-chinned petrel	1 360	1 080–1 720	1 680	1 390–2 010
Flesh-footed shearwater	987	623–1 560	710	496–1 020
Wedge-tailed shearwater	0	0–0	0	0–0
Buller's shearwater	18	6–47	17	6–35
Sooty shearwater	1 470	790–2 810	1 210	681–2 220
Fluttering shearwater	140	68–272	393	197–665
Hutton's shearwater	22	4–80	17	3–68
Little shearwater	5	1–12	6	1–12
Snares Cape petrel	19	2–74	24	5–68
Fairy prion	127	15–566	89	10–462
Antarctic prion	22	4–60	10	2–26
Broad-billed prion	11	1–35	9	1–29
Pycroft's petrel	0	0–1	0	0–1
Cook's petrel	14	0–76	7	0–36
Chatham petrel	0	0–0	0	0–0
Mottled petrel	7	0–41	4	0–21
White-naped petrel	0	0–0	0	0–0
Kerm. petrel	0	0–1	0	0–1
Grey-faced petrel	146	57–321	62	27–117
Chatham Island taiko	0	0–0	0	0–0
White-headed petrel	19	6–40	9	2–19
Soft-plumaged petrel	0	0–0	0	0–0
Common diving petrel	317	46–1 250	383	63–1 430
South Georgian diving petrel	0	0–1	0	0–1
NZ white-faced storm petrel	131	28–376	85	17–239
White-bellied storm petrel	0	0–0	0	0–0
Black-bellied storm petrel	4	0–15	2	0–9
Kerm. storm petrel	0	0–0	0	0–0
NZ storm petrel	0	0–1	0	0–1
Yellow-eyed penguin	23	8–47	21	8–41
Northern little penguin	2	0–8	13	4–26
White-flippered little penguin	0	0–3	4	0–9
Southern little penguin	1	0–7	7	1–15
Chatham Island little penguin	1	0–5	1	0–8
Eastern rockhopper penguin	1	0–3	1	0–3
Fiordland crested penguin	4	0–23	4	0–15
Snares crested penguin	1	0–4	1	0–5
Erect-crested penguin	1	0–3	1	0–4
Australasian gannet	5	0–20	3	0–12
Masked booby	0	0–0	0	0–0
Pied shag	9	0–29	8	0–25
Little black shag	3	0–11	3	0–9
NZ king shag	0	0–3	0	0–2
Otago shag	41	22–64	37	20–58
Foveaux shag	8	2–15	7	2–14
Chatham Island shag	0	0–3	0	0–3
Bounty Island shag	0	0–0	0	0–0
Auckland Island shag	0	0–1	0	0–1
Campbell Island shag	0	0–0	0	0–0
Spotted shag	335	215–484	304	198–439
Pitt Island shag	0	0–2	0	0–2
Subantarctic skua	0	0–0	0	0–0
Southern black-backed gull	87	29–200	54	18–117
Caspian tern	0	0–1	0	0–0
White tern	0	0–0	0	0–0

Table G-22: Comparison of the risk ratio estimated in the previous risk assessment (before updates; Richard et al. 2017a) and in the current assessment (after updates). At-risk taxa are in bold and coloured according to the associated risk categories as defined in the "National Plan of Action – 2013 to reduce the incidental catch of seabirds in New Zealand fisheries" (Ministry for Primary Industries 2013): Red: very high risk; dark orange: high risk; light orange: medium risk; yellow: low risk.

Taxon	Before updates		After updates	
	Median	95% c.i.	Median	95% c.i.
Gibson's albatross	**0.338**	0.186–0.586	**0.307**	0.166–0.538
Antipodean albatross	**0.203**	0.110–0.361	**0.168**	0.091–0.299
Southern royal albatross	0.020	0.007–0.053	0.025	0.010–0.053
Northern royal albatross	**0.043**	0.012–0.163	**0.048**	0.015–0.146
Campbell black-browed albatross	**0.077**	0.035–0.184	**0.058**	0.025–0.148
NZ white-capped albatross	**0.354**	0.208–0.580	**0.294**	0.180–0.462
Salvin's albatross	**0.780**	0.509–1.088	**0.654**	0.423–0.940
Chatham Island albatross	**0.361**	0.184–0.651	**0.284**	0.145–0.529
Grey-headed albatross	0.002	0.000–0.026	0.005	0.000–0.036
Southern Buller's albatross	**0.392**	0.217–0.670	**0.366**	0.206–0.604
Northern Buller's albatross	**0.253**	0.141–0.405	**0.263**	0.149–0.413
Light-mantled sooty albatross	0.001	0.000–0.018	0.001	0.000–0.014
Northern giant petrel	**0.138**	0.033–0.467	**0.153**	0.037–0.474
Grey petrel	0.037	0.018–0.075	0.026	0.012–0.051
Black petrel	**1.152**	0.505–2.032	**1.235**	0.545–2.111
Westland petrel	**0.477**	0.179–1.193	**0.538**	0.258–1.116
White-chinned petrel	0.055	0.032–0.090	**0.068**	0.039–0.107
Flesh-footed shearwater	**0.667**	0.391–1.151	**0.488**	0.301–0.797
Wedge-tailed shearwater	0.000	0.000–0.000	0.000	0.000–0.000
Buller's shearwater	0.000	0.000–0.001	0.000	0.000–0.001
Sooty shearwater	0.002	0.001–0.006	0.002	0.001–0.005
Fluttering shearwater	0.004	0.001–0.011	0.012	0.004–0.030
Hutton's shearwater	0.001	0.000–0.006	0.001	0.000–0.005
Little shearwater	0.000	0.000–0.001	0.000	0.000–0.001
Snares Cape petrel	0.010	0.001–0.063	0.014	0.003–0.064
Fairy prion	0.000	0.000–0.002	0.000	0.000–0.002
Antarctic prion	0.000	0.000–0.000	0.000	0.000–0.000
Broad-billed prion	0.000	0.000–0.001	0.000	0.000–0.000
Pycroft's petrel	0.000	0.000–0.003	0.000	0.000–0.002
Cook's petrel	0.000	0.000–0.002	0.000	0.000–0.001
Chatham petrel	0.000	0.000–0.000	0.000	0.000–0.000
Mottled petrel	0.000	0.000–0.001	0.000	0.000–0.000
White-naped petrel	0.000	0.000–0.000	0.000	0.000–0.000
Kerm. petrel	0.000	0.000–0.002	0.000	0.000–0.001
Grey-faced petrel	0.005	0.002–0.012	0.002	0.001–0.005
Chatham Island taiko	0.000	0.000–0.000	0.000	0.000–0.000
White-headed petrel	0.001	0.000–0.002	0.000	0.000–0.001
Soft-plumaged petrel	0.000	0.000–0.000	0.000	0.000–0.000
Common diving petrel	0.002	0.000–0.013	0.002	0.000–0.015
South Georgian diving petrel	0.000	0.000–0.065	0.000	0.000–0.070
NZ white-faced storm petrel	0.000	0.000–0.002	0.000	0.000–0.001
White-bellied storm petrel	0.000	0.000–0.000	0.000	0.000–0.000
Black-bellied storm petrel	0.000	0.000–0.001	0.000	0.000–0.001
Kerm. storm petrel	0.000	0.000–0.000	0.000	0.000–0.000
NZ storm petrel	0.000	0.000–0.040	0.000	0.000–0.025
Yellow-eyed penguin	**0.078**	0.027–0.186	**0.072**	0.028–0.162
Northern little penguin	0.001	0.000–0.006	0.008	0.002–0.021
White-flippered little penguin	0.000	0.000–0.006	0.007	0.000–0.023
Southern little penguin	0.000	0.000–0.005	0.004	0.001–0.012
Chatham Island little penguin	0.000	0.000–0.004	0.001	0.000–0.006
Eastern rockhopper penguin	0.000	0.000–0.000	0.000	0.000–0.000
Fiordland crested penguin	0.003	0.000–0.042	0.004	0.000–0.030
Snares crested penguin	0.000	0.000–0.001	0.000	0.000–0.001
Erect-crested penguin	0.000	0.000–0.000	0.000	0.000–0.000
Australasian gannet	0.000	0.000–0.003	0.000	0.000–0.002
Masked booby	0.000	0.000–0.000	0.000	0.000–0.000
Pied shag	0.007	0.000–0.029	0.005	0.000–0.025
Little black shag	0.008	0.000–0.043	0.006	0.000–0.035
NZ king shag	0.000	0.000–0.074	0.000	0.000–0.060
Otago shag	**0.144**	0.071–0.280	**0.129**	0.064–0.251
Foveaux shag	0.037	0.010–0.084	0.034	0.010–0.079
Chatham Island shag	0.000	0.000–0.041	0.000	0.000–0.047
Bounty Island shag	0.000	0.000–0.000	0.000	0.000–0.000
Auckland Island shag	0.000	0.000–0.002	0.000	0.000–0.003
Campbell Island shag	0.000	0.000–0.000	0.000	0.000–0.000
Spotted shag	**0.094**	0.043–0.204	**0.086**	0.038–0.187
Pitt Island shag	0.000	0.000–0.025	0.000	0.000–0.023
Subantarctic skua	0.000	0.000–0.000	0.000	0.000–0.000
Southern black-backed gull	0.000	0.000–0.001	0.000	0.000–0.001
Caspian tern	0.000	0.000–0.006	0.000	0.000–0.000
White tern	0.000	0.000–0.000	0.000	0.000–0.000

G.1 Effect of cryptic mortality

Table G-23: Comparison of the estimated risk ratio for 71 seabird taxa, with and without the inclusion of cryptic mortality in the estimation. Shown are the median and 95% credible interval (c.i.) of the risk ratios, when fishery mortalities are either considered as the annual number of observable captures (i.e., without cryptic mortality) or as the total fishing-related deaths (i.e., with cryptic mortality). The median values of non-negligible risk are in bold and coloured according to the associated risk category as defined in the "National Plan of Action – 2013 to reduce the incidental catch of seabirds in New Zealand fisheries" (Ministry for Primary Industries 2013): Red: very high risk; dark orange: high risk; light orange: medium risk; yellow: low risk. Numbers were rounded to three significant digits.

Taxon	No cryptic mortality		With cryptic mortality	
	Median	95% c.i.	Median	95% c.i.
Black petrel	**0.478**	0.232–0.909	**1.235**	0.545–2.111
Salvin's albatross	**0.11**	0.076–0.15	**0.654**	0.423–0.94
Westland petrel	**0.215**	0.115–0.376	**0.538**	0.258–1.116
Flesh-footed shearwater	**0.226**	0.145–0.35	**0.488**	0.301–0.797
Southern Buller's albatross	**0.093**	0.055–0.142	**0.366**	0.206–0.604
Gibson's albatross	**0.171**	0.097–0.291	**0.307**	0.166–0.538
NZ white-capped albatross	0.041	0.027–0.059	**0.294**	0.18–0.462
Chatham Island albatross	**0.096**	0.043–0.188	**0.284**	0.145–0.529
Northern Buller's albatross	**0.101**	0.058–0.159	**0.263**	0.149–0.413
Yellow-eyed penguin (mainland)	**0.069**	0.025–0.15	**0.172**	0.064–0.384
Antipodean albatross	**0.09**	0.05–0.153	**0.168**	0.091–0.299
Northern giant petrel	**0.06**	0.012–0.214	**0.153**	0.037–0.474
Otago shag	**0.099**	0.049–0.189	**0.129**	0.064–0.251
Spotted shag	**0.066**	0.03–0.142	**0.086**	0.038–0.187
Yellow-eyed penguin	**0.069**	0.025–0.15	**0.072**	0.028–0.162
White-chinned petrel	0.035	0.02–0.054	**0.068**	0.039–0.107
Campbell black-browed albatross	0.021	0.009–0.046	**0.058**	0.025–0.148
Northern royal albatross	0.019	0.006–0.054	**0.048**	0.015–0.146
Foveaux shag	0.026	0.005–0.061	0.034	0.01–0.079
Grey petrel	0.011	0.005–0.022	0.026	0.012–0.051
Southern royal albatross	0.01	0.003–0.022	0.025	0.01–0.053
Snares Cape petrel	0.002	0–0.01	0.014	0.003–0.064
Fluttering shearwater	0.006	0.002–0.016	0.012	0.004–0.03
Northern little penguin	0.007	0.002–0.019	0.008	0.002–0.021
White-flippered little penguin	0.007	0–0.021	0.007	0–0.023
Little black shag	0.005	0–0.03	0.006	0–0.035
Grey-headed albatross	0.002	0–0.011	0.005	0–0.036
Pied shag	0.004	0–0.02	0.005	0–0.025
Southern little penguin	0.004	0.001–0.011	0.004	0.001–0.012
Fiordland crested penguin	0.004	0–0.021	0.004	0–0.03
Common diving petrel	0	0–0.001	0.002	0–0.015
Grey-faced petrel	0.001	0–0.002	0.002	0.001–0.005
Sooty shearwater	0.001	0–0.001	0.002	0.001–0.005
Chatham Island little penguin	0	0–0.003	0.001	0–0.006
Light-mantled sooty albatross	0	0–0.004	0.001	0–0.014
Hutton's shearwater	0	0–0.001	0.001	0–0.005
Auckland Island shag	0	0–0.003	0	0–0.003
Bounty Island shag	0	0–0	0	0–0
Subantarctic skua	0	0–0	0	0–0
Caspian tern	0	0–0	0	0–0
Chatham Island shag	0	0–0.025	0	0–0.047
Campbell Island shag	0	0–0	0	0–0
Eastern rockhopper penguin	0	0–0	0	0–0
Erect-crested penguin	0	0–0	0	0–0
Snares crested penguin	0	0–0.001	0	0–0.001
Black-bellied storm petrel	0	0–0	0	0–0.001
White-bellied storm petrel	0	0–0	0	0–0
White tern	0	0–0	0	0–0
South Georgian diving petrel	0	0–0	0	0–0.07
NZ king shag	0	0–0.048	0	0–0.06
Kerm. storm petrel	0	0–0	0	0–0
Masked booby	0	0–0	0	0–0
Australasian gannet	0	0–0.002	0	0–0.002
NZ storm petrel	0	0–0	0	0–0.025
Buller's shearwater	0	0–0	0	0–0.001
Pitt Island shag	0	0–0.013	0	0–0.023
Chatham petrel	0	0–0	0	0–0
Cook's petrel	0	0–0	0	0–0.001
Chatham Island taiko	0	0–0	0	0–0
Pycroft's petrel	0	0–0	0	0–0.002
Soft-plumaged petrel	0	0–0	0	0–0
Little shearwater	0	0–0	0	0–0.001
Wedge-tailed shearwater	0	0–0	0	0–0
Kerm. petrel	0	0–0	0	0–0.001
Antarctic prion	0	0–0	0	0–0
White-naped petrel	0	0–0	0	0–0
NZ white-faced storm petrel	0	0–0	0	0–0.001
Southern black-backed gull	0	0–0	0	0–0.001
Fairy prion	0	0–0	0	0–0.002
Mottled petrel	0	0–0	0	0–0
Broad-billed prion	0	0–0	0	0–0
White-headed petrel	0	0–0	0	0–0.001

G.2 Effect of updates

Table G-24: Comparison of risk ratios between model versions used to estimate the risk of commercial fisheries to seabirds. The risk ratios from the previous risk assessment (Richard et al. 2017a) are compared to the current version, but using data for the same time period 2006–07 to 2014–15 of Richard et al. (2017a), labelled "2020 version, data up to 2014–15", to highlight the effect of data corrections between the two versions. The new base case, "2020 version, data up to 2016–17", included all data corrections and used data up to the 2016–17 fishing year, and difference with "2020 version, data up to 2014–15" highlights changes in fishing practices or location. The median values of non-negligible risk are in bold and coloured according to the associated risk category as defined in the "National Plan of Action – 2013 to reduce the incidental catch of seabirds in New Zealand fisheries" (Ministry for Primary Industries 2013): Red: very high risk; dark orange: high risk; light orange: medium risk; yellow: low risk. Numbers were rounded to three significant digits.

Species	Richard et al. 2017a		2020 version, data up to 2014-15		2020 version, data up to 2016-17	
	Median	95% c.i.	Median	95% c.i.	Median	95% c.i.
Black petrel	**1.15**	0.51–2.03	**1.13**	0.48–2.09	**1.23**	0.55–2.11
Salvin's albatross	**0.78**	0.51–1.09	**0.79**	0.52–1.12	**0.65**	0.42–0.94
Flesh-footed shearwater	**0.67**	0.39–1.15	**0.72**	0.42–1.2	**0.49**	0.3–0.8
Westland petrel	**0.48**	0.18–1.19	**0.55**	0.21–1.28	**0.54**	0.26–1.12
Southern Buller's albatross	**0.39**	0.22–0.67	**0.4**	0.22–0.69	**0.37**	0.21–0.6
NZ white-capped albatross	**0.35**	0.21–0.58	**0.38**	0.22–0.62	**0.29**	0.18–0.46
Gibson's albatross	**0.34**	0.19–0.59	**0.33**	0.18–0.57	**0.31**	0.17–0.54
Chatham Island albatross	**0.36**	0.18–0.65	**0.33**	0.17–0.6	**0.28**	0.14–0.53
Northern Buller's albatross	**0.25**	0.14–0.4	**0.26**	0.14–0.41	**0.26**	0.15–0.41
Antipodean albatross	**0.2**	0.11–0.36	**0.2**	0.11–0.35	**0.17**	0.09–0.3
Yellow-eyed penguin (mainland)	**0.19**	0.07–0.44	**0.21**	0.07–0.5	**0.17**	0.06–0.38
Northern giant petrel	**0.14**	0.03–0.47	**0.13**	0.03–0.45	**0.15**	0.04–0.47
Otago shag	**0.14**	0.07–0.28	**0.16**	0.08–0.31	**0.13**	0.06–0.25
Spotted shag	**0.09**	0.04–0.2	**0.11**	0.05–0.23	**0.09**	0.04–0.19
Yellow-eyed penguin	**0.08**	0.03–0.19	**0.09**	0.03–0.21	**0.07**	0.03–0.16
Campbell black-browed albatross	**0.08**	0.04–0.18	**0.07**	0.03–0.18	**0.06**	0.03–0.15
White-chinned petrel	0.05	0.03–0.09	0.05	0.03–0.09	**0.07**	0.04–0.11
Northern royal albatross	**0.04**	0.01–0.16	**0.04**	0.01–0.16	**0.05**	0.02–0.15
Foveaux shag	0.04	0.01–0.08	0.04	0.01–0.09	0.03	0.01–0.08
Grey petrel	0.04	0.02–0.08	0.04	0.02–0.08	0.03	0.01–0.05
Southern royal albatross	0.02	0.01–0.05	0.02	0.01–0.05	0.02	0.01–0.05
Snares Cape petrel	0.01	0–0.06	0.02	0–0.1	0.01	0–0.06
Fluttering shearwater	0	0–0.01	0.01	0–0.02	0.01	0–0.03
Little black shag	0.01	0–0.04	0.01	0–0.05	0.01	0–0.03
Pied shag	0.01	0–0.03	0.01	0–0.03	0.01	0–0.02
Northern little penguin	0	0–0.01	0	0–0.01	0.01	0–0.02
White-flippered little penguin	0	0–0.01	0	0–0.01	0.01	0–0.02
Fiordland crested penguin	0	0–0.04	0	0–0.04	0	0–0.03
Grey-headed albatross	0	0–0.03	0	0–0.03	0.01	0–0.04
Grey-faced petrel	0	0–0.01	0	0–0.01	0	0–0
Sooty shearwater	0	0–0.01	0	0–0.01	0	0–0.01
Southern little penguin	0	0–0	0	0–0	0	0–0.01
Common diving petrel	0	0–0.01	0	0–0.01	0	0–0.01
Light-mantled sooty albatross	0	0–0.02	0	0–0.02	0	0–0.01
Hutton's shearwater	0	0–0.01	0	0–0.01	0	0–0
White-headed petrel	0	0–0	0	0–0	0	0–0
Buller's shearwater	0	0–0	0	0–0	0	0–0
NZ white-faced storm petrel	0	0–0	0	0–0	0	0–0
Australasian gannet	0	0–0	0	0–0	0	0–0
Little shearwater	0	0–0	0	0–0	0	0–0
Chatham Island little penguin	0	0–0	0	0–0	0	0–0.01
Southern black-backed gull	0	0–0	0	0–0	0	0–0
Fairy prion	0	0–0	0	0–0	0	0–0
Black-bellied storm petrel	0	0–0	0	0–0	0	0–0
Broad-billed prion	0	0–0	0	0–0	0	0–0
Cook's petrel	0	0–0	0	0–0	0	0–0
Snares crested penguin	0	0–0	0	0–0	0	0–0
Antarctic prion	0	0–0	0	0–0	0	0–0
Mottled petrel	0	0–0	0	0–0	0	0–0
Auckland Island shag	0	0–0	0	0–0	0	0–0
Bounty Island shag	0	0–0	0	0–0	0	0–0
Subantarctic skua	0	0–0	0	0–0	0	0–0
Caspian tern	0	0–0.01	0	0–0	0	0–0
Chatham Island shag	0	0–0.04	0	0–0.04	0	0–0.05
Campbell Island shag	0	0–0	0	0–0	0	0–0
Eastern rockhopper penguin	0	0–0	0	0–0	0	0–0
Erect-crested penguin	0	0–0	0	0–0	0	0–0
White-bellied storm petrel	0	0–0	0	0–0	0	0–0
White tern	0	0–0	0	0–0	0	0–0
South Georgian diving petrel	0	0–0.06	0	0–0.07	0	0–0.07
NZ king shag	0	0–0.07	0	0–0.08	0	0–0.06
Kerm. storm petrel	0	0–0	0	0–0	0	0–0
Masked booby	0	0–0	0	0–0	0	0–0
NZ storm petrel	0	0–0.04	0	0–0.05	0	0–0.02
Pitt Island shag	0	0–0.03	0	0–0.02	0	0–0.02
Chatham petrel	0	0–0	0	0–0	0	0–0
Chatham Island taiko	0	0–0	0	0–0	0	0–0
Pycroft's petrel	0	0–0	0	0–0	0	0–0
Soft-plumaged petrel	0	0–0	0	0–0	0	0–0
Wedge-tailed shearwater	0	0–0	0	0–0	0	0–0
Kerm. petrel	0	0–0	0	0–0	0	0–0
White-naped petrel	0	0–0	0	0–0	0	0–0